Next Generation Automobiles
in Miyagi

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Strategic Regional Innovation Support Program by MEXT(For recovery from Tohoku Disaster) Next-Generation Automobiles / Miyagi Area

Revised March, 2013

Strategic Regional Innovation Support Program by MEXT
(For recovery from Tohoku Disaster)
Next-Generation Automobiles / Miyagi Area

Global/Local Innovations for Next Generation Automobiles

Program, abstracts, and presenting materials for

- ICFD OS5 "Global/Local Innovations for Next Generation Automobiles" on November 25-27, 2013
- "Worldwide Leaders Meeting on Global/Local Innovations for Next Generation Automobiles" on November 28, 2013

Revised March, 2014

Tohoku Economic Federation
Tohoku University
Miyagi Prefecture
The 77 Bank
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Tohoku Economic Federation
Tohoku University
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Intelligent Cosmos Research Institute

To All People around the World,

We thank you very much for your enormous support for our recovery and reconstruction in the areas devastated by the 2011 Tohoku Earthquake and Tsunami. Although we still experience many difficult days, going through this hardship has allowed us to discover new ways to strengthen bonds that invigorate our attitude toward reconstruction and revival.

In this situation, the automotive industry has largely been considered a major center of economic opportunity because of its economic impact. All over the Tohoku region but especially in Miyagi prefecture, the expectation for the automotive industry is enormous. Emblematic of this expectation is the recent startup of the Toyota Motor East Corporation.

Our project the "Strategic Regional Innovation Support Program" supported by MEXT (Ministry of Education, Culture, Sports, Science and Technology) kicked off in July 2012 in order to realize the reconstruction and revival of Tohoku, through the development of new products and system by the collaborative efforts of industry, academia and government. This collaboration is primarily based on the strong and diverse R&D at Tohoku University, a leader in domestic and international education.

As a research-oriented university, Tohoku University has been involved in a number of collaborative efforts with big business but less so with smaller, local businesses. As one might assume, the importance of developing local businesses is of the highest order. Since June 2012, we have held a wide variety of events: Research information session for local business people, over thirty lectures for manpower training, more than forty laboratory tours for local business people, our researchers were invited to tour local companies, and poster presentations by all laboratories which joined in this project. These events broke down the borders separating the university from local businesses and as a result a number of new collaborations have begun to bloom.

We also understand that there are many leaders who are trying a variety of challenges to realize both global and local innovations in next generation automobiles. We are very happy to organize an international symposium on global/local innovations for next generation automobiles by inviting such worldwide leaders and design a variety of ways to realize global/local innovations in next generation automobiles. We have to emphasize that many local companies greatly contribute to this symposium in addition to leading laboratories in Tohoku University. We sincerely hope that this symposium provides opportunities to deepen our friendship and promote reconstruction and revival of Tohoku Area through a variety of challenges for the innovations in next generation automobiles.

Katsuto Nakatsuka, Project Director

Akira Miyamoto, Chairman of Research Promotion Committee

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Please visit our official website for details of the project;
www.miyagicar.com

If you have any inquiry, please contact the laboratories and companies directly. And please don't hesitate to contact the Research Promotion Committee to refer which of them may help you.

International Conference
"Global/Local Innovations for Next Generation Automobiles"

Part1: Program of Special Session of Tenth International Conference on Fluid Dynamics (ICFD2013)
OS5: "Global/Local Innovations for Next Generation Automobiles"
Organizers: A. Miyamoto (Tohoku University)
P. Kapsa (Ecole Central de Lyon)

Date: November 25(Mon) – 27(Wed), 2013
Conference Site: Sendai International Center, Sendai, Japan

November 25(Mon)

12:00-12:50	**Session OS5　Lunch Meeting (Sakura 1)**	
13:00-13:10	**OS5 Session Opening** Akira Miyamoto and Philipe Kapsa	
OS5-1 13:10-13:50	**Convergence of Transportation and Energy in the Future** Mark C. Williams (URS, USA)	**1**
OS5-2 13:50-14:30	**Research and development of fully automated vehicles** Keiji Aoki (Japan Automobile Research Institute, Japan)	**6**
OS5-3 14:30-15:10	**Human Factor Research Using a Driving Simulator** Kimihiko Nakano (The University of Tokyo, Japan)	**8**
15:10-15:30	BREAK	
OS5-4 15:30-16:10	**Vehicle Innovations Bring Regional Community into the New Age** **– Fuel Cell Vehicle and Hydrogen Move to the 2015 Introduction –** Katsuhiko Hirose (Toyota Motor Corporation, Japan)	**10**
OS5-5 16:10-16:50	**Research and Development of Transport Simulation** Alexandre Torday (Transport Simulation Systems Pty Ltd., Australia)	**12**
OS5-6 16:50-17:30	**NDT-Innovations in The Automotive Industrial Sector** **And To Light-Weight Materials** Gerd Dobmann (Fraunhofer-IZFP, Germany)	**13**
OS5-7 17:30-18:00	**Compact-Sizing of Optical Topography Technology (NIRS)** Kiyoshi Hasegawa (Hitachi, Ltd., Japan)	**15**
19:00-21:00	**OS5 Session Dinner Party** **At Westin Hotel 25th Floor　TSUKI**	

November 26(Tue)

9:00-12:00	**Short Oral Presentations of Poster - Part 1**	50
	(BREAK 10min)	
	Short Oral Presentations of Poster - Part 2	
12:00-12:50	**Session OS5 Lunch Meeting (Sakura 1)**	
13:00-14:30	**Poster Presentations**	48
OS5-8 14:30-15:00	**Understanding the Triple Helix Model and the Finance of Innovation: Implications for Japan** Masato Hisatake (Tohoku University, Japan)	17
OS5-9 15:00-15:40	**Understanding the Triple Helix Model and the Finance of Innovation** Erik P. M. Vermeulen (Tilburg University, The Netherlands)	17
OS5-10 15:40-16:20	**Innovation, University Entrepreneurship and the Role of Triple Helix** Shigeo Kagami (The University of Tokyo, Japan)	19
16:20-16:30	BREAK	
OS5-11 16:30-17:10	**Can Functional Brain Imaging Prompt Innovations in Next-generation Automobiles?** Ryuta Kawashima (Tohoku University, Japan)	22
OS5-12 17:10-17:50	**Alzheimer's disease: from pathology to therapeutics** Takeshi Iwatsubo (The University of Tokyo, Japan)	24
18:00-20:30	**ICFD Banquet at SAKURA**	

November 27(Wed)

OS5-13 9:00-9:30	**The Japanese Next Generation Vehicle Strategy: A Successful Strategy to Achieve CO_2 Emission Reduction and Global Green Vehicle Leadership** Noriko Behling (Author, USA)	26
OS5-14 9:30-10:00	**NH_3-$DeNO_x$ Performance of the Composite [Fe-Beta + Fe(Mn)MCM-48] Catalyst: Combining SCR Activity and NH_3 Oxidation Activity for NH_3 Slip Removal** Alexandr Yu. Stakheev, Dmitry A. Bokarev, Alina I. Mytareva (N. D. Zelinsky Institute of Organic Chemistry, Russia), Rajesh Kumar Parsapur and Parasuraman Selvam (Indian Institute of Technology Madras, India)	28

Part2: "Worldwide Leaders Meeting on Global/Local Innovations for Next Generation Automobiles"

Organizers: A. Miyamoto (Tohoku University) and K. Nakatsuka (ICR)

Date: November 28(Thu), 2013

Conference Site: Sendai Trust Tower, Sendai, Japan

November 28(Thu)

Please note that some of the presentations above are not on this book.

Convergence of Transportation and Energy in the Future

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ABSTRACT

Energy and transportation are major world industries joined inextricably together. Each available energy source – fossil, nuclear, renewable - has used as used as a transportation fuel. The future of fuel availability is the future of transportation. The existing dominance of fossil fuels can only persist through a transition period. In the future hydrogen, solar, natural gas and other renewable will dominate the transportation. Solar cars, battery vehicles, PHEV, hydrogen fuel cell vehicles, and natural gas vehicles, represent tomorrow's propulsion future.

1.Introduction

Reducing energy use and reducing the negative human impact on the environment in a constrained, highly populated state with frequent interactions with multiple consequences. It is critical to do as little damage as possible and intrude as little as possible on the environment. We are obviously in a transition period for energy and transportation as we search for new fuels and attempt to use now dominant fuels more efficiently. Energy and transportation are major world industries joined inextricably together. Each available energy source – fossil, nuclear, renewable - has been used to support transportation (Figure 1). The future of fuel availability is the future of transportation. In the future hydrogen, solar, natural gas and other renewable fuels will dominate transportation. Solar cars, battery vehicles, plug-in hybrid electric vehicle (PHEV), hydrogen fuel cell vehicles, and natural gas vehicles, represent tomorrow's propulsion future. Efficient and environmentally sound energy conversion in transportation depends on new and improved transportation technology. In many cases electrochemical technology, such as fuel cells, solar, solid-state lighting and batteries, is a vital component of that future.

2. Oil

The world is rapidly consuming the finite amounts of stored energy, especially petroleum. By way of example, USA consumes 20 million barrels (BBL) per day (seven billion BBL per year) of petroleum products. Canada (2-3 million BBL/day - half from tar sands) and Middle East (1.5 million BBL/day) help supply USA petroleum [1]. Canada tar sands contain 300 BBL, one of the world's largest resources ever known, would supply USA for only 40 years. The relentless hunt for oil will continue to the limit of economic viability.

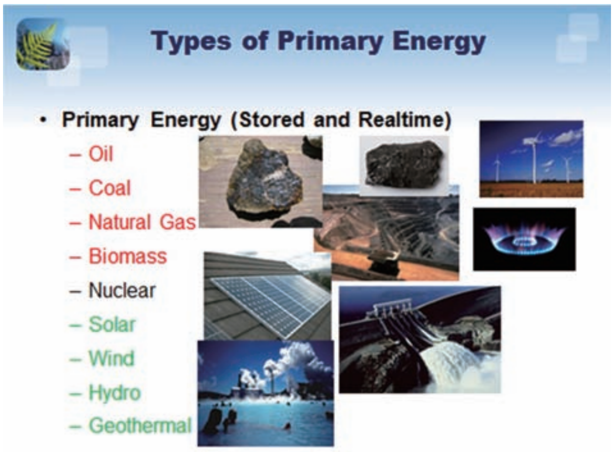

Figure 1 Types of Primary Energy

However, the internal combustion engine hybrid, such as the Prius, has already made inroads to improve automotive efficiency. Electrochemical storage with batteries is, of course, an integral part of that hybrid vehicle.

3. Natural Gas

We benefit from the chemical energy, like natural gas, extracted from sunlight on this planet. As long as there is life and sunlight, we will always have renewable natural gas on this planet in the future. Methane from human (ADG) and plant and animal and plant residues and wastes captured from sunlight are available today and in the future.

In addition, huge reserves of natural gas have been found and are being extracted with fracturing techniques. It has been estimated by Pennsylvania State University (PSU) that 4,400 trillion cubic feet of natural gas is located in the Marcellus Shale in the Eastern USA [2]. In addition, huge reserves of gas some 50,000 TCF are believed to exist in methane hydrates in the United States alone (Figure 2).

By way of comparison, the US uses only 23 trillion cubic feet per year. At the PSU estimate, the Marcellus Shale gas, if only one third was recovered, could replace USA petroleum for transportation for around 50 years. Natural gas at $5 per million BTU is the energy equivalent of $28 per BBL oil which sells for currently $100 per BBL.

Figure 2 Methane Hydrate Drilling

Currently, the only natural gas light-duty vehicle manufactured in the USA is the Honda Civic ($26,000 list price; 24 city/36 hwy/28 combined gasoline equivalent miles per gallon). Only roughly 110,000 of the 12 million CNG vehicles worldwide are in the USA, including aftermarket conversions. There are roughly 250 million registered passenger vehicles in the USA [1]. The cost to convert vehicles to NG is estimated $12,500 to $22,500 depending on the vehicle, engine, size of CNG tanks needed, and who does the converting [3]. Without the development of significant infrastructure and improved storage, natural gas vehicles cannot be a reality. Due to the short range operation of natural gas internal combustion engine vehicles, alternative electrical technology such as high-efficient solid oxide fuel cells operating directly on natural gas are being considered [4]. In addition, the fuel cell could be hybridized with a turbo-generator for additional performance [5].

4. Hydrogen

Hydrogen fuel cell vehicles will require a hydrogen infrastructure. Natural gas is currently the principle method to generate hydrogen [1]. Production from renewable energy – wind, solar, geothermal and biomass is also possible. The use of hydrogen for vehicles may require the development of two infrastructures – one for natural gas and one for hydrogen.

Fuel cell technology transforms electricity production in stationary and transportation applications because it is the most efficient way to convert chemical energy to electricity. While major, multi-billion dollar development world-wide has centered on polymer electrolyte fuel cells [6] for the future of transportation, solid oxide fuel cells operating directly on natural gas are a definite possibility, as previously mentioned.

5. Solar

All the energy stored on the earth comes from the supernova of suns or the Sun itself. See Figure 1. With the solar electric vehicle (SEV) solar system, the Toyota Prius, for example, can operate up to 30 miles per day in electric mode thus improving fuel economy by up to 34-60%. Power from a solar array is limited by the size of the vehicle and area that can be exposed to sunlight. While energy can be accumulated in batteries to lower peak demand on the array and provide operation in sunless conditions, the battery adds weight and cost to the vehicle.

The power limit can be mitigated by use of conventional electric cars supplied by solar (or other) power, recharging from the electrical grid. This is the triple hybrid vehicle—the PHEV that has solar panels as well to assist. While sunlight is free, the creation of photovoltaic (PV) cells to capture that sunlight is expensive although costs for solar panels are declining. The photoelectric effect occurs when certain materials produce electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which PV's is based. (see Figure 3)

Figure 3 Solar Vehicle – Courtesy Toyota

6. Stationary Power from Coal, Nuclear, Natural Gas, and Renewables for Transportation

Primary non-renewable energy sources for stationary power – coal, nuclear, and natural gas nuclear - will continue to be used until unavailable or until environmental pressure curtails their usage. While direct propulsion in transportation with these fuels is limited, the use of this energy for transportation and especially plug-in hybrids is increasing.

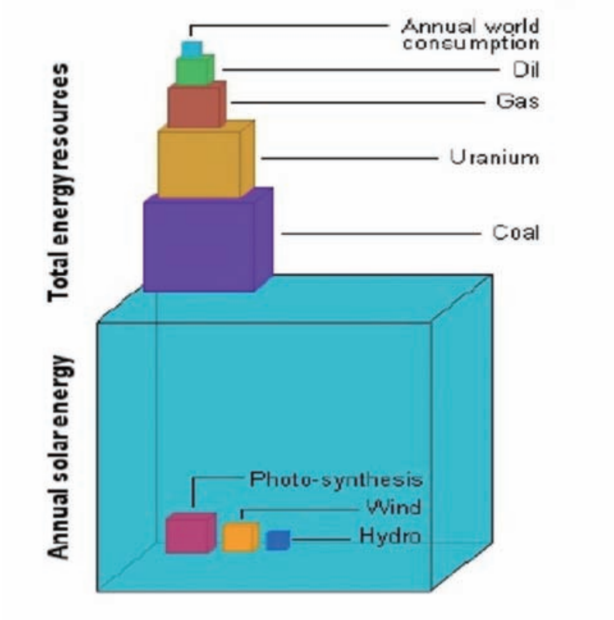

Figure 4 Energy Consumption, storage energy, and incident energy [7]

However, the efficiency of stationary power generation is problematic (Figure 2). Greater use by plug-in hybrids will only shorten the long term availability of primary non-renewable fuels like coal and increase reliance on an inefficient system.

However, electrochemical technology – solid oxide fuel cells, particularly solid-oxide fuel cell turbine hybrids, and solid-state lighting have the opportunity to increase stationary power generation efficiency by an order of magnitude [8]. See the bottom of Figure 5.

In the nuclear energy fuel cycle, the fuel rods will spend about 3 operational cycles (typically 6 years total) inside the reactor or generally until about 3% of their uranium has been fissioned [9]. Then they are moved to a spent fuel pool where the short lived isotopes generated by fission can decay away. After about 5 years in a spent fuel pool the spent fuel is radioactively and thermally cool enough to handle, and it can be moved to dry storage casks or reprocessed. There is no storage facility for nuclear waste in USA. All our nuclear waste belongs to the American people.

Despite the efficiency limitations of the current grid, complete electrochemical electrification of the transportation sector through stationary power and electric vehicles would eliminate the need to depend on petroleum. This, of course, by itself, has strategic security implications.

The use of renewable biomass is questionable. While it has been estimated by Oak Ridge National Laboratory that 600 million to a billion tons/year may be available in the USA alone [10], a reliable source of biomass within a hundred miles of power generation sources is not always feasible. In addition, ethanol production impacts food prices [11].

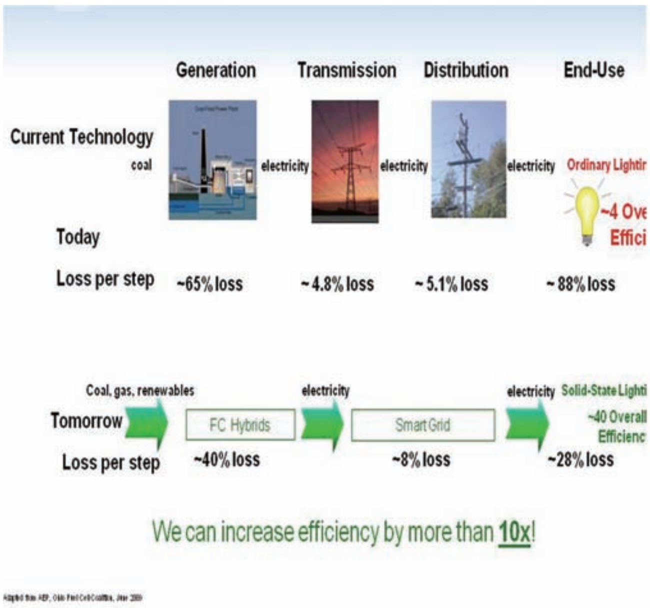

Figure 5 Energy Efficiency in Stationary Power Generation [12]

7. Electrochemical Storage Battery

Today the energy for charging batteries must come from some currently dominate, primary energy sources – fossil and nuclear. Battery vehicles depend on electricity from the current electrical grid system and stationary power. However, the grid efficiency could be improved as we have seen and, in addition, the grid is changing and renewables could account for a greater and greater share of global power [13].

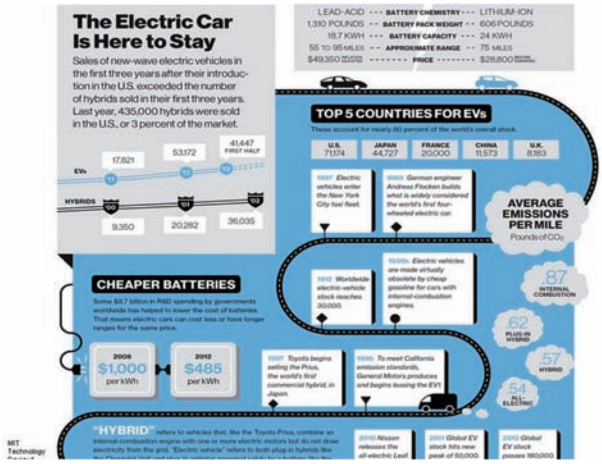

Figure 6 MIT's View of Battery Vehicles [14]

Electrochemical storage is the great enabler of PHEV's and electric vehicles. Energy storage costs are falling, but batteries remain expensive. In fact, the electric car is making great progress [14] and appears here to stay. The USA leads the world with over 70,000 battery vehicles deployed (Figure 6).

8. Future of Transportation - Concluding remarks

Energy and transportation are major world industries joined inextricably together. The available energy in the future will determine the fuel to be used in transportation. Efficiency of energy conversion will determine when and to what fuel the industry will vector. Electrochemical technology innovation with fuel cells, solar, solid-state lighting, and electrochemical energy storage batteries is helping to shape this future.

PRIMARY ENERGY	FUEL	INFRASTRUCTURE	TECHNOLOGY	CUSTOMER
NG	CNG	none	ICE	Autos/long haul trucking
NG	CNG	none	SOFC/electric motor/battery	Autos
Light	electricty	sunlight	Electric Motor/battery	Autos
NG Light Hydro Geothermal Wind Biomass	electricity	electric grid	Battery/Electric Motor	parking = charging

Figure 7 The Future of Energy and Transportation

When all practical oil, coal and nuclear energy is exhausted, transportation will have to rely on sunlight and natural gas. Any available energy from other renewables, like geothermal, wind, and biomass, will support the grid. Natural gas ICE's and natural gas solid oxide fuel cells, which can use natural gas directly as a fuel unlike other fuel cells, will provide bulk and long haul transportation needs. Battery vehicles will dominate personal and local travel. Research areas include battery cost reduction and reliability, solid oxide fuel cell cost and durability, and improving solar efficiency and lowering its cost until it can out perform any fossil fuel grid generation.

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About the Author

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Research and development of fully automated vehicles

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ABSTRACT

Automated truck platoon is focused on being able to improve the fuel economy and operation cost as next freight transportation system. In order to achieve 15 % of CO_2 reduction, an automated platoon system with closed gap distance of 4 m, have been developed. Trucks are equipped with automated steering and speed control system so that vehicles can travel at closed gap distance alone the lane. Automated platoon composed from three heavy duty trucks and one light duty truck has been demonstrated successfully at gap distance of 4 m.

1. Introduction

Automated vehicles being able to improve safety, fuel economy and traffic efficiency which are main issues on automobiles are anticipated as next generation automobiles. Currently, automated vehicles which must become next generation automobiles are being developed in Japan, Europe and United State America. Especially, automated truck platoon is focused on being able to improve the fuel economy and operation cost as next freight transportation system.

In 2008, a national project for reducing CO_2 gas emitted from heavy duty trucks on the highway, called "Energy ITS," was initiated in Japan under the auspices of the New Energy and Industrial Technology Development Organization. The mission of this project is to build an automated platoon system with closed gap distance which will be able to reduce CO_2 gas emission without engine modification. It has been already proven through many studies that the air-drag of each truck can be reduced by the closing of gap distance between trucks, resulting in improvement of fuel consumption. [1] In order to achieve 15 % of CO_2 reduction, an automated platoon system with closed gap distance of 4 m, have been developed and also the automated platoon within three heavy duty trucks have been tested at a speed of 80 km/h on oval test track.

In this paper, automated platoon technologies developed in this project will be described.

2. Concept of Automated Platoon

While it is required for platoon to keep the gap distance closely in order to improve fuel economy by reducing the air-drag, the task of keeping of closed gap distance on mixed traffic within conventional vehicles will be difficult for human drivers because of limited human's physiological response time. Automated vehicle control will be essential for keeping of closed gap distance. Both Lateral and longitudinal control can be made automatically trucks in platoon. Image of platoon is illustrated in Fig.1. The Steering is controlled automatically so that vehicles can keep the lane alone the painted lane line and also the propulsion of engine and the brake is controlled automatically for keeping gap distance between vehicles.

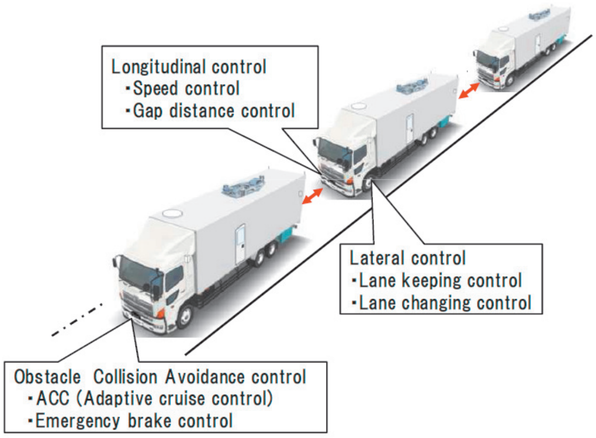

Fig.1 Concept of automated platoon

3. Detail of vehicle control

3.1 Lane keeping control

Block diagram of lane-keeping control system is shown in Figure 2. Nonlinear model based control algorithm was applied to the path following. [2]

The control algorithm consists of feed-back control and feed-forward control module in order to compensate the time lag of sensor and actuator. Feed-back control module can compensate the deviation of the lateral displacement and yaw angle and Feed-forward control module compensates the error due to both the cant and curvature of road.

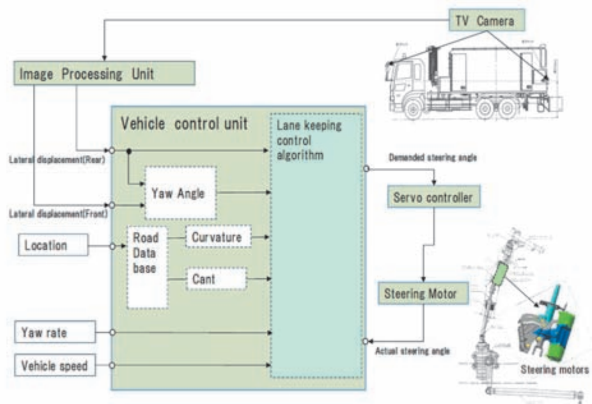

Fig2. Block diagram of lane keeping control system.

The lateral displacement and yaw angle with respect to white lane-marking line is measured by 2 kinds of lane detection sensor which are TV cameras and laser mounted on the left side of a truck. These sensors are mounted on so as to look down road surface in order to prevent the misdetection under the condition of rainy weather or against sun beam. The lateral displacement can be detected by the image processing unit which can recognize the while lane line from the image captured by TV cameras and laser. The yaw angle can be calculated from both lateral displacement of front and rear.

3.2 Longitudinal Control

For longitudinal control, in order to achieve precise controllability under the transient condition such acceleration and deceleration, cooperative distance control algorithm using the vehicle to vehicle (V-V) communication has been developed. The data concerning to vehicle speed, acceleration and deceleration rate of a leading truck is transmitted to following trucks by using V-V communication. Gap distance can be measured by 76GHz mill wave radar and laser radar. The engine propulsion and braking of a truck are controlled to maintain the inter-vehicle distance constantly.

4. Experimental vehicles

Experimental trucks have been developed in order to evaluate lateral and longitudinal controllability and fuel economy.

Figure 3 shows the configuration of experimental trucks. TV cameras and laser sensor are mounted on the top of the cabin and the rear of the cargo compartment on the left side. A mill-wave radar with 76GHz and a LIDAR for distance detection between vehicles are mounted near the front bumper. The steering motors for lane keeping are mounted on steering shaft. Radio-wave based inter-vehicle communication unit with 5.8 GHz and the communication protocol was developed specifically for platoon. HMI unit has been developed for the interface between human driver and automated control system.[3] Mission of human driver during automated control mode is to survey the control state by using display of HMI unit. If control system will be broken, human driver will take over the steering and braking operation.

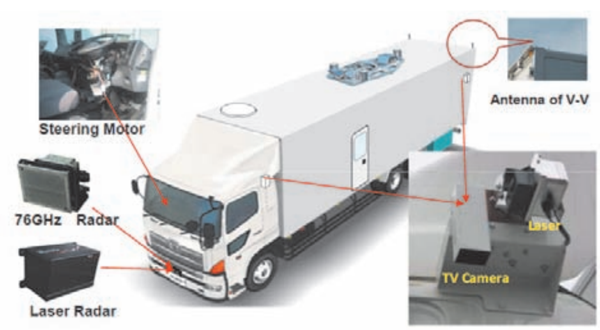

Fig.3 Experimental automated truck

5. Evaluation test result and demonstration

Controllability of lane keeping and gap distance has been evaluated on oval test track and new express-way under the construction. The lateral deviation on lane keeping control is approximately ±0.2 m during the curved road with 180 R. Longitudinal deviation for the Control of gap distance within platoon is approximately ±0.2 m at a constant vehicle speed of 80 km/h and ±1.0 m during the deceleration of 0.4 G.

It has been proven to achieve highly accurate controllability during emergency braking by using V-V communication.

Fuel economy of the platoon composed by tree heavy duty trucks has been evaluated on test track. The saving rate of fuel consumption due to gap distance is shown in Fig. 4. Fuel economy of platoon can be improved up to 15% at the condition of gap distance of 4.5 m compared to the single truck operation.

Finally, automated platoon composed by three heavy duty trucks and one light duty truck has been demonstrated successfully at gap distance of 4 m.

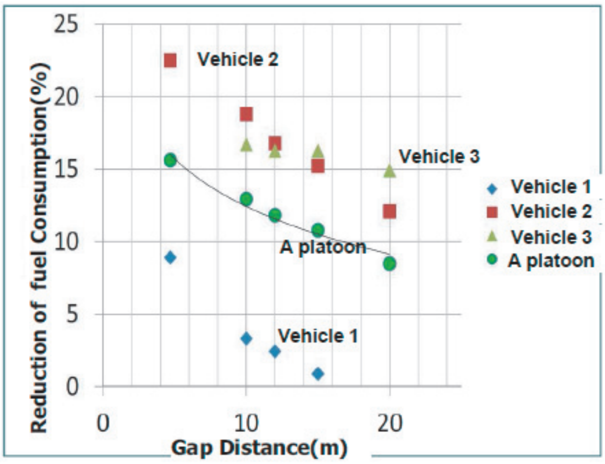

Fig.4 Result of fuel economy by platoon with 3 trucks

6. Conclusion

The automated platoon system with closed gap distance of 4 m, have been developed in order to improve fuel economy and safety on mixed highway traffic. Automated platoon composed from three heavy duty trucks and one light duty truck has been demonstrated successfully at gap distance of 4 m.

However, there are some non-technical issues to be solved so that automated platoon can be implemented to next freight transportation.

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Human Factor Research Using a Driving Simulator

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ABSTRACT
Two recent topics on human factor research using a driving simulator are introduced. One is evaluation of driving comfort by activity of sternocleidomastoid(SCM) muscle of a passenger, and the other is evaluation of human-machine interface for an automatic platooning truck. To examine human responses, it is essential to carry out experiments since it is hardly possible to make a model of human behavior for numerical simulation. In both researches, driving simulators are utilized to conduct the experiments with safe and ease. The meaningful results are obtained in both researches through the experiments using the driving simulators.

1. Introduction

In the field of automobile engineering, higher importance is placed on human related topics such as comfort, human-machine interface, and safety. It is demanded to carry out human factor researches. As it is difficult to express human behaviors with some mathematical models, we need carry out experiments including humans. Although an experiment using a test car is one of the best methods, it brings risk of accidents. Then a driving simulator is utilized to analyze behaviors and responses of drivers and passengers. Two recent researches on human factor using driving simulators are introduced. The first one is evaluation of driving comfort by activity of sternocleidomastoid (SCM) muscle[1] of a passenger. As SCM is a muscle to keep position of the head, electromyography(EMG) signal of the SCM increases when the unwanted lateral acceleration grows. Usually an automobile having poor driving comfort produces unwanted lateral acceleration when it is steered, thus the comfort can be evaluated with the amplitude of the EMG signal. The effectiveness of the proposed method is examined through experiments using test cars and a driving simulator. The second one is evaluation of human-machine interface for an automatic platooning truck[2]. This research is carried out as a part of project of Development of Energy-saving ITS Technology, financially supported by New Energy and Industrial Technology Development Organization of Japan (NEDO)[3]. Driving environment of a cabin of the truck under automatic platooning control is reproduced on the driving simulator. Then human-machine interface of the controller for the automatic platooning is evaluated on the driving simulator. Through introducing these two research topics, direction of the human factor research on the automobiles and significance of the driving simulator in the research topic are discussed.

2. Evaluation of driving comfort

The possibility to use passenger`s EMG of SCM muscles as an objective evaluation indicator to vehicle dynamics is discussed. The SCM is in the neck, and its main function is keeping the head in the appropriate position. Two same cars are prepared for the experiments. One is the normal car, and the other is the modified car, whose body is reinforced to increase its rigidity. While the test cars were driven at the speed of 65km/h in a slalom course of 30m intervals, the EMGs of 5 subjects were measured as well as the relative acceleration in the car body. Figure 1 show RMS value of EMG signal of SCM muscle of all subjects. The RMS of the EMG in the modified car is significantly smaller than the normal car.

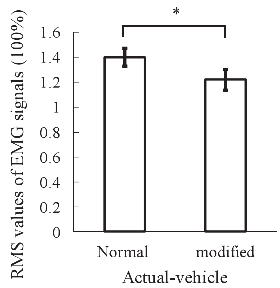

Fig. 1. RMS values of the EMG signals for SCM muscles in the test car experiments (mean ± S.D., and two-sample paired t-test: $*P < 0.05$ and $n = 5$).

The motion of the test car in the slalom course is reproduced in the driving simulator (DS), as shown in Fig. 2. Four motions are produced by adding the relative accelerations of the normal car (normal 100%), two times of it (normal 200%), the relative accelerations of the modified car (modified 100%), and two times of it (modified 200%). The EMGs of the SCMs of 10 subjects are measured on the DS. As shown in Fig. 3, RMS value in the modified car significantly lower than the normal car ($P < 0.05$ and $n = 10$).

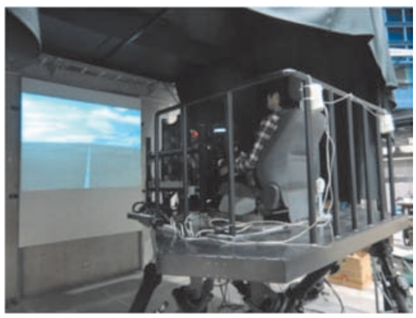

Fig.2 Photograph of the driving simulator.

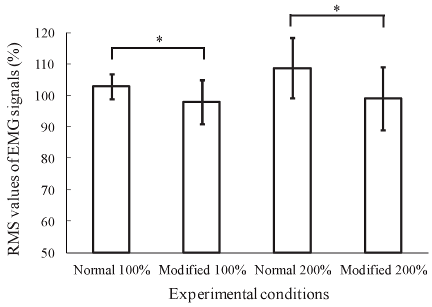

Fig. 3. RMS values of EMG signals in the DS experiments (mean ± S.D., and the two-sample paired t-test: $*P < 0.05$ and $n = 10$).

3. Human-machine interface of the controller for the automatic platooning truck

Human factors in automatic platooning are mainly about operations and conditions of driver during the processes of the formation and separation of the automatic platooning. Otherwise, it is also necessary to evaluate human-machine interface for the communication of driver and the system of the automatic platooning. As a novel technology in automobile field, a driving simulator for trucks is used for evaluate automatic platooning driving and its system considering human factors. A truck driving simulator, as shown in Fig. 4, was developed. In whole, a full-scale cabin of a real truck, steering equipment attached a servo-motor, an air seat, a sound generator based on the actual-vehicle driving of truck and control software are integrated into a driving simulator system to improve driver sense in a truck driving. TruckSim software, linked with Simulink, is connected with the host computer of DS using dSPACE. Then the Gap distance control and path following control for automatic platooning and adaptive cruise control (ACC) utilized for the actual platooning trucks, were built in the DS.

Fig. 4 The DS for the platooning truck.

For the application of the automatic platooning, three types of human-machine interface (HMI) are designed: numeric characters, graphics, and numeric characters & graphics types. Ten full-time truck drivers are cooperated in our study, for evaluation of HMI system. The mean age is 44.3 years old, license experience for truck is 15 years, driving experience of truck is 9.2 years, and driving frequency of truck is 41.2 hours/week. The subjects are asked to rank the three types of HMI system and to evaluate the information provided by the HMI system. The most popular display is that using both numeric characters and graphics, because its contents can be easily understood to master the driving conditions during the automatic platooning. The information items highly rated are control status of own truck by figure, current velocity, current gap distance, target gap distance, and number of trucks in transmission, which are closely related to safety. To the contrary, the drivers paid few attentions to the items of current acceleration, target acceleration, and instantaneous fuel economy.

(a) Numeric type

(b) Graphic type

(c) Numeric and graphic type

Fig. 5. Three types of HMI; Information is given with numeric characters in (a), graphics in (b), and both numeric characters and graphics in (c).

4. Conclusion

Two research topics are introduced. One is evaluation of driving comfort by activity of sternocleidomastoid(SCM) muscle, the other is evaluation of human-machine interface of the controller for the automatic platooning truck. In both researches meaningful remarks are derived from the DS experiments. The driving simulator will remain important as a tool to examine the human factors in the field of automobile engineering.

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Vehicle Innovations Bring Regional Community into the New Age
Fuel Cell Vehicle and Hydrogen Move to the 2015 Introduction

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ABSTRACT

Hydrogen fuel cell is the long-waited technology to improve the environment and to alternate the energy to non oil energy source. It takes more than expected but finally commercialization is announced and infrastructure preparation is in progress all over the world. Potential of hydrogen is not only fuel for the automobile but also considered to be an important long time storage media for fluctuated renewable energy. This technology may change the local community to be able to produce and consume and to control by them self rather than import and controlled by the central capital. .

1. Introduction

Mobility is the one of the most basic desire of a human being. And since the invention of automotive the human being obtained the real freedom of moving. Last one and half century automotive itself changed from coal fueled steam to current gasoline fired hybrid vehicle. If you carefully check the fuel and technologies of vehicles, evolution of technologies are also carried out by the environmental restrain. This is very similar to the evolution of life.

Coal is replaced by the liquid fuel because of the limitation of range. Manual transmission is replaced by the automatic transmission because of the comfort and convenience. Next evolution was the introduction of electric drive this was due to the high oil price and brings the hybrid electric vehicle such as TOYOTA Prius to the market.

Next evolution is expected by the sustainability of the earth and brings the new technology "Fuel cell and hydrogen" to the market.

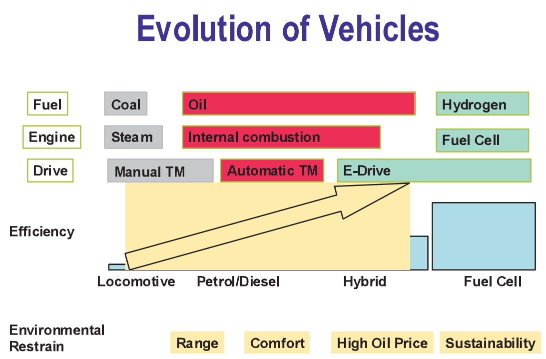

Fig. 1 Material innovation and Society

2. Progress and potential of Fuel Cell Vehicle

Hydrogen fuel cell was once a very expected technology to replace the oil burning vehicles. However engineers faced multiple difficulties to bring into the real road conditions. Day by day efforts of engineers and scientists solve the most of the problems such as durability, volume and range. then finally announced to bring the technology in to the market soon.

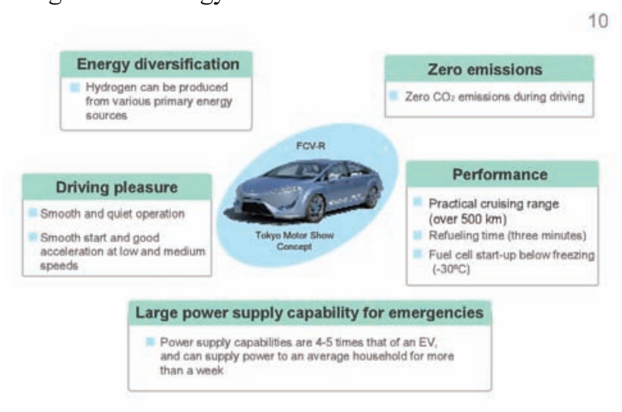

Fig. 2 Advantages of Fuel Cell Vehicle

Advantages of fuel cell vehicle are shown on figure2. In addition to the environmental performance such as zero emission, energy diversification the vehicle performance such as good drivability and slenderness are expected to realize. For the popularization of vehicle continence is very important fuel cell vehicle is now refueled within 3mininutes and is able to travel more than 500km. In addition to the normal performance it is now recognized to be an emergency power source since vehicle has a capability of generating electricity 10kw lever more than few days with stored hydrogen.

There are other zero emission vehicle and environmental friendly vehicle such as Battery Electric Vehicle (BEV) Plug-in Hybrid Vehicle (PHV). We expect those technologies will be segregated by the size and purpose of the mobility shown in figure 3.

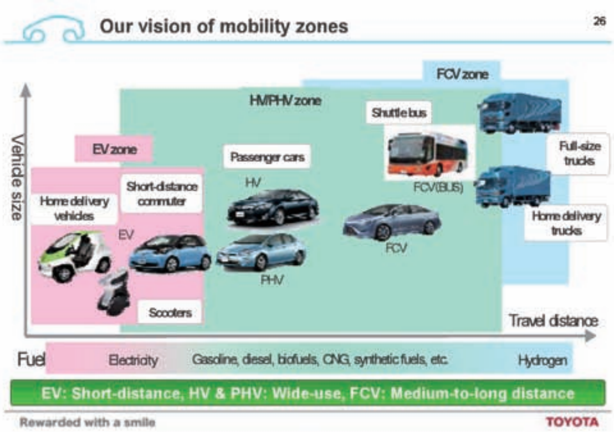

Fig. 3 Vision of Mobility Zone

3. Potential of Hydrogen

Hydrogen is already produced largely in the industry such as petroleum, chemical, fertilizer industries. Potential of those industries to provide hydrogen for early market is more than sufficient.

However recent increase of renewable energy power generation re-recognizes the potential of hydrogen as an energy vector to store the energy of this fluctuating energy source. In northern Europe hydrogen is spot light as a media to transfer the electricity to the south because of the lack of enough grid connection...

Efficiency of hydrogen just for store the electricity is lower than battery or pomp-up hydro. However the hydrogen has a big advantage of long time storage and potential of replacing more expensive/valuable fuel such as gasoline. It is now getting expected to co-grow the renewable electricity and hydrogen to accelerate carbon free world.

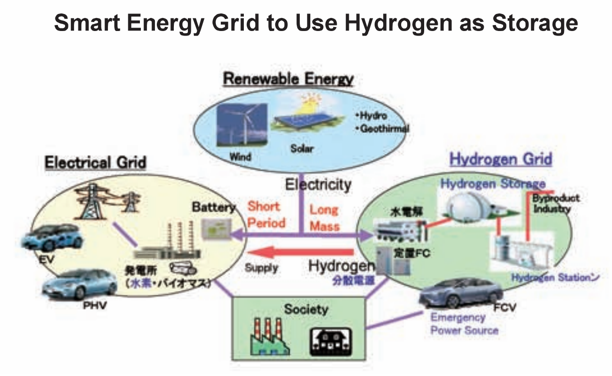

Fig. 4 Smart Grids to Use Hydrogen as Storage

4. Conclusion

Increased hydrogen usage in the society may increase the potential of regional area than ever since use of renewable enhance the regional economic balance to improve. Because of renewable energy is richer in dis centralized area either close to the sea or high mountain area rather than big city. This may lead the preferable economic condition to the local area and bring the area into self sustainable for both energy and fuel for mobility. Cheaper energy and good living condition may attract more industries and people.

5. Concluding remarks

Several car manufacture already announce introduction of fuel cell vehicle into the market, it may be the beginning of new era for the human being to enjoy the mobility of freedom without any deterioration of environment and the regional society going to the center of living life.

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Research and Development of Transport Simulation

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ABSTRACT

This presentation will aim to offer an objective review of the current trends in term of transport modeling around the world, bth in term of hoe they are applied and new models developments. As an introduction, a review of the existing modeling level will be offered with a particular emphasis on the mesoscopic level which is considered as the newcomer in this field and playing evry day a more important role in transportation planning and operation. How these different modeling levels are combined in different projects will then be described leading to a discussion about model integration and maintenance, a problem that is know facing most of the transport authorities around the world. This topic will highlight the need for a common and centralized data base of transport infrastructure representation and a brief link to a QUT research on model free databases will be established. The role of modeling to assess ITS solution will be then described with an important emphasis on V2X applications. This topic will permit to discuss about how new data sources like probe and Bluetooth can help in improving the model accuracy and trustiness. Finally, the presentation will discuss another important trend in modeling which is using it as part of an ITS solution: real-time modeling for decision support system and forecasting.

NDT-Innovations In The Automotive Industrial Sector And To Light-Weight Materials

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ABSTRACT
The challenge to produce cars with reduced weight in order to reduce then also fuel consumption and waste was in the last two decades always a driver for innovations in materials design and production. So far new materials were developed or conventional-ones were optimized there was also always the question to answer: Do we have proper NDT-technologies to characterize the quality of the optimized material components and to detect – may be now new type of irregularities – coming-up with the new materials and/or the new production technologies?

1. Introduction

Fraunhofer-IZFP is engaged in 3 industrial sectors where light-weight materials and components, on one hand are produced and on the other hand are consumed, respectively applied. In the 1st group one can find steel and other metal producing industries and the chemical industry producing polymers and polymer-based composites. In the other group we have mainly car manufacturers (automotive industry), aerospace industry and their supplying industry partners.

The here presented contribution is a selection of specific examples of Fraunhofer-IZFP solutions for the above mentioned industries which are introduced in routine practice.

2. Steel Industry

Concerning light-weight materials for car and especially car body developments the progress is by high-strength material allowing to reduce weight and therefore sheet thickness and reducing fuel consumption. This has its benefits also to reduce CO_2 and to contribute therefore against the worldwide green house effect.

2.1 NDT for high-strength steel sheets

In charge of important European steel manufacturers Fraunhofer-IZFP has developed NDT for material characterization technology [1] allowing mechanical property determination in terms of yield strength (Rp0.2), tensile strength (Rm) and texture characteristics r_m and Δr (planar and vertical anisotropy), All of these parameters have to be controlled in a very narrow scattering band concerning the properties along the length of a steel sheet (2.5 km coil length) and the full width.

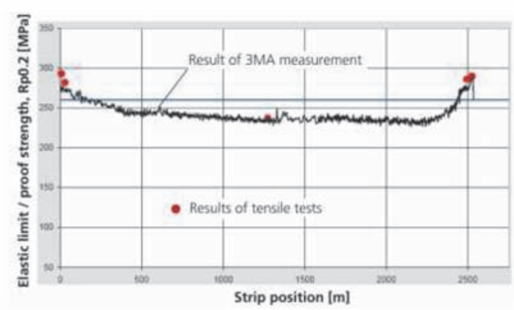

Fig. 1 Yield strength Rp0.2 predicted by micromagnetic NDT [2]

Fig.1, as example, documents the NDT materials property prediction by micromagnetic NDT [2] of which the prediction accuracy is in the range of ~ 10% compared with destructive techniques.

2.2 Cast Iron with lamellar and vermicular graphite

To reduce the weight of the power supply unit the car combustion engines cylinder crankcases can be made of cast iron with vermicular graphite (GJV), because this material in a Diesel engine allows a higher loading pressure even by reduced wall thickness. However, the service live of machining tools is substantially smaller during processing an engine block made from GJV compared with a block from cast iron with lamellar (flake) graphite (GJL) [3].

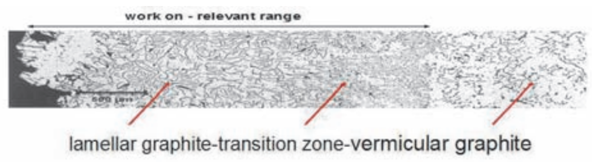

Fig. 2 Microstructure gradient obtained in a cylinder region of a cast engine

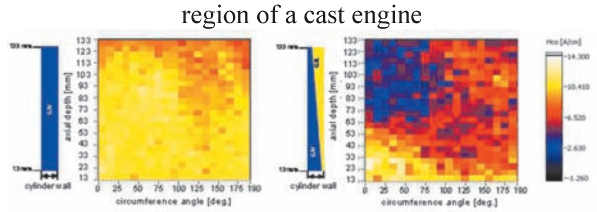

Fig. 3 Gradient of the magnetic coercivity, left hand side GJV cast cylinder block, right hand side GJV/GJL microstructure gradient

This disadvantage can be eliminated by an innovative casting technology that produces a continuous microstructure gradient in the cast iron from lamellar graphite at the inner surface of the cylinders to vermicular graphite in radial direction. By implementing some chemical additives into the core of the mold which can diffuse in the cast iron during the solidification process in the mold the gradient with a continuous transition from lamellar graphite and finally vermicular graphite is obtained. However, the technology can only be used by the casters so far the gradient quality can be characterized and monitored by NDT. Fig.2 documents in a micrograph such a gradient beginning at the left side with cast iron (inner cylinder surface) and lamellar graphite followed by a transition region and vermicular graphite on the right side.

3MA techniques always cover a certain analyzing depth depending on the magnetizing frequency and geometrical parameters of the magnetization yoke, etc. So far the gradient has different graphite compositions within the analyzing depth, 3MA quantities should be influenced. Based on measurements at an especially designed calibration test specimen set 3MA quantities were selected to image the gradient with optimal contrast. As reference quantity to calibrate 3MA the local thickness of the GJV-layer was evaluated by using micrographs and optimized pattern recognition algorithms in the microscope. A special designed transducer head was developed to scan the cylinder surface by line scans in hoop direction and rotating the head, then shifting the head in axial direction to perform the next line scan. Fig. 3 shows as example the coercivity images derived from the tangential magnetic field strength evaluation (H_{CO}).

3. Carbon Fiber Reinforced Plastics (CFRP)

As CFRP laminates have a complex lamination structure with different fiber directions (0°, 90°, ± 45°) the production process of lamination of the prepregs is complicated and different kind of quality limiting structure irregularities can occur. Therefore NDT after production is a need as well as in aerospace industries in-service inspection of the highly stressed components. As the structures are very often sandwich like where in between two CFRP plates honeycomb structures are embedded the inspection tasks are much more difficult.

However, new developments in NDT have brought progress in the inspection applications.

3.1 Eddy current testing

As CFRP has electrical conductivity the material can be inspected using eddy current (EC) technology [4]. Fig. 4 shows images of the eddy current impedance obtained by an automated scan with an EC-transducer. Frequency range of the equipment is between 10 Hz and 10 MHz. A multi-frequency approach can be performed by time-multiplexing and different typical structural defects can be detected optimal at different frequencies.

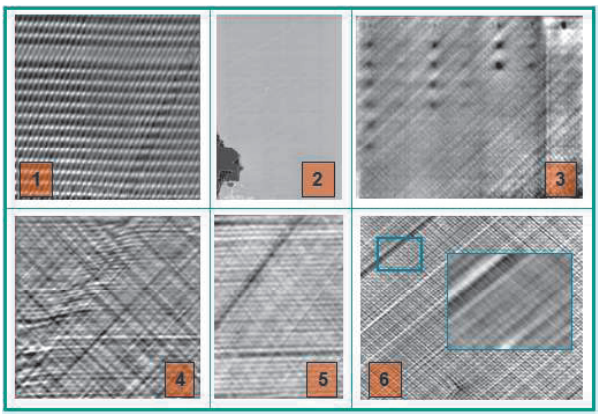

Fig. 4 Defect detection by EC in CFRP

So far direction sensitive transducers are applied angular oriented defects are detected (missing rovings (1, 5, 6), foreign body embedding (here test pieces, fuzzy balls, 3), delaminations (2), and ondulations (4).

3.2 Thermography

Flash pulsed thermography [5] can detect impact damage which by human eye is not detectable. Fig. 5 shows a thermal image of such damage in a CFRP plate

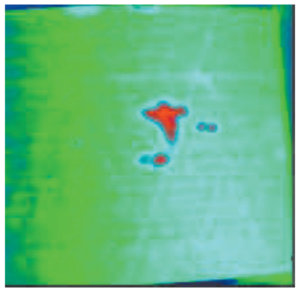

Fig. 5 Impact damage detection by pulsed thermography, field of view 60 mm × 60 mm

4. Conclusions

NDT has developed new technology to inspect light-weight materials. Successful applications were presented to

- high strength steel material property determination
- to the characterization of light-weight steel casting
- to EC and thermal CFRP inspection.

In the oral contribution also results to ultrasonic testing and imaging and X-ray CT will be discussed.

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Compact-Sizing of Optical Topography Technology (NIRS)

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ABSTRACT
There are several neuro-imaging methods, however, most of them need specialized facilities and high maintenance cost. Recently the need for measuring in the daily-life-like environment is increasing, and Hitachi succeeded to develop compact-sized Optical Topography (OT) units. Compact-sized units will realize the measurement in the various environment efficiently and economically .In this symposium, I will explain the basic technology of NIRS and potential future expansive usage.

1. Introduction

21st century is so called as neurotechnology era, while 20th century is called as physics era. Since the world faces globalization, there is an increasing need to know human itself better. In many case in the past, the way to know how people are feeling and thinking, are the subjective evaluation methods, such as questionnaire sheet or group interview. But recently many noticed that subjective evaluation methods have certain limitation, because it needs a verbal interpretation between the questioner and respondent. For knowing how people feels and think, there are some new solutions created, such as behavior measurements, brain function measurements, and etc.

In the past, in order to measure brain function, it is first necessary to prepare a specialized measuring room which needs a large initial investment as well as maintenance fee. Some measurement tools must fix the examinee's body tight.

What is highly required in the market is the tool measureable in the daily-life-like environment. Hitachi believe that OT technology would be one of the closest and best applicable solution, compared with other brain measurement tools.

2. Method

1) Background of development

OT Technology was developed by Hitachi's Central Research Lab. in 1995, and in 2001, the first medical grade product was introduced by Hitachi Medical Corporation.

Compact-sized product was developed and introduced from 2010, and there are several types of products available now.

2) Basic Principle of OT

OT technology is based on very weak near-infrared light around 800nm, and it can be used safely from neonates to seniors. Measurement system consists of the combination of irradiation sensor and detection sensor. The sensors are designed to be positioned at 3cm distance in square. The irradiated light from the surface of head skin goes inside of the brain and scatters, and a portion of light path, going up to 2 to 2.5cm depth and then come back to the surface of the head (Fig. 1).

The light around 800nm is known as a very good wavelength to measure human body, which goes through the skin, bone, and human tissue, but is absorbed by hemoglobin.

When a part of brain becomes active, it needs more oxygen and glucose. Oxygen is carried by hemoglobin, and when the brain activity becomes higher, the increase in hemoglobin also occurs. The brain activity refers as an increase or decrease of the returned light intensity. When the brain activity becomes higher, the increase in hemoglobin occurs and the decrease of returning light intensity occurs. On contrary, when the brain activity becomes lower, the decrease of hemoglobin occurs and the increase of returning light intensity occurs[1].

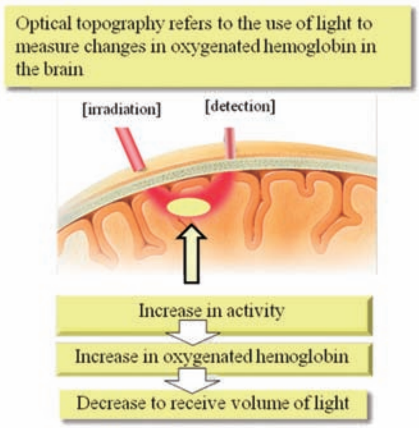

Fig.1 Mechanism of measurement

3) Comparison of measurement technologies

Compared with other measurement technologies, OT has certain merits to be usable in the daily-life-like environment. First, it can be designable as transportable and also wearable. Secondary, it is not affected by the outside radio noises, since the measurement is not electric wave, but near infrared light. The drawback of OT is that it is not possible to measure the deep portion of brain, but the surface of the brain (cerebral cortex part). And also spatial resolution is 3cm, which is wider than fMRI. Nevertheless OT is best fit to measure human's brain activity in cerebral cortex in the daily-life-like environment (Fig.2).

	Signal	Measurable in daily life like condition	Compact Sizing	Simultanous measurement	Realtime measurement	Easiness to wear
EEG	nerve	△	◎	◎	○	○
MEG	nerve	x	x	△	x	x
fMRI	Blood Volume Change(deoxy)	x	x	x	△	x
Optical Topography NIRS	Blood Volume Change	○	◎	◎	○	○

Fig. 2 Comparison of measurement technology

3. Development of Compact-Sized OT

Hitachi has developed 2 types of Compact-Sized OT, which are available commercially in research field. Those 2 models are specialized for forehead measurement.

1) Wearable Optical Topography (WOT series)

WOT's design target is that the unit should be measureable in the daily-life-like environment, so mobility is one of the most important design concept. It employs non-fiber optics ergonomic design, newly developed 2-wave-length built-in laser capsule, rechargeable built-in battery, and wireless LAN for non-cable connection to the host control computer. In addition, new probe design was adopted and soft touch style probe was realized (Fig. 3) [2].

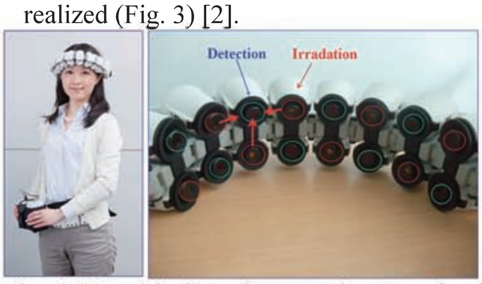

Fig. 3 Wearable form factor and new probe design

Since it employs wireless LAN, Wearable OT's another merit is to measure multiple persons simultaneously. Currently, up to 4 persons measurement becomes possible (Fig. 4), and it is effective to measure people's communications (Fig. 5), interactions, and mass data collection at one time[3].

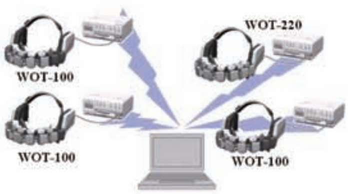

Fig. 4 Wireless System

Fig. 5 Scene of Communication measurement

2) 2 Channel NIRS(HOT121)

Furthermore, the smaller form factor HOT121 was developed to be able to wear headset by examinee itself and start measurement in the very short time. HOT121 measures 2 points of forehead, targeting working memory area (Fig. 6).

Fig. 6 Design of HOT121

Later than HOT121, by the joint research effort with Tohoku University and Hitachi, 1-channel Wireless Proto-Type System was developed (Fig.7). This Proto-Type System enabled up to 20 persons measurement simultaneously at one time.

Fig. 7 Proto-Type System of 1-channel

4. Concluding remarks

By Compact-sized OT hardware, the measurement scene will expand wider.

In the future, by the wireless communication technology, measurement scheme may lead to collect more data and do analysis in almost realtime (Fig. 8).

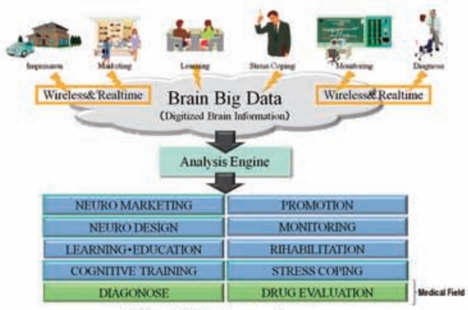

Fig. 8 Future Image

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Understanding the Triple Helix Model and the Finance of Innovation

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ABSTRACT
Governments increasingly partner with corporations, universities and research institutions in an effort to build knowledge-intensive and high tech clusters. These 'triple helix' collaborations generally ignore the importance of financial capital and financially driven incentives. Since the main purpose behind the triple helix approach is to solve economic, social and environmental problems, the policy focus should be on building venture capital ecosystems. New sources of capital, such as joint venture capital funds, crowd funding, online venture capital platforms and partnerships offer new opportunities for governments.

1. Introduction

What should governments and policymakers do to stimulate innovation and entrepreneurship? One way to do it is to encourage the launch and development of start-up companies. But, how should governments support these innovative startup companies? Is there a role for governments in the finance of innovation? There isn't an easy answer. For instance, it has often been argued that governments can only play a very limited role in spurring innovation and entrepreneurship (Lerner, 2009[1]; Hwang and Horowitt, 2012[2]). It is here where the 'venture capital ecosystem' plays a crucial role. Clearly, venture capital (provided by private parties as well as the government) is necessary to support the further growth and development of these companies (Gompers and Lerner, 2001[3]; Mazzucato, 2013[4]).

In order to stimulate innovation, policymakers mainly focus on creating environments in which governments increasingly partner with large corporations, universities and knowledge and research institutions. These triple helix collaborations are, among other things, directed to the establishment of knowledge-intensive service clusters in which the structure and dynamics of interactions among the different actors drive the transfer of knowledge and provide other resources that increase the potential for innovation, growth and value creation. The triple helix approach has proven successful in that it has led to the formation of formal and informal networks of entrepreneurs and other economic actors, thereby increasing the availability of human capital and, more importantly, social capital.

2. Methods

We assess the triple helix model by an analysis of the most innovative regions in the world. Consider Brainport in the Netherlands. Brainport is a business location that is centered around Eindhoven in the Netherlands. it was established as a triple helix cluster. This initiative is considered very successful in terms of R&D spending, the production of patents and job creation. In 2011, companies invested EUR 2.1 billion in research and innovation, which resulted in the production of 42% of the total patents (approximately 1,100 patents) that were registered in the Netherlands. More than 60,000 industry jobs were created in the region. In terms of benchmarking the success of Brainport, the triple helix approach has arguably generated an ecosystem for innovation that belongs to the best in the world. In 2011, the Intelligent Community Forum named Eindhoven the 'Intelligent Community of the Year'. What is perhaps more important is that Forbes Magazine has ranked Eindhoven as the most inventive city in the world (with 22.6 patents for every 10,000 residents) in 2013 (Pentland, 2013[5]). To put this number in perspective, in the second-ranked San Diego, which is considered the world leader in the clean technology economy, this number is 8.9 patents for every 10,000 residents.

Despite the clear benefits of the triple helix model, there is a recognized concern that the Brainport hub may not realize its full potential (European Commission, 2013[6]). Experts increasingly point to a missing fourth helix (and sometimes even fifth helix): the citizens or user communities (also called the 'civil society') and the 'natural environments of society' (Carayannis, Barth and Campbell, 2012[7]). There is something to the quadruple or quintuple helix model. The unique collaboration among academia (research), industry and government focuses on the creation of an engaging and stimulating environment for open innovation and knowledge transfer activities. However, the model does not include the drivers for knowledge production, innovation and growth. This is where the civil society (fourth helix) and natural environment (fifth helix) come into play. It is argued that these elements are necessary to provide incentives to the 'triple helix actors' to drive economic, social and environmental innovations to the market faster and more effectively (Curley and Salmelin, 2013[8]).

Still, there are problems with pushing the quadruple or quintuple helix models too far. First, the extended innovation models prove difficult to implement, because they heavily rely on the actors' willingness and ability to think and act beyond their own functional boundaries (European Commission, 2013[6]). Second, the models arguably put too much emphasis on the interrelations of human capital and social capital in the process of innovation and collaboration, thereby ignoring the importance of financial capital and financially driven incentives (The Economist, 2013[9]). These financial incentives are necessary to accelerate growth and achieve market leadership. Venture capitalists and other risk capital providers can and must play a crucial role not only in the area of knowledge transfer and innovation, but also as 'social impact' investors that attempt to solve global economic, social and environmental problems, such as global warming and healthy aging (Bennett, 2012[10]; Martin, 2013[11]). This brings us to the challenges that policymakers and governments face in building a venture capital ecosystem.

3. Results and Discussion

The creation of a venture capital ecosystem remains one of the biggest challenges for governments. There are several reasons for this. Most traditionally structured venture capital firms have (with a few notable exceptions) delivered uninspiring returns (Mazzucato, 2013[4]; Mulcahy, 2013[12]). This has not only led to a significant decrease in the number of venture capital funds, but has also moved many of them towards the less risky financing of already profitable later stage companies or companies founded by so-called serial entrepreneurs with considerable track records. Clearly, this development has created an 'investment gap' in the funding of early to mid-stage companies in Europe (see Figure 1). The decreasing number of venture capital funds and their propensity to move to later stages of funding has contributed to the emergence of a 'liquidity gap' in the venture capital ecosystem (see Figure 1). This gap is tied to the significant increase in the time that elapses between the inception of the company, the first involvement of risk capital providers and their ultimate exit.

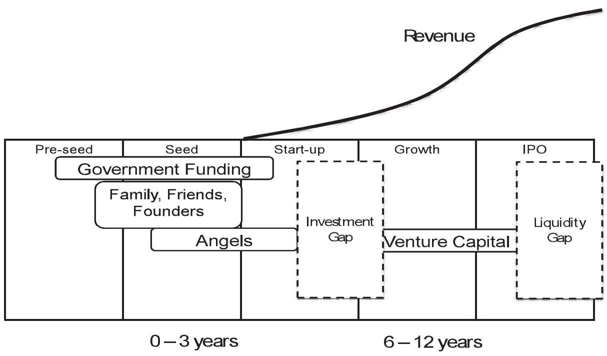

Fig. 1 Gaps in the Venture Capital Ecosystem

Policymakers and governments usually intend to bridge the gaps in the venture capital ecosystem by (a) creating a legal, fiscal and economic environment that is conducive to venture capitalists and (b) providing direct or indirect venture capital in the form of debt and equity. By doing so, governments hope to replicate the success of the world's most successful ecosystem: Silicon Valley. We are all aware of the success stories of entrepreneurs that started their businesses – and developed their innovative ideas with the help of venture capitalists – in garages and basements and built them into global market leaders. The Silicon Valley model, however, is not easily replicated (Hwang and Horowitt, 2012[2]). It appears that providing (access to) venture capital is not sufficient. Policymakers should focus on the specific characteristics of Silicon Valley: the personal interactions among both public and private capital providers that turn innovative ideas into vibrant start-up companies. However, there is good news. Although venture capital has drawn most attention from policymakers in many countries, the venture capital ecosystem is currently evolving. In particular, we observe new breeds of risk capital providers, such as corporate venture capital funds and crowd funding.

4. Concluding remarks

Policymakers have long been committed to create an environment in which high-potential growth companies are able to flourish into large, world-leading companies in a relatively short period of time. Seeing the importance of developing a venture capital ecosystem where innovative firms can prosper, governmental efforts should be geared towards supporting the market-based initiatives that have already emerged to cover the 'gaps' in the venture capital cycle (both in the early and later stages). Again, we will analyze and assess the world's most innovative clusters to get a clearer understanding of the financial and personal factors that drive the venture capital ecosystem.

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Innovation, University Entrepreneurship and the Role of Triple Helix

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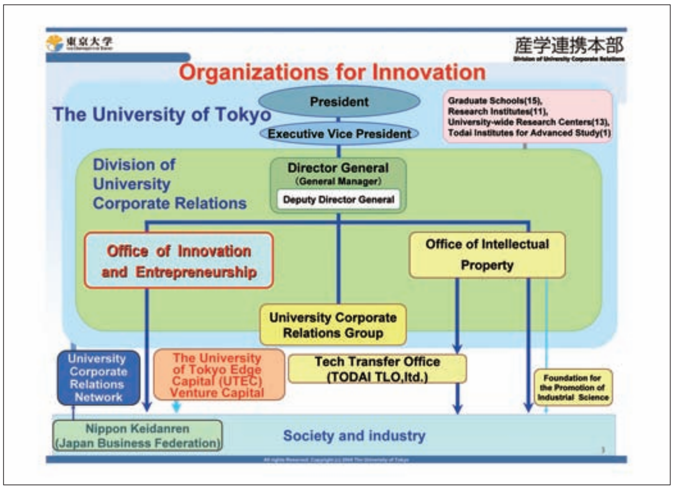
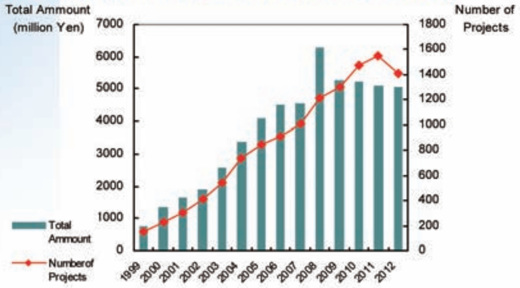
ABSTRACT

In the early 2000s government policymakers acknowledged the importance of innovation in restarting the economy and identified the national universities as a driver for increasing entrepreneurship and innovation. The universities were made independent from the national government and given the mandate to disseminate and utilize their research for the benefit of society. The University of Tokyo provides an example of how these goals have been implemented over the last ten years through entrepreneurship education, university-industry collaborations, start-up support, and seed funding.



Collaborative Research Projects at the University of Tokyo (primarily with the private sector)

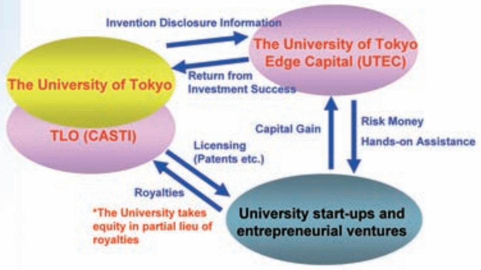


Source: THE UNIVERSITY OF TOKYO 2013 (Data Book)

Promotion of University Entrepreneurship

- Consultation
  - Offer one-stop advisory services to the university's researchers, students and spin-off entrepreneurs
- Mentoring
  - The University of Tokyo "Mentors (UT Mentors)"
  - External network of professionals (VCs, Attorneys, Accountants, Bankers, Analysts, ….)
  - UT Venture Squares
    - Network with the entrepreneurs who are UT graduates
- Venture Capital
  - Offer seed money to spin-off ventures
    - The University of Tokyo Edge Capital (UTEC)
  - Offer hands-on assistance for university-spin-offs in developing businesses
- Incubation
  - Offer facilities and assistance to university start-ups
    - The UT Entrepreneur Plaza
- Education
  - *UT Entrepreneurship Dojo* **for the entire schools**
  - *Innovation and Entrepreneurship* **at Graduate School of Engineering**
  - *Entrepreneurship* **at School for Engineering**

University Entrepreneurship Ecosystem in the University of Tokyo



UT Entrepreneur Dojo

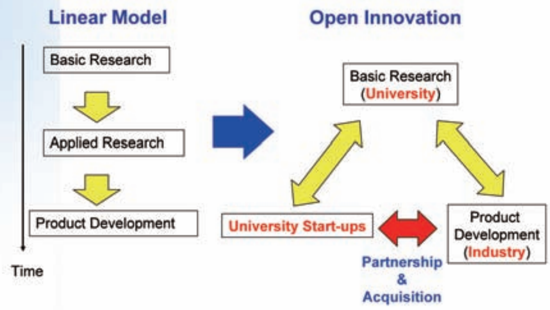
- Started in 2005
- Recognized as one of the most important educational initiatives at the University
- 150-200 students are enrolled every year
- 6-month and three-phase entrepreneurship educational program
  - April-June: Lectures & Development of Business Ideas
  - July-August: Seminars & Writing of Business Plans
  - September-October: Mentoring & Training Camp
  - Mid October: Business Plan Competition
- Sponsored by DUCR, UTEC (Venture Capital) and UT TLO (Technology Licensing Organization)
- Student exchange program with Peking University
- UTEC is ready to offer initial capital if the business plan developed by a student team is feasible enough

UT Entrepreneurship Education Program & Business Plan Competition

Profile of Enrolled Students: 2005~2013 Total

	Freshman & Sophomore	Junior & Senior	Graduate School	Total
Science & Engineering	48	275	797 (50.6%)	1,120 (71.2%)
Humanities & Social Science	60	245	147	452 (28.8%)
計	108 (6.9%)	520 (33.1%)	944 (60.1%)	1,572 (100.0%)

"Paradigm Shift" in Innovation System



東京大学 産学連携本部 Division of University Corporate Relations

Market Capitalization of the Leading Japanese and the U.S. Corporations (Trillion JPY)

JAPAN

- Toshiba (1904) 2.3
- Hitachi (1910) 3.7
- Takeda Pharmaceutical (1925) 3.9
- Toyota (1937) 22.9
- Canon (1937) 5.1
- Sony (1946) 2.2

U.S.A.

- Johnson & Johnson (1886) 25.5
- General Electric (1892) 25.1
- IBM (1911) 23.8 trillion JPY
- Microsoft (1975) 29.9
- Apple (1976) 42.4
- Google (1998) 30.9

Note: ( ) Year of Incorporation (Foundation), As of May 21, 2013 $1=102.7 JPY

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東京大学 産学連携本部 Division of University Corporate Relations

Exits of Venture-Backed Companies in the U.S.A.

Year	Total M&A Deals	M&A Deals with Disclosed Value	Total Disclosed M&A Value ($M)	Average M&A Deal Size ($M)	Number of IPOs	Total Offer Amount ($M)	Average IPO Offer Amount ($M)
2004	**349**	188	16,043.8	85.3	**94**	10,481.6	111.5
2005	**350**	163	17,324.7	106.3	**57**	4,482.4	78.6
2006	**377**	164	19,034.8	116.1	**57**	5,117.1	89.8
2007	**379**	168	29,460.0	175.4	**86**	10,326.3	120.1
2008	**351**	119	13,775.4	115.8	**6**	470.2	78.4
2009	**273**	92	12,525.6	136.2	**12**	1,642.1	136.8
2010	**445**	129	18,404.4	142.7	**74**	7,432.5	100.4
2011	**467**	166	24,081.8	145.1	**53**	9,921.9	187.2

Source: Thomson Reuters & NVCA "Venture-Backed Liquidity Events

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東京大学 THE UNIVERSITY OF TOKYO 産学連携本部 Division of University Corporate Relations

Thank you for your attention!

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東京大学 産学連携本部 Division of University Corporate Relations

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Professor, General Manager – Office of Innovation and Entrepreneurship Science Entrepreneurship, Division of University Corporate Relations (DUCR), The University of Tokyo.

Dr. Kagami is a graduate of Hitotsubashi University (BA in Commerce, 1982), and gained his MBA from IMD (Lausanne Switzerland, 1989), and completed his doctoral work in corporate governance at Weatherhead School of Management, Case Western Reserve University (2000).

Before he joined The University of Tokyo, Dr. Kagami was a consultant at Boston Consulting Group (1982-1986), a founding partner of Corporate Directions Inc. (CDI, 1986-1997), and Partner of Heidrick & Struggles International (2000-2002). At the University of Tokyo, he became Associate Professor, Pharmaco-Business Innovation Course at Graduate School of Pharmaceutical Sciences, and he had been Professor and General Manager – Science Entrepreneurship and Enterprise Development (SEED), Division of University Corporate Relations (DUCR) from 2004 until the end of March 2013. Professor Kagami has become General Manger of the Office of Innovation and Entrepreneurship, a newly created organization as a merger of two offices at DUCR; Office of Development of Collaborative Research and Office of SEED.

Professor Kagami's responsibilities include 1) Development of large scale research collaboration projects with the industry for innovation, 2) Entrepreneurship education program and student business plan competition for the University, 3) Management of incubation facilities for university start-ups, 4) Relationship management with The University of Tokyo Edge Capital (UTEC) as a board member (~June 2013), and 5) Consulting and mentoring for the University researchers and students for their start-up initiatives.

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Can Functional Brain Imaging Prompt Innovations in Next-generation Automobiles?

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ABSTRACT

Information about cognitive processing that occurs when an automobile is being driven can be obtained using neuroimaging techniques. Such information will certainly be advantageous in the near future for automobile design, given that automobiles are more than mere tools for transportation; they're a man-machine interface. Therefore, it would be in the best interest of engineers to invest in some knowledge of recent neuroimaging techniques from cognitive neuroscientists, and to at least comprehend the advantages and disadvantages of those techniques. In this symposium, I will discuss the possibility of applying neuroimaging techniques to the R&D of next-generation automobiles.

1. Introduction

Recent advancements in neuroimaging techniques enable us to visualize brain activity during various kinds of cognitive activities. We believe the utilization of information from human cognitive activity is certain to directly contribute to innovations made for the next-generation automobile. Recent automobiles and, of course, those of the future are emphatically acting as a man-machine interface, directly connecting one's intention to move with the mechanical systems of the automobile.

Functional magnetic resonance imaging (fMRI) is one of such techniques which is able to measure changes in brain activity. One of the significant advantages of the fMRI technique is that it can make visualization with relatively high spatial resolution of whole brain networks involved in specific cognitive function(s), and even access those structures located in deeper parts of the brain. However, a few restrictions apply to fMRI experiments. One is that fMRI experiments must be done in a MRI scanner room and the subjects must be put inside a MRI scanner. The MRI system is very large and heavy. Another restriction is that, since the MRI system uses string magnetic power, metals with electrically conductive parts cannot be used within or near the MRI scanner.

Near infrared spectroscopy (NIRS) is another neuroimaging technique. It records activity at the surface of the cerebral cortex by measuring related changes in the concentration of oxygenated hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb). The advantage of NIRS is that it can be used in daily life situations. For example, it can measure the temporal course of cortical activity while a person actually drives a car. Nevertheless NIRS only can measure the activity of the brain's surface and nothing can be known about what is happening in deeper structures. In addition, its spatial resolution is very low- only several centimeters.

2. An example of an fMRI experiment

As mentioned, one cannot bring metals and electric parts close to the MRI scanner. Nevertheless, one can present any visual and auditory stimuli inside of the MRI scanner through a projector and a pair of MRI compatible headphones. The subject's head must be fixed on a head rest, but he/she is free to move his/her hands and feet during the MRI scans, as long as those movements do not cause any movement of the head.

We previously ran an experiment to measure brain activity when detecting hazardous situations while driving. In this experiment, we placed an accelerator and a brake pedal at the end of the MRI scanner bed and, through the projector, presented several video clips of different driving situations (Fig. 1). Subjects were asked to imagine they were driving their own car and to step on the brake when they came upon a hazardous situation. We then calculated brain activation at the time subjects moved their right foot from the accelerator. In addition, the activity of the activated areas was compared with the subject's score for individual sensitivity to hazard detection, which was measured by psychophysical tests on a different day.

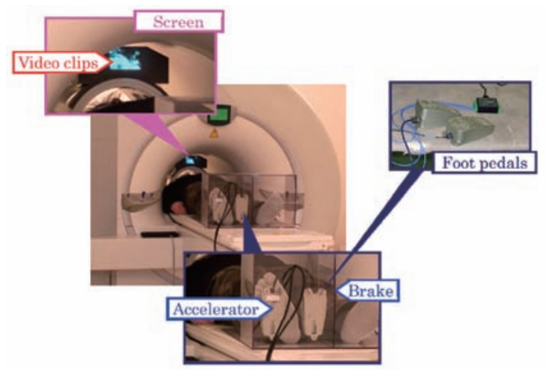

Fig. 1 An example of the experimental set-up for fMRI

The results indicate that a brain network consisting of the premotor cortex of the left hemisphere, the posterior parietal, and the occipital cortices of the bilateral hemispheres are involved in hazard detection. The activity of the left premotor cortex was shown to be related to the sensitivity of one's hazard detection abilities (Fig. 2).

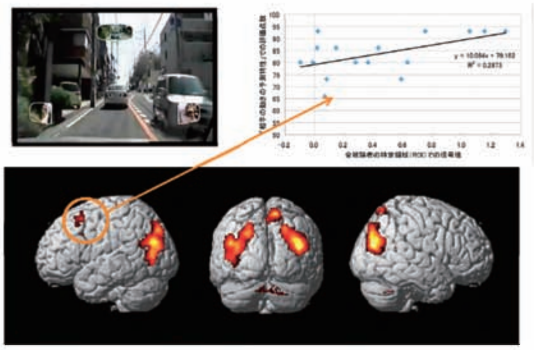

Fig. 2 Brain areas involved in hazard detection

This study gives us the following idea for developments in future automobiles. If we could continuously monitor the brain activity of the left premotor cortex using some device while one is actually driving, we can estimate one's ability to detect hazards as they occur, and then use that information to control the driving system of the automobile.

3. An example of NIRS experiment

We measured the activity of the dorsolateral prefrontal cortex (DLPFC) while cars were being driven using a prototype of the wearable optical topography (WOT) system (Hitachi Ltd., Tokyo, Japan) based on NIRS (Fig. 3). The DLPFC is known to play a key role in cognitive functions directly related to safe driving, such as attention, inhibition, decision making, etc.

A probe unit of the WOT system can be adjusted to fit on the head of a subject, and a processing unit can be strapped to the subject's body. Therefore, we can monitor changes in cortical activities while subjects are driving cars, or even riding motorcycles, in daily life situations.

Fig. 3 A prototype of the wearable optical topography (WOT) system

In our previous preliminary experiments, the activity of the DLPFC in healthy adults was measured while the adults drove cars in a closed driving course using the WOT. While driving cars with manual transmission, only the right DLPFC showed high activation. While driving cars with automatic transmission, the DLPFC of both hemispheres did not show any activation. It is interesting to note that driving a kart activated the bilateral DLPFC.

The left DLPFC showed activation only while a kart was being driven. Activation of the left DLPFC is often related to verbal tasks requiring executive processing. The drivers probably used a logical and/or verbal approach when considering how to handle the kart. In contrast, it has been argued that executive demand increases activity in the right DLPFC for spatial working memory processing. Thus there may be a greater requirement for spatial working memory when driving cars with manual transmission and karts. Cognitive load was relatively low when driving a car with manual transmission.

In general, the rate of age-related decline in measures of cognitive functioning will be less pronounced for people who are more mentally active, or, equivalently, the cognitive differences among people who vary in level of mental activity will be greater with increased age. When we design specific cars for our elderly population, we may have to consider designing cars that lend a hand to those with lower mental activity.

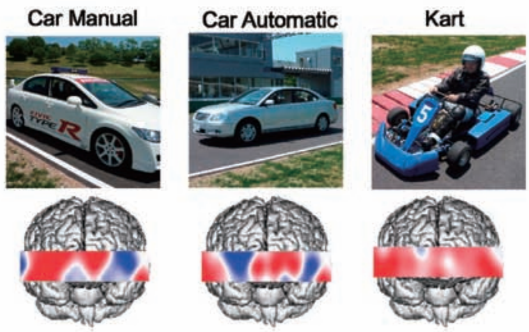

Fig. 4 Typical patterns of cortical activity when driving cars

4. Concluding remarks

We believe that applying what is known about cognitive functions through neuroimaging techniques to the R&D of next-generation automobiles can bring forth a new perspective. Creating a platform for discussion between cognitive neuroscientists and car engineers would surely be fruitful for innovation.

Alzheimer's disease: from pathology to therapeutics

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ABSTRACT

Amyloid β peptides are the most characteristic neuropathological protein deposited in the brains of patients with Alzheimer's disease, which is implicated in its pathogenesis and deemed as the prime target for the disease-modifying therapy. In this talk, the molecular pathology of Alzheimer's disease, the most frequent cause of dementia in the elderly and often linked to traffic accidents, will be discussed in relation to the efforts to develop mechanism-based therapeutics for this devastating disease.

Deposition of amyloid β peptides (Aβ) as senile plaques is the most characteristic neuropathological feature of Alzheimer's disease (AD), which is implicated in its pathogenesis and deemed as the prime target for the disease-modifying therapy (DMT) [1] (Figure 1). Aβ deposition is determined by the production and clearance. Aβ is produced by sequential proteolytic cleavages by β- and γ-secretases. γ-Secretase, harboring presenilins (PS) as the catalytic center, forms the C terminus of Aβ that determines its propensity to aggregate: missense mutations in PS genes cause familial AD by altering the preferred γ-secretase cleavage sites in a way to increase production of pathogenic Aβ42 species [2,3]. γ-Secretase forms a hydrophilic pore within the membrane lipid bilayer, which enables the unique mode of intramambrane proteolysis to form Aβ, and inhibitors of β- and γ-secretases with different targets and mode of action are being developed. Aβ immunotherapy facilitates the clearance of Aβ from brain parenchyma through the activities of anti-Aβ antibodies with different characterististics. Efforts to clinically develop the DMTs for AD, including establishment of imaging and fluid biomarkers that surrogate the AD pathology through clinical studies like AD Neuroimaging Initiative (ADNI) and Japanese ADNI are currently underway.

J-ADNI was started in 2008, aiming at conducting a longitudinal workup of standardized neuroimaging, biomarker and clinico-psychological surveys [4] (Figues 2). The research protocol was designed to maximize compatibility with that of US-ADNI, including structural magnetic resonance imaging analysis for the evaluation of brain atrophy, fluorodeoxyglucose and amyloid positron emission tomography, cerebrospinal fluid sampling, *APOE* genotyping, together with a set of clinical and psychometric tests that were prepared to maximize the compatibility to those used in the North America. Japanese ADNI has recruited 545 participants (239 amnestic mild cognitive impairment (MCI), 152 normal aged and 154 early AD). A number of significant results, including the predictive values of amyloid markers (i.e., amyloid PET and CSF Aβ42) for conversion of MCI to AD, are being obtained and analyzed. ADNI activities world-wide will establish the rigorous quantitative descriptions of the natural course of AD in its very early stages. The data, as well as the methodologies and infrastructures, will facilitate the clinical trials of disease-modifying therapies for AD using surrogate biomarkers that will enable the very early treatment of AD, which will further be supported by J-ADNI2 focusing on preclinical AD population as well as early and late MCI.

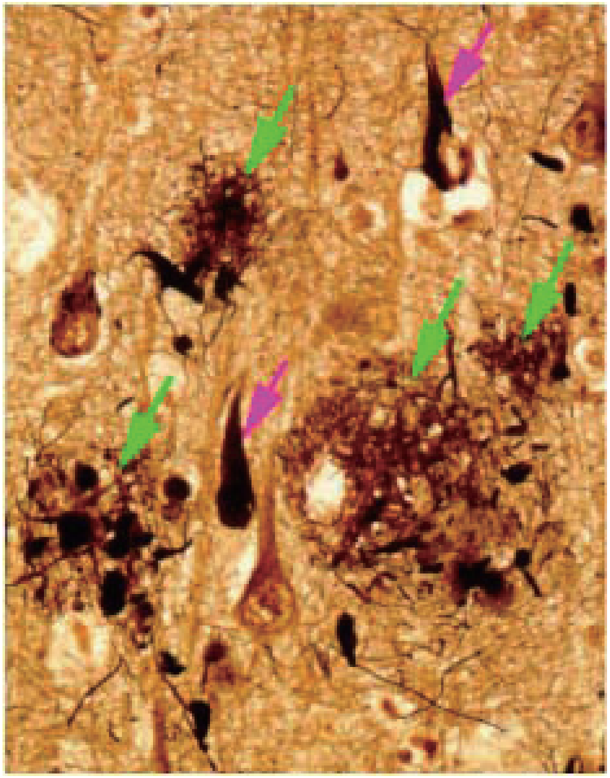

Figure 1. Neuropathology of Alzheimer's disease Green and pink arrows denote senile plaques (amyloid deposits) and neurofibrillary tangles, respectively.

AD and other types of dementias sometimes cause traffic accidents by wrong-way driving. Current status as well as causes of this type of traffic accidents will also be discussed.

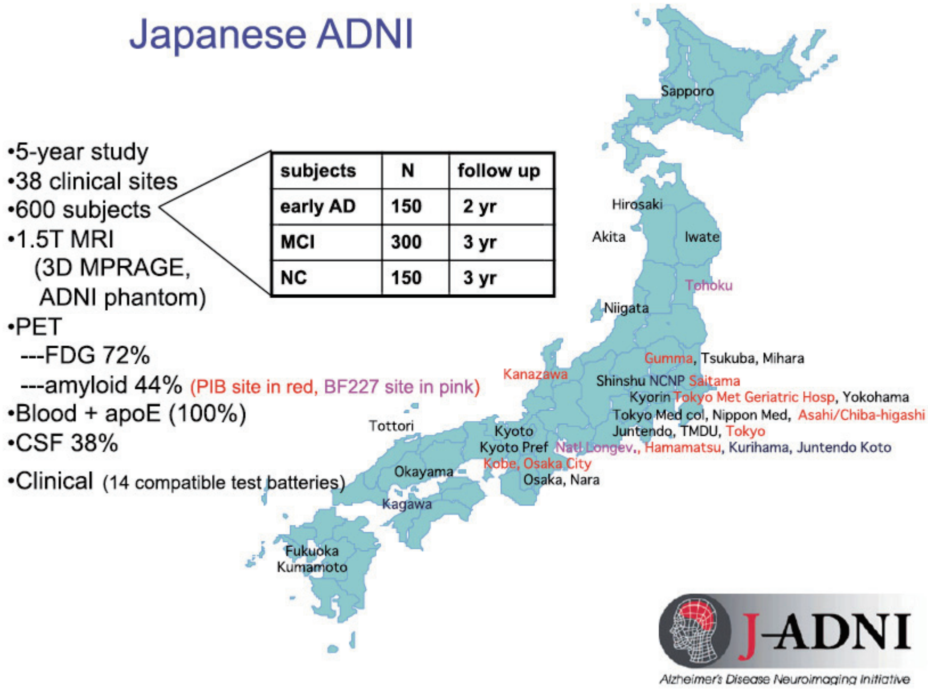

Figure 2. Overview of J-ADNI

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The Japanese Next Generation Vehicle Strategy: A Successful Strategy to Achieve CO_2 Emission Reduction and Global Green Vehicle Leadership

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ABSTRACT

Japan has long committed itself to a Low Emission Vehicle (LEV) policy to reduce greenhouse gas emissions as well as to maintain the viability of its automotive industry. For more than ten years, Japan has been implementing a series of programs supported by a multitude of well-designed policy measures. The rapid growth in next generation vehicle sales suggests these efforts are paying off and have led to significant declines in CO_2 emissions within the transport sector. Government implementation of two new action plans will encourage further advances in technologies for next generation vehicles that could obviate the need for fossil fuel engines.

1. Introduction

In early 2000s, Japan started to implement a series of low emission vehicle policies to promote the widespread use of fuel efficient, low emission vehicles (LEVs) in Japan. The government was committed to reduce greenhouse gas emissions and believed that one path toward that goal was to increase the number of high fuel efficient, low emission vehicles on the road. The policy initiatives began when there were relatively few LEVs and fuel supply facilities for serving LEVs were very limited.

- In 2000, the total number of LEVs in use in Japan was only about 600,000 vehicles, and the number of eco-stations was about 230.

2. Implementation of the First Two Low Emission Vehicle Action Plans in 2001 and 2004

Japan implemented "Prime Minister Koizumi's "Low Emission Vehicle Diffusion Action Plan" in 2001 and the "the World's Most Advanced Low Emission Vehicle Society Action Plan" in 2004. Both action plans called for 10 million "low emission vehicles" and 50,000 fuel cell vehicles on the road by the end of FY2010.

- LEVs included low emission gasoline vehicles, CNG vehicles, hybrid vehicles, hydrogen vehicles, methanol vehicles, and fuel cell vehicles.

To promote their plans, Japan deployed a multitude of creative policy measures. For example, Tokyo established a pool of $460 million in incentives to encourage the purchase of LEVs and devised an innovative classification system to determine the level of tax cuts for which a vehicle qualified. Vehicles received one to three stars depending on how much lower the vehicle emission was relative to the current standard, with "three star" vehicles receiving the greatest tax cut. Similarly, vehicles were provided with a certification sticker bearing a percentage number, such as 10, 25, or 50 percent, depending on how much higher the vehicle's fuel efficiency was relative to current and future standards.

This ingenious incentive system effectively shaped both current and future market demand. Tokyo did not need to enforce specific standards, but instead defined a road map that linked future market incentives to increasingly stringent standards. Responding to these incentives, many automakers pledged by 2005 to have 80 to 100 percent of their domestic vehicles qualify for three star emissions standards and bear the highest fuel efficiency ranking certificate. At the same time automakers invested in new technology to meet future standards. Tokyo thus was able to attain higher emission and fuel efficiency standards easily and faster.

Tokyo set vehicle emission and fuel economy goals that far exceeded any standard in the world. Tokyo also compiled a plan for new nitrogen oxide (NOx) and particulate matter (PM) standards for 2005 that were about equal to the Euro IV emission standards placed in force in 2005. Tokyo also has implemented a revised Vehicle NOx/PM Law that would encourage replacement of most trucks, buses, and diesel vehicles, thereby improving the chances for cleaning up NOx and PM pollution in 12 years.

- Incentives included subsidies at the time of vehicle purchase, reduction in the vehicle acquisition tax, and the annual vehicle tax, as well as the reduction in corporate tax and property tax. There were also reverse financial incentives. Owners of older vehicle models paid a greater annual vehicle tax, which created an additional incentive to replace them with new LEVs. Low interest loans were also available for corporate purchasers.

3. Assessment in 2007 Indicated Mixed Results

The two Action Plans triggered a marked increase in gasoline powered LEVs (but did not succeed in reducing CO_2 emissions). The goal of 10 million vehicles on the road was achieved in 2005, five years earlier than planned. Total number of LEVs in use was 16.5 million in 2007, a 26-fold increase since 2000. In 2000, LEVs were less than 1% of the total vehicle fleet but were 13% in 2004 and 22% in 2007.

Hybrid vehicles also increased about 8-fold. Growth was initially slow but became robust starting in 2004. This outcome pointed to an important lesson, namely that technology advances in vehicles would radically alter buyer behavior. In the case of hybrid LEVs, the increase was triggered by the introduction in 2004 of the more technologically advanced, more fuel efficient 2nd generation Prius.

- The government assessed that the increase in hybrid vehicles was due to its inherent commercial appeal and that government subsidies for the vehicle were no longer necessary. It discontinued subsidies for hybrid vehicles in March 2007.

Sales of other LEVs, such as CNG vehicles, methanol vehicles, hydrogen combustion vehicles, and fuel cell vehicles, were unremarkable. CNG vehicles achieved a modest, 3.7-fold increase but methanol vehicles declined to the point of nearly fading away. Fuel cell vehicles and hydrogen vehicles did not perform well at all. Fuel cell vehicles were too costly and not viable for practical use.

- The government viewed methanol vehicles to be commercially uncompetitive and policy support was discontinued. It appears that the government might have dropped hydrogen combustion vehicles from its policy support as well.

4. Lessons Learned from the Outcome of 2007

The goal of 10 million LEVs was met, and the inventory of LEVs increased. But no significant reduction in CO_2 emissions was achieved.

Gasoline LEVs have a limited ability to cut greenhouse gas emissions because the vehicles still burn fossil fuel. Moreover, efficiency improvements in these vehicles encouraged owners to drive their cars more, undercutting reductions in CO_2 emissions. The government recognized that the key to building a fleet of LEVs that met CO_2 emission reduction goals would require a significant shift away from fossil fuels. It also recognized that R&D on next generation vehicle technology must be promoted because the future vehicle fleet would be based on technology advances derived from non-gasoline LEVs.

5. Implementation of Next Two Action Plans in 2008 and 2010

Japan implemented the "Low Carbon Society Construction Action Plan" in 2008. The Plan called for one out of two new vehicles sold by 2020 to be next generation vehicles (NGVs), which would include hybrid vehicles, electric vehicles, plug-in hybrid vehicles, fuel cell vehicles, clean diesel vehicles, and CNG vehicles. The government aimed to reduce greenhouse gas emissions by 60-80% by 2050. Japan subsequently launched the "Next Generation Automobile Strategy 2010." The Plan stipulated that 20 to 50% on the road should be NGVs by 2020 and 50-70% by 2030. It called for up to 1% of that number to be fuel cell vehicles by 2010 and up to 3% by 2019. Japan continued the same policy measures as before with minor modifications as needed.

6. Outcome as of 2011 Positive

The outcome, as of 2011, shows that the policies have achieved encouraging results. The rate of increase in sales of NGVs is greater than for gasoline LEVs. Sales of gasoline LEVs increased by 40% from 2007 and 2011, but NGVs increased five-fold during the same period.

Electric vehicles and hybrid vehicles both increased substantially. The increase was primarily due to technology advancements. Electric vehicles increased 11-fold due to introduction of two new vehicles, Mitsubishi i-MiEV and Nissan Leaf. Hybrid vehicles increased 5-fold, due to introduction of the 3rd generation Prius in 2009.

- As a result, NGVs comprised 3% of total vehicles in use.

The increase in NGVs in the vehicle inventory notably contributed to a decline in CO_2 emissions. After peaking in 2001, CO_2 emissions in Japan's transport sector steadily declined. It registered 267 million tons in 2001, 245 in 2007 and 230 million tons in 2011—well below the 2010 emissions target for the fourth consecutive year.

7. Challenges Ahead: Japan's Overall CO_2 Emissions Must Be Lowered

While CO_2 emissions in the transport sector have declined, total greenhouse gas emissions in the overall Japanese economy rose to 1,307 million tons in 2011, 3.6% above the 1990 level or 9.6% higher than the target. This is because, following the 2011 earthquake and tsunami, Japan's consumption of fossil fuels increased due to thermal power generation, which outweighed the reductions in emissions from the transport sector and a decline in greenhouse gas emissions from the manufacturing sector caused by decreased production due to the natural disaster. Faced with this challenge, Tokyo is now determined to achieve reductions in emissions that are 6 percent below the 1990 target.

8. Outlook - Japan will Likely Achieve its CO_2 Emission Target as well as Remain the Global Green Car Leader

The past record suggests that Japan's automakers will continue to aggressively reduce emissions and improve fuel efficiency and create breakthrough technology for NGVs, ultimately obviating the need for fossil fuel engines. Consequently, it seems likely that Japan will remain the global green vehicle leader and hold that position as long as it maintains its strong R&D focus on advancing NGV technologies.

NH_3-DeNO$_x$ Performance of the Composite [Fe-Beta + Fe(Mn)MCM-48] Catalyst: Combining SCR Activity and NH_3 Oxidation Activity for NH_3 Slip Removal

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1. Introduction

Diesel engine vehicles are becoming widespread due to their higher fuel efficiency and lower CO_2 emissions compared to gasoline engine vehicles. However, in view of future legislation of efficient NO_x abatement from the diesel exhaust gas becomes a challenging task, which requires more effective methods of exhaust gas purification. In general, NO_x abatement can be achieved by using a catalytic system comprising zeolite-NH_3-DeNOx catalyst (e.g., Fe-Beta or Cu-Beta) followed by NH_3-slip catalyst. The latter usually contains noble metal components such as Pt or Pd, which are quite expensive.[1] In this study, we made an attempt to replace noble-metal catalyst with mesoporous Mn-containing FeMCM-48.

2. Method

2.1. Catalyst preparation

Microporous Fe-Beta catalyst was prepared by incipient wetness impregnation of H-Beta (Si/Al = 12) with an aqueous solution of $Fe(NO_3)_3 \cdot 9H_2O$ followed by calcination at 550°C in flowing air. The estimated Fe content by atomic absorption spectroscopy was found to be ~ 0.7 wt%.

Mesoporous Mn-modified FeMCM-48 catalyst, designated as Fe(Mn)MCM-48 (Si/Fe = 60) was prepared hydrothermally as per the procedure reported earlier[2] with $Fe_2(SO_4)_3 \cdot H_2O$ having trace amounts of Mn. The nominal iron content of the sample was 1.5 wt%.

Composite [Fe-Beta + Fe(Mn)MCM-48] catalysts were prepared by thorough mechanical mixing of both Fe-Beta and Fe(Mn)-MCM-48 powders in agate mortar followed by pelletization using hydraulic die. The Fe-Beta : Fe(Mn)MCM-48 component ratio was varied from 1 : 1 to 5 : 1.

2.2. Catalyst characterization

The catalysts thus prepared were systematically characterized by various analytical and spectroscopic techniques such as XRD, BET surface area, DRUV-VIS and ESR. The characterization data indicated that Fe cations in Fe-Beta are located in (exchangeable) cationic positions and the amount of iron oxide species is negligible. On the other hand, the characterization data for Fe(Mn)MCM-48 clearly indicate isomorphous substitution of trivalent iron into tetravalent silicon in the framework structure.

2.3. Catalytic tests

Fe-Beta, Fe(Mn)MCM-48, and the composite [Fe-Beta + Fe(Mn)MCM-48] were tested in NH_3-DeNO$_x$ using a fixed-bed reactor with a feed gas containing 600 ppm NO, 700 ppm NH_3, 10 vol% O_2, 6 vol% H_2O, balanced with N_2 at GHSV = 270,000 h^{-1}. An FTIR GASMET-4000 analyzer was used for the reaction product analysis. Note that the reaction was carried out under NH_3 excess (100 ppm above reaction stoichiometry) for evaluation of NH_3-deNO$_x$ and NH_3-slip removal efficiency.

3. Results and Discussion

Fig. 1(A) depicts the XRD of Fe(Mn)MCM-48. The diffraction pattern shows all the reflections characteristic of cubic MCM-48 structure.[2,3]

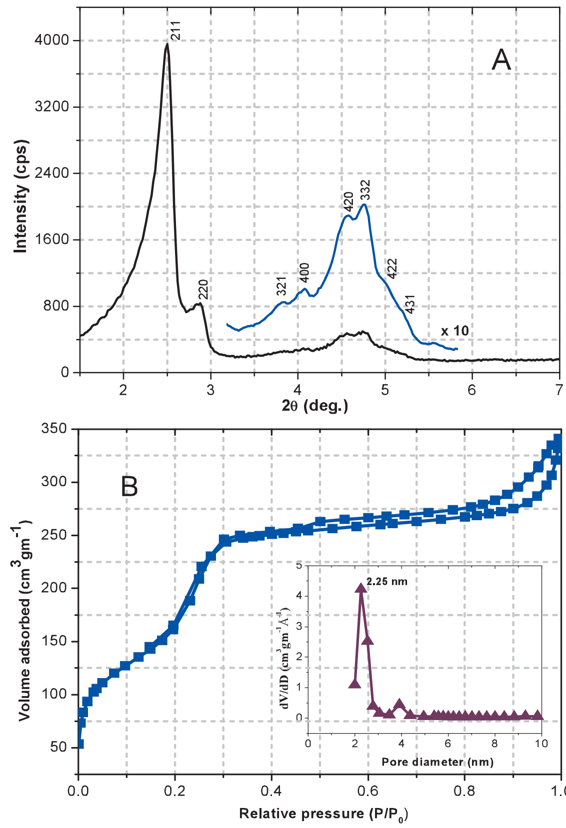

Fig. 1 (A) XRD pattern; (B) N_2 sorption isotherms of Fe(Mn)MCM-48

Specific surface area and pore-size distribution were obtained respectively by BET and BJH methods. Fig. 1(B) presents the N_2 adsorption–desorption isotherms which show typical type IV pattern with a sharp inflection in the range 0.2–0.3 (P/P_0) corresponds to capillary condensation with uniform mesopores (inset). Further, the isomorphous substitution of trivalent iron in the tetrahedral framework positions was supported by DRUV-VIS and EPR studies (not reproduced here).

Catalytic tests of the plain Fe(Mn)MCM-48 (not shown here) revealed significant activity of the catalyst in NH_3 oxidation, while its activity in NO_x selective catalytic reduction was marginal. It was found that the NH_3 oxidation activity of FeMCM-48 can be additionally boosted by modification with Mn, and hence Mn-modified FeMCM-48 sample, viz., Fe(Mn)MCM-48, was used for the preparation of the composite [Fe-Beta + Fe(Mn)MCM-48].

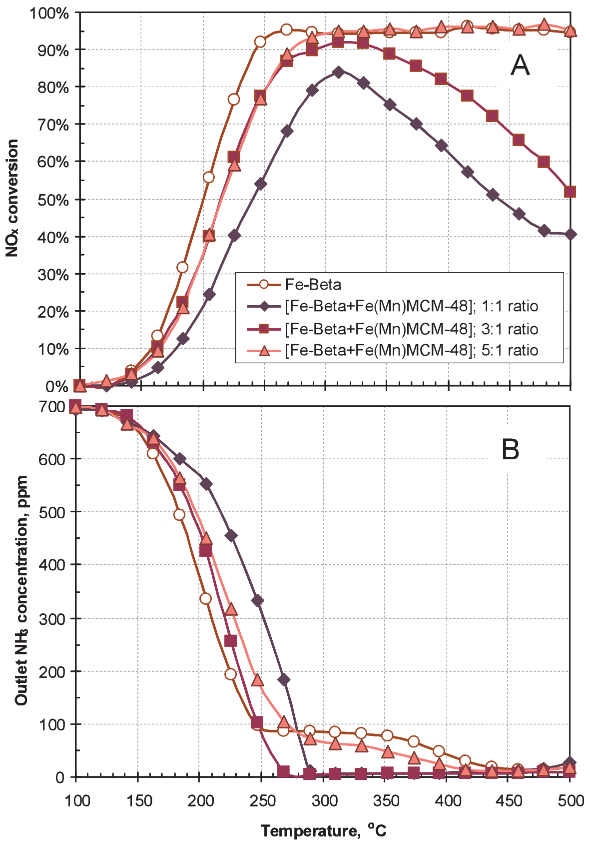

Fig. 2 NH_3-DeNO$_x$ performance of Fe-Beta zeolite and the composites [Fe-Beta + Fe(Mn)MCM-48] with different component ratio. (A) – NO_x conversion; (B) – outlet NH_3 concentration

NH_3-DeNO$_x$ performance of the composite [Fe-Beta + Fe(Mn)-MCM-48] catalysts having different component ratios are compared in Fig. 2(A). Efficiencies of the catalysts in NH_3 slip removal are compared in Fig. 2(B). [Fe-Beta + Fe(Mn)MCM-48] with 1 : 1 weight component ratio demonstrates efficient NH_3 slip removal, however its oxidation activity appears to be excessive, as indicated by the downward bending of NO_x conversion profile at ~ 300°C. This bending originates from unfavorable NH_3 over-oxidation over Fe(Mn)MCM-48 leading to undesirable NO formation and NH_3 depletion.

Variation of Fe-beta /Fe(Mn)MCM-48 component ratio allows us to minimize the unfavorable NH_3 over-oxidation and to balance activities in NH_3-DeNO$_x$ and NH_3-oxidation. The favorable performance was attained for the composite catalysts with 3 : 1 and 5 : 1 ratios. The data suggest that the performance can be optimized further by careful adjustment of the component ratio.

4. Conclusion

The data on NH_3-DeNO$_x$ performance of the composite [Fe-Beta + Fe(Mn)MCM-48] catalyst indicated that the favorable NO-SCR activity and the efficient NH_3 slip removal can be attained within the wide temperature range. The performance of the composite catalyst can be optimized by variation of Fe-Beta and Fe(Mn)MCM-48 ratio.

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Li-ion Battery Module for Small Electric Vehicles

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ABSTRACT
Li-ion Battery is superior in a characteristic with a high energy density and long cycle life. We try to use these good points and exchange lead acid battery for Li-ion on the small electric vehicles. We report on the development battery module for two kinds of different electric vehicles. As a result, we understand that Li-ion battery influenced the vehicles to be light-weight, and the life of the battery became long.

1. Introduction

The Li-ion battery has been developed as a power supply for a mobile-phone and a small video, notebook-sized personal computer since 1990. It has spread to the most mobile devices recently. A zero-emission design of the State of California atmosphere resources station was announced in the latter half of 1980's, and the development of a fuel cell and the battery car started the application to a movement body, and a car using a lead acid battery and the Ni-MH battery was produced experimentally then. The large-sized Li-ion battery has been developed recently. So, we experimented on the battery exchange to small electric vehicles using the large-sized Li-ion. We report this result.

2. Method

We try to battery exchange from lead acid battery to Li-ion battery on the small electric vehicle. Case-A is use for "COMVOY-88" by MITSUOKA-Motor Company. Case-B is use for "COMOS" by TOYOTA-Body Company. A lead acid battery is used both vehicles. Table 1, 2 shows battery exchange data. Figure 1 is a photo of batteries.

Li-ion cell specification is
Case-A
- Cathode material is Li(Mn/Ni/Co)O2
- Anode material is Carbon
- Rated voltage is 3.6V
- Rated capacity is 15AH
- Weight is 530g
- Dimensions 148x210x6.5mm
- Energy density is 100Wh/kg
- Case is can type

Case-B
- Cathode material is LiMnO2
- Anode material is Carbon
- Rated voltage is 3.7V
- Rated capacity is 10AH
- Weight is 270g
- Dimensions 120x207x6.1mm
- Energy density is 140Wh/kg
- Case is laminating type

Table 1. Case-A "COMVOY-88" battery exchange data

COMVOY-88	Lead Acid	Li-ion
Battery	12V-70Ahx6S	21Sx4P
	72V-70AH	75V-60Ah
Vehicle Weight	236kg	
Battery Weight	129kg	56kg
50km/h run	43.5Ah(62%)	53.0Ah(88%)
	48km	68km
30km/h run	48.8Ah(70%)	58.0Ah(97%)
	67km	102km
Battery cycle life	1.5 years	4years over

Fig. 1 Photo of the Vehicle and Battery in case-A
Lead Acid type (L)/Li-ion type (R)

Table 2. Case-B "COMOS" battery exchange data

COMOS	Lead Acid	Li-ion
Battery	12V-60Ahx6S	21Sx4P
	72AV-60AH	75V-40Ah
Vehicle Weight	284kg	
Battery Weight	126kg	30kg
Battery Capacity	60Ah at 0.2C	40Ah at 0.2C
	43Ah at 1C	39Ah at 1C
Distance per change	50km	55-60km
Battery cycle life	1.5-2.0 years	6years

Fig.2 Lead acid battery in case-B

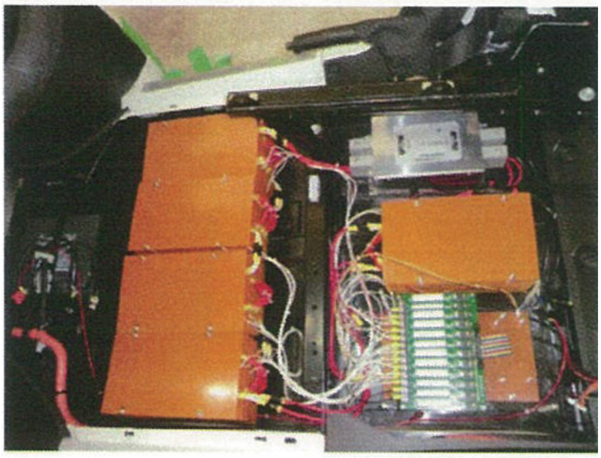

Fig.3 Li-ion battery in case-B

Fig.4 EV " COMS " with Li-ion Battery

3. Results and Discussion

Li-ion battery becomes 25V by 7 series. This voltage is same as two lead acid battery series. It is the same voltage that lead acid battery is 6 years and Li-ion battery is 21 series. The weight energy density of the Li-ion is 3 times of the Lead acid, and large weight loss is possible. In this experiment, light weighting from 70kg to 100kg was possible with small electric vehicles for single passenger.

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Research and Development of Tribological Techniques for Automotive Parts

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ABSTRACT

According to the prevention of global warming and the energy saving policy, the diversification of fuels (bio diesel, ethanol, etc.) for vehicles and the growth of market share of electrical and hybrid vehicles have been increasing. In this paper, a unique in-situ analysis technique and a typical achievement in the fuel tribology related to automotive parts were described as a 1st topic. And as a 2nd topic, tribological and electrical behaviors of a metal containing Diamond-Like Carbon nanocomposite coating deposited on an electrical contact material were discussed.

1. Introduction (topic 1)

As an industrial application, Diamond-Like Carbon (DLC) has been used in various components. Especially, in the automotive application, DLC is used in variety of conditions such as dry, E/G oil and fuel. However, the optimum structure of DLC has not been clarified in each environmental condition.

Recently, we have developed an in-situ system to observe the behavior of lubricant during friction by combining the fast-scan Fourier transform infrared attenuated total reflection (FTIR-ATR) spectrometer with the friction equipment as shown in Figure 1 [1]. In this study, we will report the experimental data of structural changes of DLC in various conditions as measured using the in-situ observation system.

2. Experiment (topic 1)

The infrared spectra were obtained by two experiments, annealing test and in-situ friction test. The annealing test was conducted at 500°C for 2hr. Table 1 shows the test condition for in-situ friction test.

3. Results and Discussion (topic 1)

Figure 2 shows the infrared spectra after annealing at 500°C. We have assigned bands of DLC with some papers (e.g. [2]). The spectra after anneal test shows the large change at ca. 1100 cm-1 which represented the aroma structure and ca. 1600 cm-1 corresponding to sp2 conjugated C=C. It is clarified the graphitization and aromatization are caused by the high temperature.

The intensity of the band at 1600 cm-1 and the friction coefficient obtained by using in-situ observation system are shown in Figure 3. In the running-in region, the intensity of sp2 band obviously increases. The intensity of aroma band also increases during friction. However the behavior of sp1 band intensity is difference between anneal test and friction test. The sp1 band intensity decreases as the temperature rises. In contrast, that intensity increases during friction (Table 2).

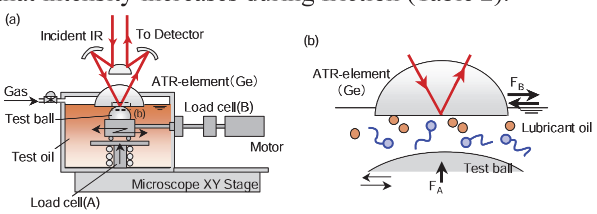

Fig. 1 Schematic diagram of in-situ observation system

Table 1. Experimental conditions

Specimen	a-C:H (on S45C Cylinder)
Speed	0.5mm/s
Load	55N (125MPa)
Time	6hr

Table 2. Structural changes of DLC for each test

	Aroma	sp1C-C	sp2C=C	$sp3CH_3$
Annealing	+	-	+	-
Friction	+	+	+	-

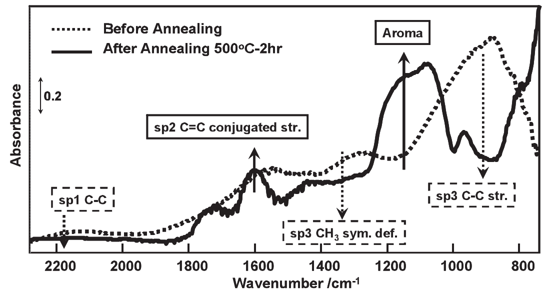

Fig. 2 Infrared spectra after annealing

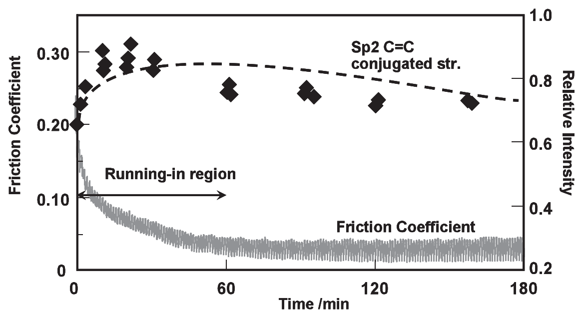

Fig. 3 Time dependence of band intensity and COF

4. Summary (topic 1)

The structural changes of DLC under friction were researched. The experimental results clearly show that friction induces the structural changes of DLC.

5. Introduction (topic 2)

Demands for innovative technology on electrical contacts in vehicles have been increasing with the growth of market share of electrical and hybrid vehicles. Reducing the electrical contact resistance (ECR) and the coefficient of friction (μ) are the major technological issues. In this study, tribological and electrical behavior of a copper containing Diamond-Like Carbon (Cu-DLC) nanocomposite coating deposited on a brass (Copper-Zinc alloy) substrate was investigated.

6. Experiment (topic 2)

Experimental materials and conditions are shown in Table 3. A hybrid deposition process, coupling plasma enhanced chemical vapor deposition and DC magnetron sputtering of a copper target, was used for the deposition of the Cu-DLC [3]. A brass ball was used as the counterpart of the Cu-DLC. The tribological and electrical contact behavior was investigated by using a ball-on-plate linear reciprocating tribometer. The four-terminal method was used for the measurement of ECR between the ball and the plate during the tribo-test. A combination of an uncoated brass plate (the substrate of the Cu-DLC coating) and a brass ball was performed for comparison purpose.

7. Results and Discussion (topic 2)

Figure 4 and Figure 5 show the typical ECR, μ responses of each material combination, respectively.

In the case of the uncoated brass plate, ECR was initially around 50 milliohms but it decreased down to 1.0 to 2.0 milliohms after few cycles. The initial value of μ was approximately 0.3 and it increased rapidly to around 0.8 after few cycles. After, the variations of ECR and μ around these average values were relatively wide.

In the case of the Cu-DLC, while initial value of ECR was hundreds of milliohms, it gradually decreased with cycles and reached 1.5 to 2 milliohms after 600 cycles. μ started below 0.35 and decreased progressively, and stabilized around 0.25, also after 600 cycles. Observation of worn surfaces of the different number of sliding cycles reveals that a tribofilm was built up on the sliding surface of the ball, and it grew as the sliding cycle increased, consisting mainly of copper according to energy dispersive X-ray spectroscopy. The Cu-DLC coating on the plate wore gradually and delamination of the Cu-DLC was observed at 450 cycles. Around this number of cycles, ECR started decreasing, suggesting that such decrease resulted from the delamination of the Cu-DLC coating. After less than 1000 cycles, the Cu-DLC was almost worn out. However, detrimental effects could not be observed either on ECR or on μ. So the tribofilm on the ball should have a key role in achieving and preserving these good electrical and tribological characteristics.

8. Summary (topic 2)

The electrical contact resistance and the coefficient of friction behavior of a Cu-DLC nanocomposite coating deposited on a flat brass substrate with a brass ball combination were investigated. A Cu-rich tribofilm was built up on a brass ball by sliding with a Cu-DLC deposited on a brass substrate. This tribofilm provides the good tribo-electrical characteristics.

Table 3. Experimental materials and conditions

Materials	Ball (φ6.35mm)	Brass	
	Plate (20 x 20 x t0.5mm)	Brass (uncoated)	Cu-DLC (brass substrate)
Conditions	Normal load	1N	3N
	Track length	0.8mm	
	Frequency	0.5Hz	
	Electrical current	0.2Amps	
	Sliding cycles	up to 2000	
	Atmosphere	Ambient air (20-25 °C, 25-35%RH)	

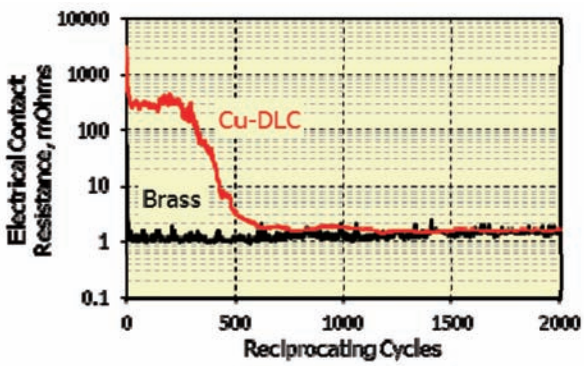

Fig. 4 Electrical contact resistance

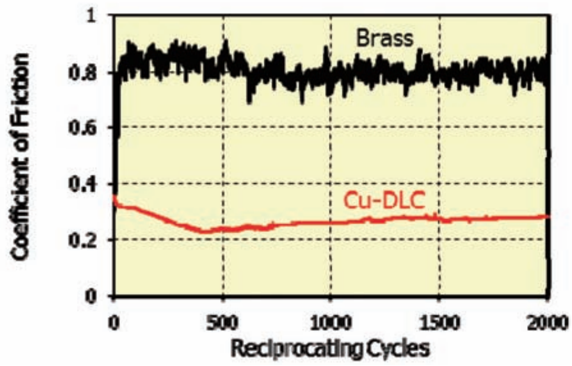

Fig. 5 Coefficient of friction

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Starved Lubrication: Contribution of Laser Surface Micro-Texturing

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ABSTRACT

To prevent the occurrence of wear and the increase in friction in case of lubricant starvation between two surfaces in contact, this study demonstrates experimentally the possibility to create oil feeding in the high pressure zone, by controlling the micro-topography of the surfaces. Thanks to a femtosecond laser, micro-cavities are generated on the surface and locally increase the lubricant film thickness.

1. Introduction

The ability of a fluid to separate two surfaces in contact under severe mechanical conditions is outstanding. However, the persistence of this protective film will be challenged in case of inadequate contact feeding in lubricant, that is to say when starvation occurs. Although various experimental [1,2] and numerical [3] studies have focused on starvation and replenishment mechanisms under stationary conditions, only little work has taken into account transient conditions.

The goal of this paper is to evaluate the contribution of a laser micro-textured surface to maintain a lubricating film and to prevent wear. We also analyze the onset of partial starvation based on an effective feeding volume in the convergent zone. The consumption of this volume leads to severe starvation regime.

2. Experimental

In this context, starvation mechanisms in elastohydrodynamic regime were experimentally investigated in pure rolling, in rolling/sliding and also reciprocating conditions for fluid viscosity ranging from 50 to 3000 mPa.s. Thanks to a ball/disk tribometer [4] with an optical interferometric system, the convergent, contact and outlet zones are simultaneously visualized (see Figure 1), and the film thickness distribution and the friction force in the high pressure zone under controlled contact kinematics are measured.

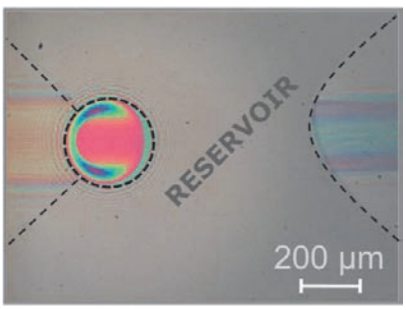

Fig.1 EHL contact. The air/lubricant meniscus is clearly visible in the inlet zone. The flow direction goes from right to left.

Occurrence of starvation will be discussed in terms of film thickness, location of the air/lubricant meniscus and friction.

3. Results and discussion

Severe starvation occurs when an effective volume of lubricant in the convergent zone is consumed: the film thickness decreases and the friction force simultaneously increases. We show that starvation process is function of two time scales. For short time, inferior to 1s, the film thickness and the location L_M of the air/lubricant meniscus are correlated as shown in Figure 2. For longer times, few hundreds of s, a progressive diminution of the film thickness down to few nanometers in the contact zone results from the lubricant deficit induced by the ratio leakage/flow rates. This decrease of the film thickness causes the occurrence of wear in the contact. In presence of a laser micro-textured surface, the shearing of the lubricant entrapped in the micro-geometries is able to provide a local increase of the film thickness, protecting the mating parts. The ability to diminish wear is governed by the density and the depth of micro-texturing.

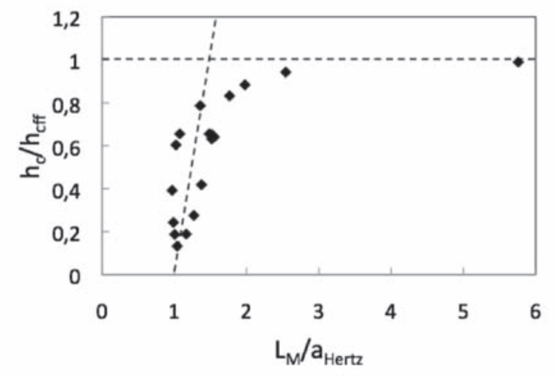

Fig.2 Correlation between the central film thickness h_c and the location of the air/lubricant meniscus L_M.

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Traffic Management Future

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ABSTRACT
The economic development in the last 100 years have been mainly enabled by the improved mobility options for persons and goods due to the development of efficient vehicles and provision of transport infrastructure for road, rail, air, maritime and inland waterways. Whilst the number of vehicles today excessively increased beyond one billion adverse effects occurred on safety, efficiency, sustainable use of natural resources, environment and economy. The development of new technologies mainly will allow new regimes in traffic management will to reduce the negative impacts towards a more sustainable mobility of persons and goods.

1. Introduction

Mobility supported by engines has started around 200 years ago with development of steam driven locomotives for transportation of persons and goods. Around 50 years later Maritime transportation changes from wind driven vehicles towards engine driven with similar propulsion principles. Again 50 years later a new generation of engines with ignition principle could be built much smaller and less weight applicable for road vehicles and finally about 30 years later this type of engine have been applicable also for a new generation of aircrafts. In parallel to the development of vehicles it was also necessary to develop a dedicated transportation infrastructure for rail, road, maritime and air transportation (Rail tracks, dedicated roads for road vehicles, ports and air ports). This (technological) development has built the basis for the economic development globally but also was building the basis for the motorized armed forces where the mankind has suffered dramatically in the last 100 years also globally.

2. Technological Development

The technological development induced the production of a huge number of vehicles – specifically in the last five decades-we now can see around the globe. Today we account about 1bn road vehicles, about 180mio rail vehicles, about 80mio ships all sizes and more than 10mio aircrafts requiring an adequate infrastructure to be operated. The investment on transport infrastructure in the last 5 decades has been enormous in all countries and is expected to grow even further due to aging of infrastructure and the demand to extend their capacity to balance the demand. Beside all financial effort we experience a decreased efficiency in transportation and still a much too high number of fatalities and injuries due to accidents in transportation. The European Commission counts the economic loss due to inefficient traffic (traffic jams, loss of workforce by delays, etc.) to about 120bn€ annually and economic loss on social level due to fatalities and injured person to about another 130bn€ annually. Similar figures have been reported from the USA on their economy. Today’s most urgent demand beside the significant reduction of GHG emission induced by transport is to increase efficiency and safety in transportation on short notice.

Therefor the organisation of transport (generally addressed as traffic management) on all modes need to be carefully analysed and measures to be identified to improve safety and efficiency specifically in view of the most recent technologies emerged in the last 2 decades.

3. Advances in Traffic Management

Analysing the principles in organizing traffic on the different mode in a general manner one can easily conclude two diverse regimes.

1., A strictly centralised regime as for rail and air traffic – ‘the vehicle is only allowed to move with dedicated (individual) advise from a central management point (via signal or message) and

2., A so-called ‘decentralized’ regime, as there is only an indirect way to impact vehicle movement (e.g. via traffic lights, road side signs, etc.) – ‘the vehicle move on the command of the driver more or less independent from centralized advise only steered by some general rules (not addressing each vehicle individually)’.

The first regime applies for rail traffic management and air traffic management, the second regime applies for road traffic management and for maritime and inland waterway traffic management.

In view of the most recent technological developments on all transport mode - the so called ‘co-operative systems’ - one can see a significant change in organizing traffic for the near and long term future. The key enabler for this ‘co-operative systems’ in transport are the automated exchange of messages between vehicles (V2V) and between vehicle and infrastructure (V2I). Based on the experience we have made so far in the developments of the last decade globally we will need an additional element to organize traffic in a safe and efficient manner. This element is the ‘autonomous function’ to allow the vehicle to drive automatically within a limited sphere.

4. Summary

Due to the increasing technological capability of electronic systems based on efficient data capture by sensors, fast processing of mass data and automated data/message exchange between vehicles and infrastructure (e.g. DSRC, GNNS, digital maps, etc.) new ways to ‘organise’ traffic can be developed. Introducing the 3 elements (V2V, V2I, and autonomous function) will consequently influence the above mentioned divers ‘traffic management regimes’ to a new harmonised single approach on traffic management equally applicable to all mode of transport (road, rail, air traffic, maritime and inland waterway traffic). This will allow manage traffic in an integrated way across all modes without traffic jam and respect to utmost utilisation of infrastructure capacity while increasing safety of transportation with the goal for zero accidents on road, rail, air and waterways maritime transportation.

Tribology for the Future: Biomimetism and Surface Engineering

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ABSTRACT
While Mechanics can be considered as the science permitting the solids to support forces by contacts, Triblogy is the science, which permit the motion of solids. Tribological processes are always dissipative; a friction force is opposed to the motion and then creating an energy loss. As a consequence, engineers are always trying to lower the friction force in order to decrease the energy losses. This objectives associated to a search of increasing the lifetime of mechanical systems are in fact a challenge for the future Tribologists. Considering some systems from the nature can help to find some interesting ideas for surface engineering.

1. Introduction

The word Tribology was defined in 1968 but the "tribology" fact is very old. As soon as men for their daily activities used the contact between solids and motion, the tribological problems were present: friction force and wear, with their negative consequences.

At first, Tribology was not considered as a problem but people optimize the tribological systems step by step by performing simple dedicated experiments. An example is shown Fig. 1.

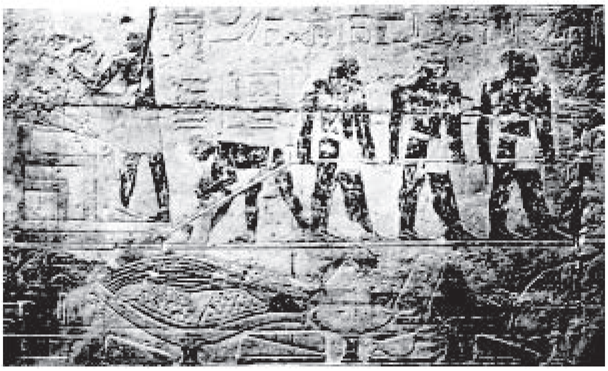

Fig. 1 Already at the Egyptian time lubrication was used to decrease the friction force. (transporting the statue of Ti – from a tomb at Saqqara – 2400 B.C.)

Then, people realize that contact between solids and friction exists and that friction and wear is a consequence of the interaction between the surfaces of matting solids. More sophisticated experiments where then developed in order to have information on friction and wear.

After that, the society was more and more developed for mechanical systems and tribological problems were more and more studied. It was then considered that material nature is important for the behavior and performances of tribological systems.

Surfaces appear after this period to be also a determinant factor… and then scientists were studying more and more the surfaces in order to find some way to improve their behavior (Fig. 2).

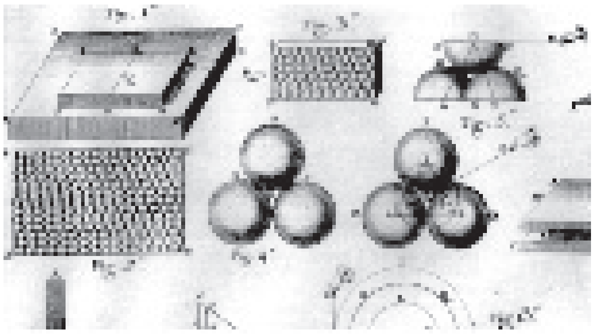

Fig. 2 In 1737 Tribologists begin to consider that the surface topography is an important parameter for friction processes. Belidor, a French scientist, represented the surface geometry using some ideal spheres.

The more simple was first to develop surface treatments in order to modify their mechanical properties; then various surface heat treatments were invented to form at the surface of metals some ompound with higher mechanical properties than the substrate. After, more complex strategies were developed to protect a solid surface by a coating with particular nature, structure and properties (see an example Fig. 3). Consequently, the tribological behavior is considered to be related to the behavior of coated surfaces. Of course, the adherence of the coatings appeared to be very important. In this period, very numerous coatings were investigated: hard coatings, soft coatings, multilayer coatings, composites coatings… always now, this strategy of protecting a sliding surface by a coating is under investigation in order to develop new and high-performence solutions.

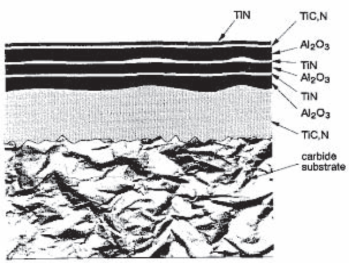

Fig. 3 An example of a multilayer coating for protecting cutting tools (cross section observed with a SEM).

More recently, surface topography was a parameter becoming of the first interest. Studies are trying to understand the relationships between surface topography and friction force and surface damage (Fig. 4). Machining surfaces with conventional machines was investigated: it becomes important to know what is the effect of machining parameters on the characteristics of the machined surface. Particular surface treatments such as sand blasting where used to modify the surfaces.

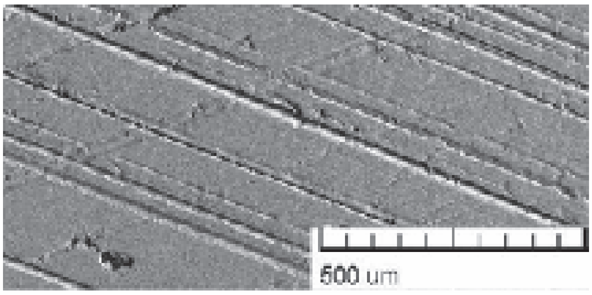

Fig. 4 Surface topography used for the sliding internal surface of diesel engine liners. Scratches with various sizes, which can act as lubricant reservoir and wear particles retainer, compose the particular roughness, manufactured by Honing.

With the development of machining technologies, scientists try to manufacture textured surfaces at a scale being smaller and smaller. Currently, the femto second laser can be considered as one of the most sophisticated machine tool for modifying surfaces; it can be used to create networks of very small holes in order to improve the behavior of surfaces in lubricated conditions (Fig. 5).

In a parallel way, the nature was in fact also optimizing the things in order to adapt them to a function. The structure, the materials and the surfaces are naturally designed in order to present the desired function: adherence, friction noise, mechanical resistance, wettability, colors, … many examples can be considered for this (Fig. 6).

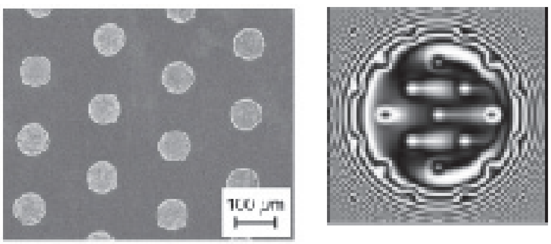

Fig. 5 Laser texturing can be used for tribology: creation of small dimple on a surface (left). This particular topography modifies the lubricant film formation in the case of elastohydrodynamic lubrication (right: result of modeling the film thickness).

(PhD of L Mourier, ECL - 2006)

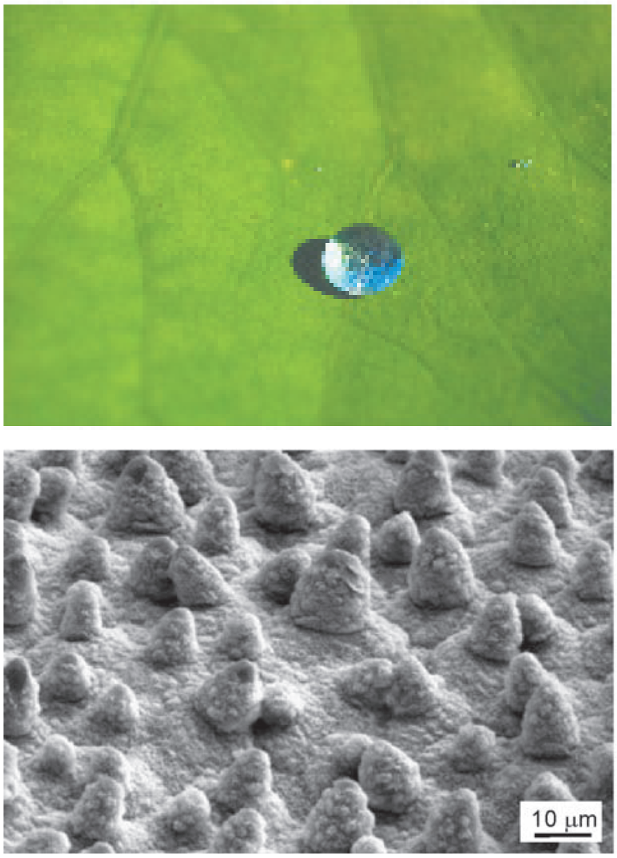

Fig. 6 Observation of a water drop on a Lotus leave (top) showing the super hydrophobicity created by the roughness and nature of surface (SEM picture, bottom).

Then, scientists and tribologists considered the idea of biomimetism. They try in fact to imitate the nature to have some particular function. But now, it is very important to think about the real challenges in the field of Tribology.

2. Future Trends in Tribology

Nowadays, Tribologists have developed a lot of effort to understand tribological processes with the use of high-performent equipements and complex modeling. Predictions are then more and more present but it is always necessary to continue theses efforts.

The present challenges are to develop mechanical systems with high output (low friction losses) and long lifetime. In the field of automotive industry, this challenge has also to be completed by considerations on production costs, recyclability and ecology.

With these aims, surface modifications represent a very attractive strategy. The development of new surface coatings and new surface topography is always a key problem for the future. We have for this to consider not only scientific progress in the field of surface science but may be interesting ides can be found in the nature to optimize a surface for a given purpose.

Synthetic Biofuels From Biomass

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ABSTRACT

The importance of biofuels is growing rapidly in Germany and world-wide. This is reflected in steadily increasing research activities in both academia and industry, as well as in an increasing number of joint ventures comprising several institutions. Thus, not only the extent of publications on this highly dynamic topic is strongly increasing but also the public interest due to its obvious socioeconomic relevance. First generation biofuels such as bioethanol and biodiesel are state of the art today. However it is obvious that neither the quantity nor the quality are sufficient to meet the production potential and the standards expected. The second generation currently under development aims at the use of lignocellulosic feedstocks by-produced in agriculture and forestry. Third generation biofuels are issued in diverse research activities ranging from microbial fuels or algal fuels.

1. Introduction

The bioliq® project at the Karlsruhe Institute of Technology (KIT) aims at large scale production of synthetic second generation biofuels from biomass (BTL, biomass to liquids). The bioliq process concept has been designed to overcome scientific challenges and engineering problems, which arise when low grade, residual biomass shall be used to a large extent in a BTL process. Biomass such as straw, hay or residual wood usually exhibit on the one hand low energetic densities, thus limiting collection area and transportation distances. On the other hand, the production of synthetic fuels requires large scale production facilities in accordance with economy of scale considerations. In the bioliq process, biomass is pre-treated in regionally distributed fast pyrolysis plants for energy densification. The products, being pyrolysis char and liquid condensates, are mixed to form stable, transportable and pumpable slurries also referred to as biosyncrude. Biomass is thus energetically concentrated allowing economic transport also over long distances. In industrial plants of reasonable size, the biosyncrude is gasified in an entrained flow gasifier at a pressure slightly above that of the following fuel synthesis. In the bioliq pilot plant synthetic fuels are produced via methanol as an intermediate. The process requires a gasification pressure of up to 80 bar.

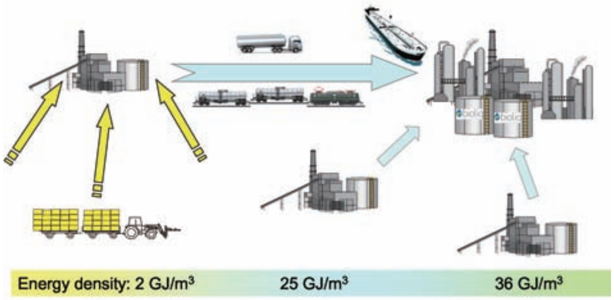

Fig. 1 bioliq concept

On site of KIT, a pilot plant is constructed for process demonstration, to obtain reliable mass and energy balances, for gaining practical experience, and to allow for reasonable cost estimates. The fast pyrolysis plant, already in operation, has a biomass feed capacity of 500 kg/h (2 MW(th)). A twin-screw reactor, equipped with a pneumatic heat carrier loop with sand as the heat carrier medium is the main technical feature of the plant. The biosyncrude is prepared in a specially designed colloidal mixer and stored in stirred container tanks. To prevent from potential sedimentation, the content of the tanks is continuously circulated.

The further process steps have been mechanical completed and commissioned separately in 2013. The high-pressure entrained flow gasifier is designed for 5 MW_{th} (ca. 1 t/h) slurry feed and can be operated at up to 80 bar. The burner is equipped with a twin fluid injection nozzle using oxygen and steam as atomization and gasification media. A 1 MW_{th} burner fed with natural gas is used for process stabilization, e.g. when using low calorific fuels or slurries with a wide and varying specification range. The pumps are designed to feed suspensions with up of 5 Pas viscosity, the burner nozzle is designed for a maximum viscosity of 1 Pas. The gasifier is specifically designed for lower fuel calorific values in the range of 13 - 25 MJ/kg. For adjustment of viscosity the biosyncrude can be heated up to 120 °C in the feed line to the burner nozzle. The gasifier is operated in slagging mode and is equipped with an internal cooling screen, particularly suited for conversion of ash rich feeds and fast start up and shut down procedures. Ethylene glycol slurries with char can be used as model fuel for scientific research. Ash and flux can be added to the fuel feed flow in order to adjust slag melting behavior.

The raw synthesis gas is purified and conditioned by a high pressure hot gas cleaning system, consisting of a hot gas filter with ceramic filter elements, a fixed bed adsorption for HCl and H_2S removal and a catalytic converter for decomposition of nitrogen and sulphur containing trace compounds. Afterwards, CO_2 and water are separated. The purified synthesis gas is then converted to dimethylether in a one-step synthesis process, which is converted in a subsequently following reaction into gasoline. A ZSM-5 zeolite-type of catalyst is used here. In all reactors, a new heat pipe based system is used for heat exchange, providing nearly isothermal conditions in the catalyst bed and improving process control.

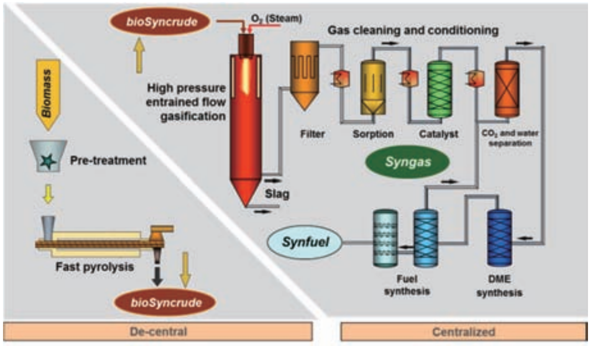

Fig. 1 bioliq process scheme.

Based on mass- and energy balances, an economic analysis of the whole process chain has been performed and will be worked out in more detail when experimental data from the pilot plant become available. Depending on the plant configuration and the selected production scenario and synthesis concept, overall process energy efficiencies from biomass to fuel between 34% and 42% have been estimated.

The process development is embedded into a coherent R&D framework, allowing for scientifically based operation and further development. Process development units for pyrolysis, gasification, gas cleaning and synthesis are utilized to increase the fundamental understanding of the underlying processes, to obtain representative product materials and process data, to develop technical improvements and new process variants, which then can be tested in the pilot plant.

Fig. 2 bioliq pilot plant at KIT.

Acknowledgements

The bioliq pilot plant is constructed and operated in cooperation with partners from chemical engineering and plant construction industries: Lurgi GmbH (Frankfurt), MAT Mischtechnik GmbH (Immenstadt) MUT advanced heating GmbH (Jena), and Chemieanlagenbau Chemnitz GmbH (Chemnitz). Financial support is provided by the Germany Ministry of Agriculture, Food, and Consumer Protection (BMELV) and the state Baden-Württemberg und the European Development Fund.

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VEHICLE TECHNOLOGY & ENERGY CENTRE
Canadian Applied Research Experience at Red River College

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ABSTRACT

Red River College, a recognized Canadian college leader in applied research, has demonstrated capabilities and expertise in vehicle technology and the use of renewable fuels – with an emphasis on performance in extreme climates, especially cold. Local, national and international partners have collaborated on vehicle-related product and prototype development, fleet demonstrations, testing and evaluation, and the use of renewable or zero/low emission fuels (such as biodiesel, hydrogen, and electric/hybrid technologies). A case study will illustrate the College's integrated research, education and training approach to *Mobility from "Green Energy"*.

1. Introduction

Red River College's integrated approach to research, education and training approach for *Mobility from "Green Energy"* has resulted in extensive experience in advanced transportation and energy-related applied research over the last decade.

In close proximity to the geographic centre of North America, the College's main campus is in Winnipeg, Manitoba, Canada (on approximately the 50th parallel) and can experience extreme temperatures in both the summer (35°C) and winter (-35°C). The opportunity to evaluate fuels and technologies in a cold climate environment has encouraged research on vehicles which use renewable and alternate fuels.

Cold climate and/or renewable fuels are often key elements in many applied research activities [1] such as the Red River Raycer (solar car); Hybrid Hydrogen Internal Combustion Engine and Hydrogen Fuel Cell bus demonstrations; Plug-in Hybrid Electric (passenger) Vehicle fleet conversion, demonstration and evaluation; diesel highway coach prototypes to meet new emission requirements; Compressed Natural Gas heavy vehicle winter performance evaluation; and development, demonstration and evaluation of an all-electric battery transit bus prototype. These projects complement the $2,400,000 (CDN) investment by the Government of Canada in vehicle technology research infrastructure.

In 2011, the Province of Manitoba provided $645,000 to establish the Electric Vehicle Technology & Energy Centre. EVTEC is a virtual centre which complements and supports provincial policy [2] concerning sustainable transportation. EVTEC serves to test and demonstrate electric vehicle technologies, while allowing the College to enhance applied research, education and training, as well as to raise public awareness of electric vehicle (EV) technology. EVTEC's startup was catalysed by a three-year, $3,000,000 international collaboration to develop an all-electric transit bus and charging system. Subsequent initiatives have led resulted in a $10,000,000 investment for a five vehicle, four-season, four-year demonstration under regular urban transit system operating conditions.

2. Discussion

Nearly 98% of Manitoba's electricity is generated from renewable hydro power, which is a key driver to pursue EV technology. In late 2010 Manitoba and Mitsubishi Heavy Industries of Japan signed a Memorandum of Understanding with the objective of exploring renewable energy development opportunities; including the electrification of transportation and recharging infrastructure, as well as battery-storage technologies.

An international consortia was created and brought together the Province of Manitoba, Manitoba Hydro, Mitsubishi Heavy Industries (MHI), New Flyer Industries (NFI) and Red River College to undertake the development of an all-electric battery transit bus, including the related charging infrastructure, with the ensuing research to be carried out through EVTEC. Anticipated benefits of the "Zero Emissions" bus are:

- only two tonnes of greenhouse gas emissions (from a renewable supply), compared to 108 tonnes for a diesel-electric hybrid and 162 tonnes for conventional diesel;
- assurance of a long-term renewable fuel supply;
- overall energy efficiency improvements, including electrification of ancillary accessories and improved drive train efficiency; and
- longer life and lower maintenance requirements due to reduced maintenance when compared to conventional engines, transmissions and accessories, coupled with longer drivetrain life.

Within one year, the prototype "Zero Emissions" bus (Figure 1), which integrates lithium ion battery packs from MHI in a NFI Xcelsior chassis, was operational. The batteries provide direct current power to a nominal 650-volt system, using an air-cooled 120 kWh battery which is ultimately targeted to be a comparable weight range as the engine and fuel on a diesel bus. The prototype has a range of 80 kms/four hours in typical stop-and-go transit operation, and is the first of its kind in Canada. The prototype has near zero emissions, although a bio-diesel heater is required in winter operation to heat the interior of the bus.

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Fig. 1 Electric battery transit bus prototype – June 2012

Manitoba Hydro has completed installation of a first generation On Route Rapid DC charger with a dual module output design which is targeting 300 to 500 kW.

Initial validation and testing of the prototype vehicle over a two-year period in Winnipeg has begun, operating primarily on a private route shuttling Manitoba Hydro employees between its current and former head office locations. [3] Initial in-field prototype operating performance test results indicate:

- an overall average energy consumption of 133.kWh/100km;
- HVAC consumption of 32 to 45 kWh/100 km at 35°C ambient; and
- sound (noise) output ranging from 50 dBa at idle (all systems operational) to 61 dBa when at full-throttle acceleration.

The additional energy requirement for winter heating of the interior when using electric heating will drive energy consumption to over 300 kWh/100 km. This high consumption limits available range and increases charging frequency, which in turn limits battery life and increases costs. An alternative is catalytic diesel or bio-diesel heaters with 85 to 90% thermal efficiency.

In late October, 2012 New Flyer Industries was awarded $3.4 million by Sustainable Development Technology Canada to work with the other members of the consortium, as well as Winnipeg Transit; to develop and deploy four additional prototypes and a high capacity charging system by the end of 2013. A four-year evaluation period, while in revenue service, will follow to assess the high capacity charging station, battery capacity and component life and reliability. Red River College is working directly with Mitsubishi Heavy Industries and New Flyer Industries on the integration of the battery packs for two bus prototypes.

In summary, through the combined efforts of the consortium partners, one prototype has been completed and four others are under development. Validation testing of the first prototype has completed its first year. A rapid DC charger for on route use has been deployed. NFI has demonstrated the prototype across North America; and was awarded a contract by the Chicago Transit Authority for two battery electric buses, as well as electric hybrids to other properties.

3. Conclusions

Initiatives such as EVTEC directly complement and support Province of Manitoba policy concerning sustainable transportation; and enable electric vehicle applied research and innovation amongst Manitoba's transportation sector; enhance electric vehicle education at the College and in the region; and increase public awareness of EV technology. [4] Opportunities for future study include the repurposing of ground vehicle batteries for stationary applications, determination of appropriate business models, and the availability of commercial-grade, high-capacity, fast-charging infrastructure, and passenger EV end-of-life.

With a strong industry network and a history of partnering with to conduct practical applied research projects, the College is applying its successful model of supporting innovation to enhance and improve vehicle performance, reduce emissions and integrate the use of renewable and/or alternate fuels. The pursuit of *Mobility from "Green Energy*" has advanced vehicle technology and renewable energy research, development, testing and manufacturing capabilities in Manitoba.

4. Acknowledgements

Red River College greatly appreciates the generous support provided by the Government of Canada (including the Department of Foreign Affairs and International Trade, the Natural Sciences and Engineering Research Council of Canada, the National Research Council of Canada and Western Economic Diversification), the Province of Manitoba (the Council on Post-Secondary Education, Manitoba Innovation Energy and Mines, and Manitoba Entrepreneurship Training and Trade) and local, national and international industry partners such as Atomic Energy of Canada Limited, the Centre for Emerging Renewable Energy, Kraus Global Industries, Manitoba Hydro, the Manitoba Vehicle Technology Centre, Motor Coach Industries, Mitsubishi Heavy Industries, the Natural Gas Vehicle Alliance of Canada, New Flyer Industries, Persentech, the University of Manitoba and the City of Winnipeg. The dedication and effort of the faculty, staff and students at Red River College enable these partnerships.

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RED RIVER COLLEGE VEHICLE TECHNOLOGY & ENERGY CENTER
Applied Research Project Selection: "Student & Staff Centered"

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ABSTRACT
Red River College has become an identifiable forerunner in applied research activities within the motive power field. With the focus upon development of technicians for the future, Red River College and its staff have been actively involved in the integration of applied research activities to enhance current curriculum content. Through selective project involvement, Red River College has seen the learning activity within the programs expand and more proactive thinkers return in subsequent apprenticeship training levels.

1. Introduction

There has been a conscious effort to structure an integrated approach to applied research activities within the various programs delivered within the Transportation Heavy Apprenticeship Trades division (THAT) of Red River College (RRC). This approach has allowed for the enhancement of learning opportunities for both students and staff that previously weren't available to them.

Beginning in 2006 THAT division of RRC; has been actively involved in applied research activities with the support of the Applied Research & Commercialization (AR&C) department of RRC and a wide variety of industry and government stakeholders. The division has been focused on three major themes of research activity.

- Cold Weather Testing
- Alternative Fuel Vehicles
- Emission Testing

Within these areas the division has been successfully able to expose both students and staff to new technologies and involve all parties in using the research as an active component of the student's studies and for staff development.

With a student centered approach to project selection, we have found that this selective process has had a major effect on the students ability to become better prepared for the technological change they will be exposed to when in industry. From the staff perspective, it has been found that the willingness to pursue expanded research activities internally has also grown such as that of the original bio-diesel project (fig. 1). Case in point; is the current Bio-diesel reactor that is nearing completion and is a joint venture between five separate departments within the college (fig. 2). The interest has spilled beyond the divisions preverbal borders and has other areas of the college now seeking to become involved in applied research. As a group that is made up of technicians and technologies, the desire to expand ones knowledge base comes natural to most staff.

Fig. 1 Original bio-diesel reactor from Red Deer College

Fig. 2 New high capacity PLC equipped reactor (June2013)

2. Discussion

Situated near the geographic center of North America, Manitoba has for many years played host to manufacturers when testing the performance of their vehicle in a region of extreme temperature ranges. With temperatures that will vary seasonally from +35^{0}C to -35^{0}C and at times beyond both of these values, the climate facilitates data acquisition that may not be achievable in a real world situation anywhere else.

As a result, the applied research that occurs here is very often focused on out three themes of research activity preferences. The College and THAT division has fast become a recognizable institution that provides opportunities for its students and industry partners (Mongeon, 2008).

The division has found that while cold weather has been the catalyst to bring in a project, most projects are based upon validating alternative fuels or propulsion systems. These two areas are closely tied to the fundamental business of the institutions training mandate. As such, the projects fit the criterion for project selection in almost every case. The projects we have been involved with or are currently involved with are varied. Our current list of applied research activities that have been completed or are in progress are as follows:

- EPA Certification for engine and induction system installation for Bus Transportation industry (2007 standards).
- Hydrogen Hybrid cold weather testing.
- Hydrogen production and distribution.
- Hydrogen Fuel Cell Bus project.
- PHEV conversion and service.
- Power Generation Unit assembly project for use in arctic environment.
- Electric bus battery assembly project.
- Electric bus battery design and assembly project.
- EPA Certification for engine and induction system installation for Bus Transportation industry (2010 standards).
- CNG cold weather testing and report submission for Transport Canada.
- Bio-diesel production and vehicle testing.
- Bio-diesel reactor design and commissioning

All of these projects have been well received by the students and staff with no shortage of volunteers to participate in almost every project. It is important to mention that many of these projects are done when faculty are instructing with students (to enhance the learning) or in their non-contact period. When staff participates in their non-contact hours they do so on a purely voluntary basis.

3. Conclusions

With the numerous projects that the division has had the opportunity to be involved in, we have all gained a tremendous amount value from our participation. The support that the college administration, supporting departments such as AR&C, the Province of Manitoba, the Government of Canada and Industry stakeholders and participants from both Canada and abroad, have all given immeasurable opportunities to our students. The growth that the division has experienced to date is only to be out shadowed by our future growth potential. The applied research activity that we have been exposed to has had a major impact on the culture of the division and has become contagious. With the support of AR&C I would expect continued opportunities for our students and staff and future technicians.

4. Acknowledgements

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Modeling, Simulation, Analysis and Control of Freeway Traffic Corridors

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ABSTRACT

This talk describes a set of modeling, simulation and analysis tools for planning and executing traffic operations management strategies in freeway corridors. These tools were originally developed to provide quick and quantitative assessments of the benefits that transportation management center control policies can provide, in order to decrease congestion in a freeway traffic corridor. The tools are based on macroscopic models, which run at a significantly faster rate than conventional microsimulation models, and are easily and reliably calibrated using traffic data collected from existing infrastructure mainline loop detectors. The tools are now being used in the development of a decision support system for active traffic management of freeway corridors in order to perform short-term traffic density and flow forecasts and to evaluate possible traffic management strategies.

1. Introduction

Vehicular traffic congestion remains one of the major worldwide sources of productivity and efficiency loss, wasteful energy consumption, and avoidable air pollution. This talk describes a set of modeling, simulation and analysis tools for planning and executing traffic operations management strategies in freeway corridors and their use as part of a real-time decision support system [1]. A freeway corridor typically comprises a 40-kilometer freeway segment on a highly populated urban area, together with its adjoining major urban streets or arterials. The movement of vehicles in a corridor is regulated by programmable field control elements including arterial intersection signals, ramp-metering signals, and message signs that announce emergency conditions, set speed limits and tolls, and provide driver information. Traffic data is primarily collected through inductive loop detectors buried roughly every kilometer along the freeways' payment, as well as detectors located in some of the major corridor arterials.

2. Model calibration, imputation and sensor fault detection and handling

The modeling, simulation and analysis tools that will be described in this talk utilize a self-calibrated Cell Transmission Model (CTM) [2] traffic macroscopic simulator. This simulator relies on a well-accepted theoretical model of traffic flow; it is parsimonious and does not require parameters that cannot be estimated from traffic data; and has been tested for reliability on several freeways [3]. Moreover, it is fast, running several hundred times faster than real time, which can be used with real-time measurements and statistically predicted short term future traffic demands to keep track of the current freeway traffic state, as well as make short-term predictions.

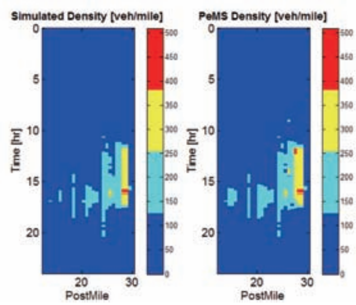
We first present system identification, fault detection and fault handling methodologies for automatically building calibrated models of freeway traffic flow. The algorithms that are presented work with loop detector data that are gathered from California freeways. The system identification deploys a constrained linear regression analysis that estimates the so-called fundamental diagram relationship between flow and density at the location of a given sensor.

Subsequently, we present an imputation algorithm for estimating the ramp flows in a freeway network [4]. We use measurements along the freeway - flows and densities collected by the existing loop detectors, to estimate the flows entering and exiting the system using ramps. The algorithm is based on the Link-Node Cell Transmission Model (CTM), which describes the traffic dynamics along the freeway, once the on-ramp demands and the off-ramp split ratios are provided as inputs. The model based imputation algorithm estimates the on-ramp flows and off-ramp split ratios that match the observed mainline measurements of density and flow. We employ a two-step procedure in the algorithm. In the first step, we find an effective demand parameter (which captures the aggregate input into a freeway section), by matching the model-calculated densities with the observed densities. This step employs an adaptive iterative learning algorithm, which continuously updates the effective demand parameter across iterations until sufficient convergence is achieved. In the second step, the effective demand parameter is split into the on-ramp flows and off-ramp split ratios using flow measurements. In this step, we derive the ramp flows using a linear program with an objective that minimizes the error between the model calculated flows and detector measurements. Finally, we demonstrate the application of the algorithm with a synthetic example and also using real life data from Several California freeway sections.

A fault detection algorithm, which has been developed to facilitate the automatic model building procedure, is also discussed in this talk. CTM models require consistent observations along the modeled freeway section for an accurate calibration to be possible. When detectors are down or missing, the model has to be modified to a less accurate representation, in order to conform with a configuration where a sensor is assigned to each cell of the model. In addition, on most California freeways the ramp flows in and out of the mainline are not observed. Since the estimation of these unknown inputs to the system also hinge on healthy mainline data, the identification of faulty mainline sensors becomes crucial to the automatic model building process. The model-based fault detection algorithm presented herein analyzes the parity between simulated and measured state, along with estimated unknown input profiles. Subsequently, it makes use of look-up table logic and a threshold scheme to flag erroneous detectors along the freeway mainline.

A fault-handling algorithm that accompanies the fault detection aims to revert the model to its original configuration after the aforementioned modifications are made to the model due to missing or bad sensors. Using a relaxed model-constrained linear optimization, this algorithm seeks to fill in the gaps in the observations along the freeway that are a result of poor detection. This method provides a reconstruction of the unobserved state that conforms to the rest of the measurements and does not produce a state estimate in a control theoretical sense.

The identification of fundamental diagram parameters and the estimation of unknown ramp flows produce a complete model. Simulated densities and measurements contour plots along the freeway provide an important visual inspection tool to assess if the model is able to replicate the congestion patterns and important bottleneck locations on the freeway.



In these contour plots, the horizontal axis is the spatial coordinate whereas the vertical coordinate axis corresponds to the time of day in hours. The plots show a single day, i.e. a 24-hour period. The traffic flows from right to left in these particular plots. The color palettes next to the plots define the color vs value matching for the contours. This example shows a calibrated 23-mile stretch of eastbound I-80 on August 15h, 2008 for a 24 hour time range.

3. Coordinated Ramp Metering and Variable Speed Limits

A computationally efficient model predictive controller for congestion control in freeway networks is presented in this talk. The controller utilizes a modified Link-Node Cell transmission model (LN-CTM) to simulate traffic state trajectories under the effect of ramp metering and variable speed limit control and compute performance objectives. The modified LN-CTM introduced here simulates freeway traffic dynamics in the presence of capacity drop and ramp weaving effects. The objective of the controller can be chosen to represent commonly used congestion performance measures like total congestion delay measured in units of vehicle hours. The optimal control formulation based on this modified model is non-convex making it inefficient for direct use within a model predictive framework. Heuristic restrictions and relaxations are presented which allow the computation of the solution using optimal solutions of a sequence of derived linear programs. Mainly, the freeway is cleverly divided into regions, and limited restrictions are placed on solution trajectories to allow us to derive computationally efficient control actions. In the absence of capacity drop, this solution strategy provides optimal solutions to the original optimal control problem by solving a single linear program. The properties of the solution are discussed along with the role of variable speed limits when capacity drop is present/absent. Examples are provided to showcase the computational efficiency of the solution strategy, and scenarios are analyzed to investigate the role of variable speed limits as a congestion control strategy.

The use of these tools as part of a decision support system for a freeway traffic management system will be discussed in this talk.

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