are important.

In a design process of machine equipment the designer must to ask and answer oneself "what part do you have to break?" or "how much is damaged if this part breaks down?" and ask same question to persons in job site and make them to think. Above actions are important in order to discover latent troubles, arrange counterplans, practice them and prevent troubles. They are also necessary to polish up the sense for prevention of trouble in daily work in which the sense of value is apt to becomes simple easily. Continuing above actions, we can develop the ability of forecasting danger, managing safety and preventing troubles. The basis of prevention plan of accident are summarized as follows,

① Polishing up the sense to a latent danger using total body (putting much importance on the mind to be aware of danger).
② Quick action to remove a latent danger (acting power).
③ Avoid the connection of plural latent dangers (individual management).
④ Perfect management of the source of danger (essential management).
⑤ Advance preparations on the assumption of emergency (for example, practical training in order to minimize the damage).
⑥ Advance preparations of first-aid on the assumption of accident resulting in injury or death (materials and machines for first-aid treatment, established method and practical training).

JSME AWARDS IN 1995

JSME DISTINGUISHED ENGINEERS AWARD

Hidetaka Nohira, Toyota Motor Corporation
for Research and Development of Low Emission and Fuel Efficient Engine

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Experimental Identification of a Hand-held Tennis Racket and Prediction of Racket Vibration during Impact
Yoshihiko Kawazoe, Saitama Institute of Technology

Mathematical Structure of Numerical Analysis and Regularization of an Inverse Boundary Value Problem in Laplace Field
Shiro Kubo, Osaka University, Shinjiro Kuwayama, Graduate School of Osaka University (present by Sumitomo Metal Industries, Ltd.), and Kiyotsugu Ohji, Osaka University, (present by Ryukoku University)

Stess Analysis for Nano-Scaled Elastic Materials (Elastic Contact Problems Considering Surface Stresses)
Hideo Koguchi, Nagaoka University of Technology

Heat and Mass Transfer in Strong Stable Stratification
Satoru Komori and Kouji Nagata, Kyushu University

Improvement of Dynamic Performance of Trucks with Longitudinally Unsymmetric Structures by Semi-Active Control for Rail Vehicles
Yoshihiro Suda, University of Tokyo and Ronald James Anderson, Queen's University

Improvement of Axial Dispersion by Intermittent Oscillatory Flow
Kazuo Tanishita, Keio University, Gaku Tanaka, Yoshiro Ueda and Hideki Fujioka, Graduate School of Keio University

Three-Dimensional Detailed Numerical Simulation of Bubbly Flow in Vertical Square Duct
Akio Tomiyama, Kobe University, Akira Sou, Graduate school of Kobe University, Hideo Yoshikawa, KOZO KEIKAKU Engineering Inc., and Tadashi Sakaguchi, Kobe University

An Extinction Analysis of Counter flow Diffusion Flames in Supersonic Airflow
Takashi Niioka and Ken'ichi Takita Tohoku University

Vibration Control of a Gondola by Passive-Type Dynamic Absorber
Hiroshi Matsuhisa, Kyoto University, Rongrong

Gu (present by Zhejiang University), Yongjin Wang, Osamu Nishimura, Kyoto University, and Susumu Sato, Kyoto University (present by Kinrankai women's Junior College)

On Regeneration of Quasi-streamwise Vortices of Near Wall-Turbulence

Yutaka Miyake, Osaka University, Ryuusuke Ushiro, Takenaka Corporation, and Takeshi Morikawa, Graduate School of Osaka University

Finite-Element Analysis of Tape-Head Interface of VTR

Hiromi Kita, Matsushita Electric Industrial Co., Ltd., Hidetoshi Kotera, Kyoto University, Yoshiaki Mizoh and Hiroshi Yohda, Matsushita Electric Industrial Co., Ltd.

Float Characteristics of Squeeze-Film Gas Bearings Using Elastic Hinges For Linear Motion Guide

Shigeka Yoshimoto, Yoshiro Anno, Science University of Tokyo, Yuichi Sato, Fuji Xerox Co., Ltd., and Kenji Hamanaka, Mitsubishi Heavy Industries, Ltd.

JSME MEDAL for the Development of New Techniques

◆ DEVELOPMENT OF LEAN BURN SYSTEM WITH NOx STORAGE REDUCTION 3-WAY CATALYST

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Hirofumi Shinjoh, Toyota Central R & D Labs., Inc., Syuji Tateishi, Cataler Industrial Co., Ltd.

Abstract

A lean burn system is recognized as a consistent method to achieve lower exhaust emissions and better fuel consumption of the gasoline engine.

TOYOTA has introduced this system into Japanese and European markets since 1984 with such technologies as combustion improvement and precise lean mixture control.

Even with those systems, however, lean operating area was limited to a relatively light load area, because conventional 3-way catalyst doesn't work in lean operating area as for NOx. So there must be more room for improvement in fuel economy.

Therefore, lean NOx catalyst is considered as the essential key to the further refinement of the lean burn system.

This new concept 3-way catalyst does not only work as a conventional 3-way catalyst, but also purifies NOx from the lean mixture operating conditions by using a NOx storage-reduction (NSR) function. This system also employs a special air/fuel mixture control to make the best of this function.

It has been confirmed that a vehicle with this lean combustion system successfully meets the Japanese emission(s) standards and improves fuel economy by 8 percent.

System Outlines

1. *NOX Storage-Reduction Catalyst* — Authors have investigated the selective reduction of NOx by HC. This type of catalyst has been studied by many organizations as well with regard to various chemical compound families, including zeolite, alumina and complex oxides. These catalysts, however, posed a number of problems, such as low conversion efficiency, narrow temperature window (temperature range where catalyst has high conversion efficiency), and low heat resistance. During studies, NOx storage-reduction function was found in catalyst with basic oxide component. This new catalyst features the following technologies to obtain best efficiency.
   1) Effective NOx storage components in lean operating conditions
   2) High heat resistant washcoat material

Fig.1 illustrates the NOx conversion mechanism of this catalyst. In the oxidizing atmosphere (left), NOx is oxidized on the noble metal, reacts with the storage component, and is eventually stored as nitrate. In the stoichiometric air/fuel mixture condition (right), stored NOx is reduced to N2 by reaction with HC, CO and H2.

2. *Air Fuel Mixture Control for this New Catalyst* — With this catalyst, a stoichiometric or rich mixture is occasionally necessary even if the engine is running under average lean operation. Then specially-configured air/fuel mixture control systems have been developed. Following are the two types of rich mixture supply control method employed for the system.

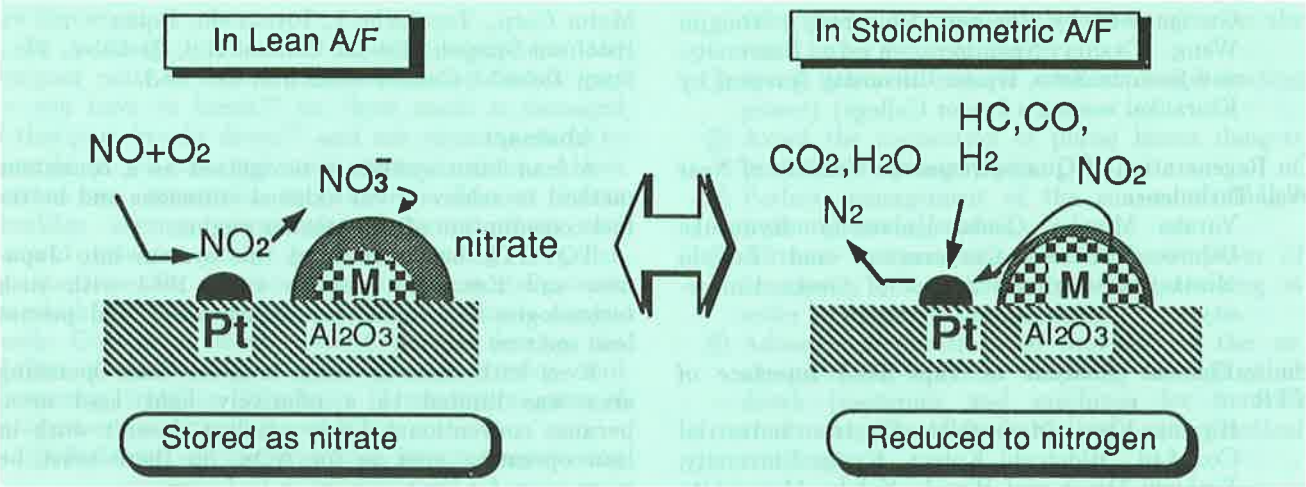

Fig. 1 NOx Storage-Reduction Mechanism

First, rich mixture supply at the decelerating timing after the lean operation was employed. The most effective NOx decomposition is known to be available when the engine is running with small intake (i.e. exhaust) air volume as in idling or deceleration, because the space velocity of exhaust gases which pass through the catalytic converter is low enough to obtain good conversion efficiency.

Second one is a rich mixture control during continuously lean operating conditions. The torque variation was mitigated by retarding the spark timing so that the output torque of the rich operation equaled that of the lean operations. The interval of each rich supply control was determined by estimating the NOx stored in the catalyst according to the driving conditions such as engine speed, intake manifold pressure, and air/fuel ratio. With the intermittent rich air fuel mixture control in cruising conditions, fuel economy losses are less than 0.5 Together with this new air/fuel mixture control, this new catalyst successfully works as a lean NOx catalyst in any lean operating condition.

3. *Lean Burn System* — This system features new helical intake ports with swirl control valve for combustion improvement in lean mixture conditions. Precise lean mixture control is realized by lean limit feedback control using a combustion pressure sensor. The NOx storage-reduction catalyst is located down under the floor of the vehicle to keep the catalyst temperature around 250 to 450°C in usual driving conditions in Japan as well as in Japanese 10-15 test mode cycle.

Results

With this new concept catalyst together with the new air fuel mixture control method, 4% fuel economy improvement was obtained over the previous version (8% over the stoichiometric system), while the NOx emission satisfied the Japanese standard (0.25g/km). These results have been obtained from a vehicle with a 4-speed automatic transmission and 1250 kg (2625lbs) equivalent inertia weight.

As for NOx conversion, 90% or higher efficiency on a fresh catalyst was obtained. Even after 100,000 km-equivalent durability running with Japanese regular gasoline, this catalyst retained 60% or greater NOx conversion capacity.

◆ DEVELOPMENT OF REFRIGERANT RECOVERY AND RECLAIM SYSTEM

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Abstract

The policies of reducing the production of CFCs gradually and banning it in this century are published in order to protect a global environment, especially to prevent the ozone depletion and the conventional refrigerant for automobile air-conditioner, CFC12 has been replaced an alternative refrigerant (HFC134a) for newly produced automobile. Meanwhile, CFC12 in air conditioner of the conventional automobile needs to be recovered and recycled to reduce the escape amount to atmosphere and to secure the replenishment without delay.

To meet the above demands, we have developed a recovery method of cooling a small container with a refrigerator to lower the inside pressure, not a recovery method of sucking and pressurizing a refrigerant to a large bomb with a compressor. Eventually we have succeeded in manufacturing a safe and handy refrigerant recovery and reclaim system (see Photograph) as a product.

2 Technology

2-1 Recovery Method

There are two methods for recovering the refrigerant in automobile air conditioning systems.

In one method, sucked gaseous refrigerant is com-

pressed to high pressure and temperature by a compressor, then liquefied at an outside air temperature and collected into a large pressure vessel. This method consists basically of a simple open-ended refrigerator with a sufficient recovery capability to forcefully remove the refrigerant. Unfortunately, this method requires maintenance of the lubricating oil and involves high pressure in the system.

In the other method, refrigerant is liquefied at a low temperature generated by a refrigerator and then collected into a small tank. This is safer, because the pressure in the system is comparatively low. In addition, its maintenance is easy because there are no mechanical parts along the recovery route. But, because the refrigerant is extracted only by the pressure difference between the air conditioner and the recovery system, not by external force, recovery capacity is inevitably lower.

We adopted the latter because of its safety and the specifications of the refrigerator were determined to attain the same capacity as that of the former.

2-2 Mechanism of Recovery Unit

The recovery uint consists of a cooling vessel to cool and liquefy a refrigerant and a detachable tank. The cooling vessel has a coil type evaporator inside, a stop valve and a motor-driven cam at the bottom, and a mechanism to pull up the recovery tank. The recovery tank has a stop valve identical to that in the cooling vessel and a valve guide. When the cam rotates to open the two stop valves after the tank has been pulled up to contact the bottom of the cooling vessel, the refrigerant liquefied in the vessel falls into the recovery tank by gravity. A portion of dropped liquid refrigerant evaporates again to lower the tank temperature because the temperature of the liquid refrigerant is lower than that of the tank. Evaporated refrigerant stays in the space surrounded by the valve guide and the tank wall, so that the tank is never completely filled with liquid refrigerant.

2-3 Air Purge Mechanism

The most important problem for practical use of this recovery system was the existence of air in automobile air conditioners. Over a long-term use, air has permeated into air conditioners through rubber hoses. If air flows into a cooling vessel in recovery, it interferes with refrigerant condensation. As a result, the recovery takes more time. Moreover, recovered refrigerant also results in including noncondensable gas.

To solve this problem, we have set a refrigerant inlet under the cooling vessel and have set an air purge mechanism which consists of an electromagnetic valve and a capillary tube at the top of the cooling vessel. The above mechanism enables this system to efficiently purge air stored in the upper potion of the vessel.

2-4 Reclaim System

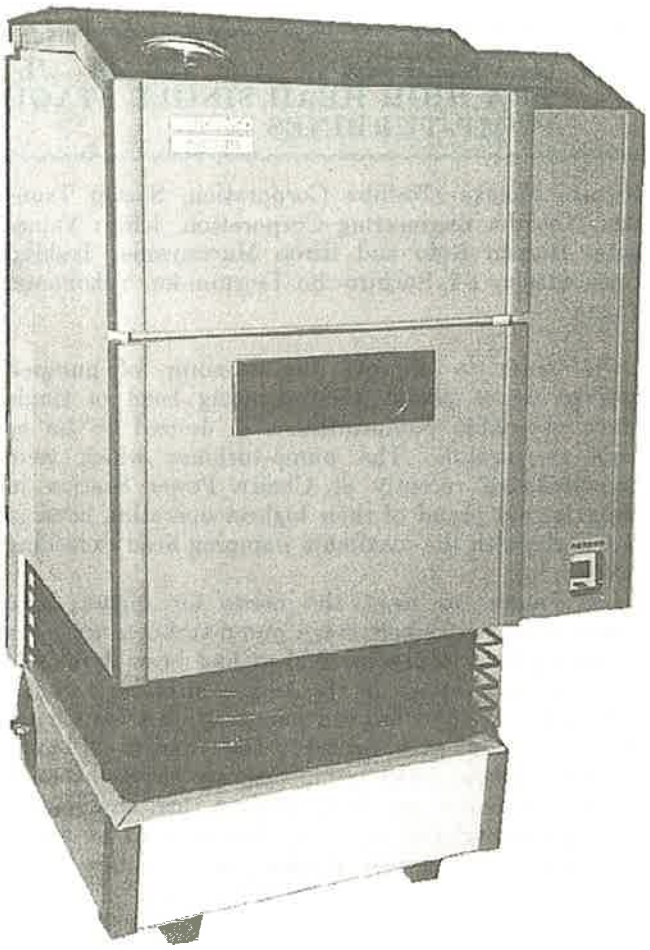
To reclaim refrigerant, evacuating noncondensable gas, oil, and moisture is necessary. Noncondensable gas is evacuated by air purge mechanism of a refrigerant recovery unit. We have designed the system that oil and moisture would be evacuated at reclaim unit before they flow into the recovery unit.

The main body of a reclaim system is a cylinder with ϕ 64 bore. A refrigerant, which has blown into the cylinder through the inlet, evaporates in gas-liquid separation room, and oil included by liquid refrigerant is separated. We have designed that the splashing oil would be filtered through wire elements and felts set above. Moreover, we have controlled liquid level of gas-liquid separation room with a level sensor so that its level would be lower than that of refrigerant inlet. With zeolite, moisutre will be evacuated from refrigerant without oil. We charged 500g of zeolite so that the concentration of moisture in recovered refrigerant would be 15 PPM, which is the recycled refrigerant standard value, or less even after the 500th recovery.

2-5 Performance Evaluation

We examined performances of this system from recovery tests at a laboratory and from component analysis of recovered refrigerant.

The recovery tests were done in three cases: the first was a case in which no air was mixed with refrigerant, the second was a case in which the 10^{-3} m^3 of air was mixed with refrigerant



and the air purge mechanism was not operated and the last was a case in which the air purge mechanism was operated. When air was not mixed, the recovery rate of the refrigerant reached more than 90% in 10 minutes. When 10^{-3} m^3 of air was mixed in, however, the recovery rate was only 70% unless the air purge mechanism was operated. This resulted because the pressure in the cooling vessel did not decrease sufficiently for the air in the air conditiner to flow into the cooling vessel. When the air purge mechanism was operated, the pressure in the cooling vessel immediately started to fall and the refrigerant flowed into the vessel again. So that the recovery rate improved to 90%.

From the field tests, each contamination ratio of refrigerant recovered in this system is within the recycled refrigerant standards.

3 Conclusion

We have developed the recovery mechanism to cool and liquefy refrigerant with a freezing machine and the reclaim mechanism working with recovery mechanism.

This product has contributed to reducing escape amount of CFC12 to atmosphere as well as securing the replenishment as a safe and handy recovery system in the field related to the automobile industry.

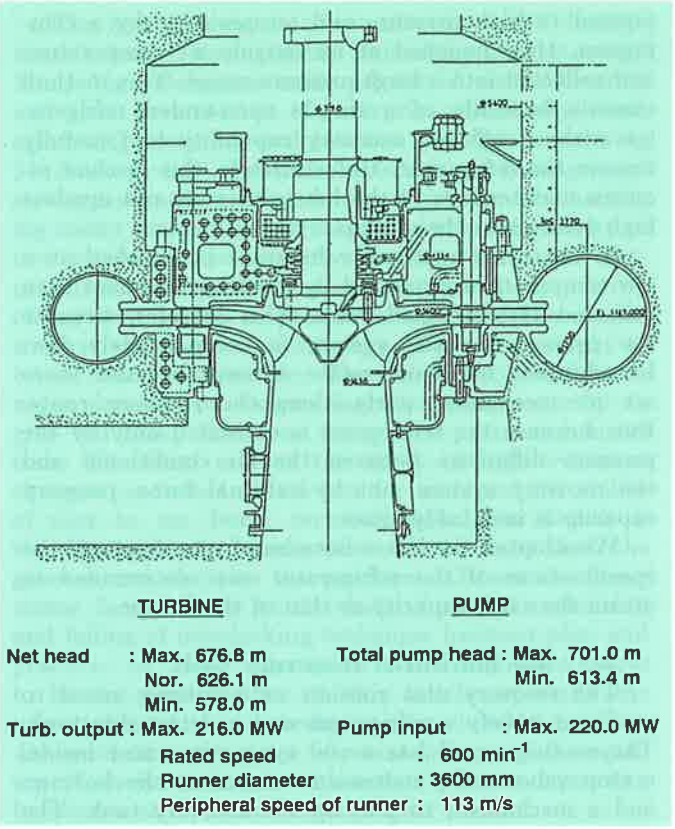


Fig. 1 Single stage reversible pump-turbine for CHAIRA Power Station

◆ DEVELOPMENT OF 700 M ULTRA HIGH HEAD SINGLE STAGE PUMP-TURBINES

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In order to improve the economy of pumped storage power plants, the operating head of single stage reversible pump-turbines is desired to be as high as possible. The pump-turbines which were commissioned recently at Chaira Power Station in Bulgaria are proud of their highest operating head in the world with the maximum pumping head exceeding 700 m.

In Japan, to meet the needs for higher head pumped storage, single stage pump-turbines with the operating head exceeding 500 m had been developed and put into service in the 1970's. However, around 1980 when the 700 m head pump-turbines for Chaira Power Station were ordered, the runners of some of these 500 m head pump-turbines showed serious cracks due to fatigue. It was feared then that higher head pump-turbines exceeding 500 m head might be unfit for practical use if such fatigue failure could happen.

To cope with this problem, Toshiba commenced comprehensive studies on the vibration of high head pump-turbine runners in parallel with those on the fatigue strength of the runner material.

These studies revealed the following findings;

1) The vibration of runners is caused by the hydraulic excitation force resulting from hydraulic interaction between rotating runner vanes and stationary guide vanes and detrimental vibration stress may be caused by resonance. The hydraulic excitation force has rotating modes with various numbers of diametrical nodes, which are determined by the combination of the numbers of runner vanes and guide vanes.
2) The most significant mode of the hydraulic excitation force is the combined mode consisting of two specific modes, one mode showing oscillatory wave motion propagating on the runner crown or band progressively (the rotation of the mode is the same to the runner rotation) and the other showing the wave motion propagating retrogressively (the rotation of the mode is opposite to the runner rotation).

   Although the two component modes do not have any fixed node point on the periphery of the runner, the combined mode of these two modes has equally spaced fixed node points of the same number with the runner vanes.

3) Usually, a runner has a normal mode having a similar mode shape to that of the hydraulic excitation force as stated in 2) above.
When the frequency of the hydraulic excitation force of that mode, which varies with the rotating speed of the runner, becomes close to the natural frequency of the runner of the corresponding normal mode, large vibration stress appears on the runner due to resonance.

4) The natural frequency of the runner confined in a turbine casing is decreased considerably compared with that in air due to the added mass effect of the surrounding water in the confined space which is much larger than that in open water. The ratio of the natural frequency of the runner in water against that in air may fall to 0.5 or less depending on the number of the diametrical nodes of the mode.

5) The natural frequency of the runner can be shifted by the modification of the external profile of the runner crown and band. By this means, the resonance can be avoided and the excessive vibration stress may be eliminated.

The pump-turbines for Chaira Power Station were designed based on the above studies. During the commissioning test of one of the prototype units, actual working stress of the runner was measured and it was verified that the vibration stress was sufficiently low. The vibration stress was even lower than that of 500 m head pump-turbines of conventional design.

The design method to reduce the vibration stress of runner has been already applied to some high head units following Chaira units, and its usefulness has been proved also in these units.

It is expected that this technology wil contribute not only to improve the reliability of high head pump-turbines, but also to encourage the further development of ultra high head pumped storage power plants.

◆ FORGED BRAKE DISC WITH FINS FOR HIHG SPEED TRAINS

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Noriyuki Shirakuni, Central Japan Railway Company, Kikuo Takao, Railway Technical Institute, Haruo Sakamoto, University of Washington, and Fusao Kusumoto, Sumikin Design & Engineering Co., Ltd.

According to the recent trend of high speed Shinkansen vehicles, the brake disc with high strength and sufficient durability has been required. Due to such demand, new type of forged brake disc with fins has been developed by processes such as (a) estimation of thermal crack resistance and material modification for the existing cast iron brake disc, (b) fracture analysis of fractured forged brake disc and understanding of material characteristics required, (c) material selection based on the fracture toughness for forged material, (d) evaluation of cooling efficiency for fins and decision of adequate fin configuration. As shown in Fig. 1, the full size brake disc was manufactured and confirmed to have superior brake performances by dynamometer testings. Following the subsequent running tests in vehicles, the modifications both for countermeasures of bolt stuck and for formidability of forging has been done. In such manners, the new brake disc resulted in reality for Shinkansen vehicle high speed more than 270 km/h such as Nozomi, etc.

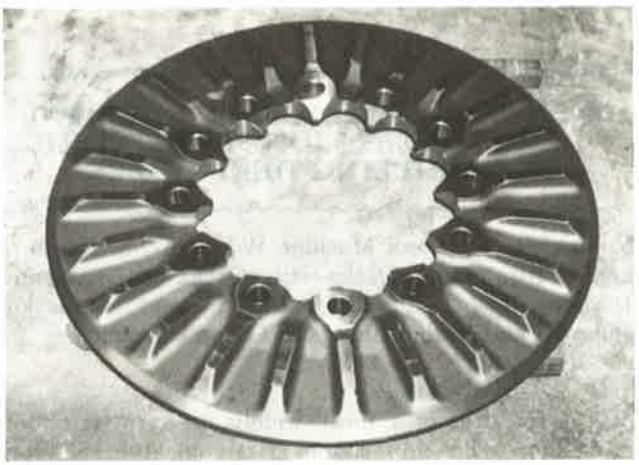

Fig. 1 Forged Brake Disc with Fins

Brief explanation of development for each process is in the followings. To improve the thermal crack resistance for the existing cast iron brake disc, graphite configuration, graphite amount, other chemical contents, and base metal microstructure for a variety of cast irons were investigated. The result clarified that the existing cast iron with Ni, Cr, and Mo has the highest resistance among cast irons, and forged material can be a disc material candidate if the fracture toughness and cooling efficiency are high enough.

The first trial produced forged brake disc was made of medium carbon steel and without fins. During the evaluation tests, the forged disc brittle fractured. After fracture analysis of the fractured disc, it was understood that that the forged material needs to have sufficient fracture toughness under usage conditions. Through the material selection based on the fracture toughness, the material of modified AISI4330 was decided to be the one for forged brake disc.

Cooling efficiency is the one of important factors for brake disc. Therefore, the cooling efficiency had been investigated by experimental study to measure the air flow between fins and analytical study to evaluate thermal cooking braking. It was found that among the configuration factors of disc the area to be cooled is the main one to consider, and the thickness does not affect by itself.

Based on the result, the configuration was decided so that the forging to produce fins can be done in an appropriate manner. However, the formidability of this kind can be done in an appropriate manner. However, the formidability of this kind of material is difficult to make fins, and needed to investigate by studies of lubrication, temperature for heating, die configuration in the forging process.

Final obstacle for reduce to practice was bolt stuck, which was realized during vehicle running tests. Special configuration for reducing residual stress around bolt holes by pre-deformation of disc surface solved the problem, and resulted in reality of new brake disc for next generation Shinkansen, which already started.

◆ A HIGH FEED RATE CONTINUOUS OPERATION TWIST DRILL FOR DRILLING DEEP HOLES

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1. Introduction

A twist drill is a most widely used cutting tool in drilling. The chip shape is a conical helix type at first and then changes to a segment type in drilling with a conventional twist drill. The segment type chip tends to clog drill flutes under continuous feed, and causes drill fracture. The step feed is necessary to exhaust chip in deep-hole drilling with it. However, the drilling efficiency is poor in this method. A new type twist drill which can drill a deep hole at high feed rate without stepping was invented. Its geometrical features of cutting edge and the flute controll chip formation and chip exhaust. The wear form of this drill is different from that of the conventional one, and the tool life is longer.

2. Technical Details

2.1 Drill geometry: Fig. 1 shows the cross section and the point geometry of this new twist drill. The web of this drill is 3.3 times thicker than that of the conventional one at the point. Thus, it has high flexural and torsional rigidity. The main flank and the rake of the central part (rake angle; 0 degree) are formed by a flat grinding method. And the drill tip forms a point perfectly. This perfect point of the drill tip is same as that of the three rake geometry, but the grinding procedure of the second main cutting edges (the cutting edges of the central part) and the joint of the first and the second main cutting edges are different from those of the three rake geometry. The second main cutting edges are not formed by the thinning, but formed by the simultaneous grinding of the second main flank and the rake of the central part. The angle between the first and the second main cutting edges is about 120 degrees, which is relatively small. Since the cutting action of each main cutting edge is independent, the chips generated by them can be distinguished each other. The first main cutting edges have large oblique angle. The second main cutting edges occupy half of the drill diameter. The point angle is 130 degrees (That of the conventional one is 118 degrees).

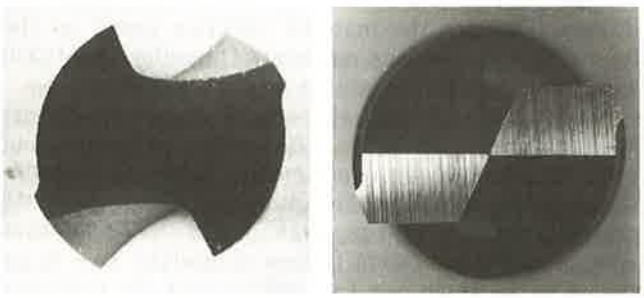

Fig. 1 Cross section and point geometry

2.2 Situation of chip exhaust: The chip is a conical helix type at first, successively changes to a segment type. After the hole depth exceeds approximately 7 times the drill diameter, a long helix type chip appears. This long helix type chip consists of two parts. One is generated by the first main cutting edge and account for 75% of the total volume. The other is generated by the second main cutting edge and is attached to main part of the chip discontinuously. As the pitch of this helix type chip is equal to that of the flute, the chip slides upwards along the flute, collides with the tool holder and then breaks into small pieces. As the segment type chips are lined up along the flute, they are pushed out sequentially. As these are the removing condition of chips, the flutes do not clog with chips in spite of the narrow ones; all types of chip are exhausted out of the drilling hole very well. And the space between chip and the flute wall, which is not the rake face, is large, the cutting fluid is supplied to the cutting region even the external fluid supply with a nozzle. Therefore, it can drill a deep hole under continuous feed and a high feed rate. Under conditions of wet drilling of a S50C strip, a 12 mm-diameter twist drill with a carbide (M20) tip achieved deep drilling of 265 mm i.e. 22 times the drill diameter (cutting speed; 45 m/min, feed rate; 0.26 mm/rev, cut flute with an end mill), and a 10 mm-diameter HSS twist drill achieved 15 mm i.e. 15 times (cutting speed; 16 m/min, feed rate; 0.3 mm/rev, ground flute). The ratios introduced here were the physical limit of drills used in the experiment. That is to say, their flutes were almost buried in the drilling holes.

2.3 Tool life: It is general that the wear of the conventional drill is severe at the outside edge of the main flank. The cause of this phenomenon is considered as follows: Both the maximum wear of the main flank and that of margin meet at the edge

region in which both faces intersect, and therefore the wear at this region grows rapidly. In case of this new type twist drill, the maximum wear width on the main flank locates a little inside from the outside edge, and the wear of the margin is reduced. Under conditions of wet drilling of a S50C strip without mill scale, a 10 mm-diameter HSS twist drill achieved a total drilling depth of 80m (through hole drilling of 60 mm×1340 holes, cutting speed; 16 m/min, feed rate; 0.3 mm/rev). It is considered that this is almost the tool life from the situation of the wear of the main flank and the margin. The dependence of the flank wear upon the through hole drilling depth (30, 60, 100 mm) was low (10-mm diameter HSS twist drill, wet drilling of a S50C strip without mill scale, cutting speed; 16 m/min, feed rate; 0.3 mm/rev, total drilling depth; 30m), strictly speaking the flank wear in case of 100 mm-hole depth was a little smaller than that in case of 60 mm-hole depth. The experiment was quit at the total drilling depth of 30m, and drills did not reach the tool life.

3. Conclusion

As the web of this new twist drill is the 3.3 times thicker than that of the conventional one and it has high rigidity, and moreover as chip is exhausted out of the drilling hole very well, it can drill a deep hole under continuous feed and a high feed rate.

Its wear form is different from that of the conventional one and the wear of its margin is reduced, so its tool life is very long.

◆ DEVELOPMENT OF ENERGY-SAVING TYPE AIR-CONDITIONERS

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Abstract

Energy saving type air-conditioner, which saves annual running cost to half of the conventional model, was developed in 1993. The improvement of efficiency of the air-conditioner is more than thirty percent, which is achieved by developing new compact heat exchanger, random pitch blade cross-flow fan for indoor unit, new compressor motor and inverter which drives variable speed compressor, new propeller fan for out-door unit. Energy saving is also achieved by adopting constant PMV(predicted mean vote, prescribed by ISO7730) control method. The 1995 year model has adopted new dry operation cycle and reduced annual running cost to 27,900Yen.

1. Introduction

The increase of electricity consumption in home use in Japan is remarkable and is 30% higher compared to 5 years before. The energy consumption ratio used by air-conditioners to the total energy consumption at home is more than 20%, and is still increasing annually. From the standpoint of electricity demand and environment problem, saving energy consumption of the air-conditioners is strongly required. On the other hand, the investigation of user's complaint shows that high running cost of the air-conditioner is listed as the worst complaint. Considering these circumstances, the energy saving type air-conditioner (RAS-251NTD) was developed in 1993. The air-conditioner saves annual running cost to half of our conventional model (RAS-251UT). The improvement of efficiency of the air-conditioner is more than thirty percent and is made by developing new compact heat exchanger, random pitch blade cross-flow fan for indoor unit, new compressor motor and inverter which drives variable speed compressor, new propeller fan for out-door unit. Energy saving is also achieved by adopting constant PMV(predicted mean vote, prescribed by ISO7730) Index control method. This method saves power consumption by 20% compared to the conventional room temperature constant control method. The air-conditioner is refined every year with reducing annual electricity charge by 5000 yen and Genetic Algorithm control (GA control) is first adopted to the air-conditioner among all household appliances. The 1995 year model (RAS-251GD) is improved to have power consumption rate up to set COP (Coefficient of performance = heating capacity/power input) of 4.65 at rated heating operation, annual electric charge of 27,900yen and to have new dry operation mode which can dehumidify efficiently as dehumid machine without room temperature decrease.

2. Compressor

Two cylinder rotary compressor driven by DC brushless motor was developed to the air-conditioner. The conventional DC motor has a outer stainless steel can around the magnet and has an eddy current loss on the can. The new motor is designed that permanent magnet is inserted into laminated-steel core to decrease the eddy current loss. With digital control inverter, total efficiency of the compressor and motor improved by 20% compared to the conventional AC motor compressor. The 1994 year model adopts anti-arc shape layout of the magnet to the rotor. The magnetic flux is concentrated to the 120 degree electric angle where motor torque is generated. Digital control inverter system for DC compressor was developed. Rotor position is detected by direct sampling of induced voltage. Compared to conventional sensorless system which generate process signal through analog filtering of induced voltage, it can detect rotor position in advance of switching timing and optimize switching timing to have high efficiency.

3. Heat Exchanger For Indoor Unit

The 1994 year model adopts multi bending heat exchanger for indoor unit. The heat exchanger is bended at five position to have round shape at front side so that heat exchanger which have large heat transfer area is laid out in a compact indoor unit body. The cross flow fan locates at the center of the indoor unit and the fan casing has almost ideal shape. The multi bending heat exchanger helps the fan to generate high air flow rate with low noise emission and low power input. The heat exchanger surrounds the fan and air flow distribution is uniform along the heat exchanger so that whole heat transfer area is used effectively. The heat exchanger has fine slit on its aluminum fin plate and high ripple inside of the refrigerant pipe to enhance heat transfer between the air and refrigerant. Total heat transfer coefficient of the heat exchanger is improved by 25% compared to the conventional heat exchanger by the effect of large heat transfer area, heat transfer enhancement of the slit fin and ripple tube, uniform air flow and high air flow rate. The heat exchanger is modified for 1995 year model to have circular arc shape to avoid bending process and to obtain optimized copper pipe layout.

4. Random Pitch Blade Screwed Cross Flow Fan

The random pitch blade screwed cross flow fan was developed for the 1994 year model for noise reduction. The one of the major noise comes from the cross flow fan is share flow after the fan blade rotation near narrow space, such as contact point to the heat exchanger, fan nose. There occurs fan blade noise at the frequency of fan speed multiplied by number of the fan blade. To decrease the blade noise, fan blade is arranged in a random pitch along the fan rim and fan blade is screwed along the fan rotation center direction. The peak noise power is eliminated by the random and screwed fan blade arrangement. The random pitch arrangement pattern is deigned by computer simulation to avoid unbalance of rotational moment of the fan. The random pitch screwed blade cross flow fan can offer higher flow rate with same noise level at maximum power operation and quiet characteristics at normal low power operation.

5. Constant PMV Index Control Method

Energy saving is also achieved by adopting constant PMV(predicted mean vote, prescribed by ISO7730) index control method. PMV index predicts thermal comfort which is mean response of a large group of people in thermal environment. PMV is an index which represents the atmosphere most people feel comfortable. PMV index is defined from six parameter such as, ambient temperature, humidity, radiant temperature, air flow rate, amount of clothing and activity. The air-conditioner calculates PMV index from room temperature, humidity, out-door temperature, fan speed and louver angle. It controls room atmosphere to keep PMV index constant as comfortable. For example, the heat radiation from the

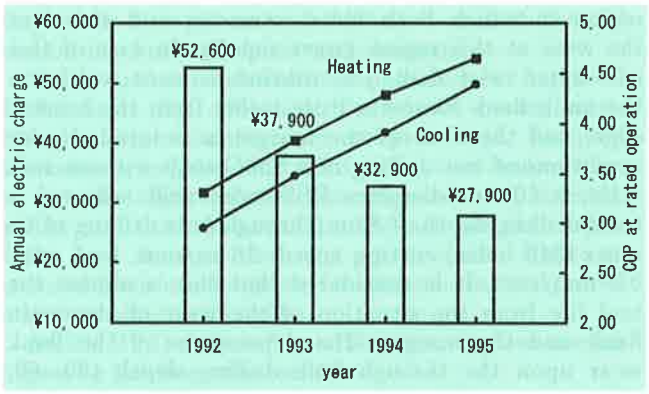

Fig. 1 Performance of the Air-conditioner

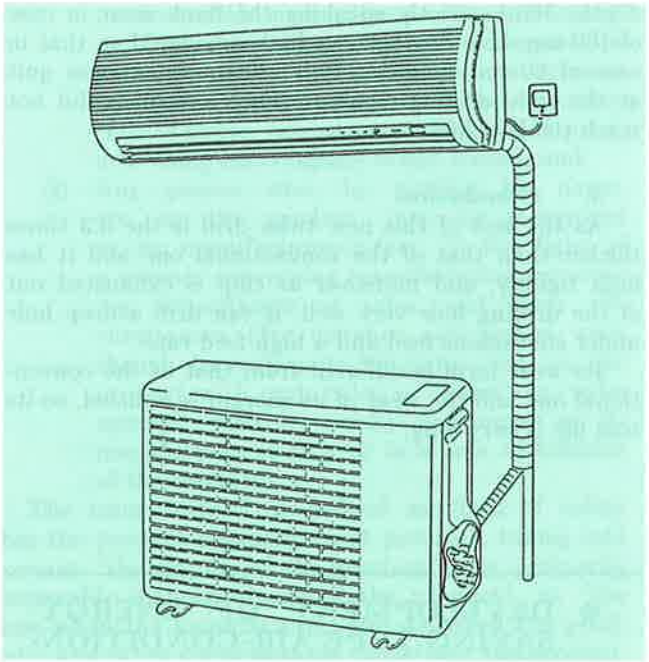

Fig. 2 Outlook of the 1995 year model (RAS-251GD)

wall is higher at warm day so that people feels too warm in same room temperature compared to cold day. This method can avoid unnecessary warming nor cooling and offers both comfortable and energy-saving operation compared to constant room temperature control method. The PMV calculation data table is set in the microcomputer of the indoor unit. The effect of the constant PMV control method to the energy saving is almost twenty percent and is evaluated through the room type laboratory test at various out-door temperature.

6. New Dry Operation

Conventional dry function is dehumidifying on the whole heat exchanger of the indoor unit by operating air-conditioner as cooling cycle with slow fan speed and has problems such as few amount of water dehumidified, cold outlet air, decrease of room temperature. The 1995 year model adopts new dry function. It has small heat exchanger in the

indoor unit and refrigerant cycle is controlled to keep only the small heat exchanger at low temperature by the mechanical valve with short circuited air flow around the indoor unit. By decreasing total cooling performance(latent heat and sensible heat) and increasing dehumidification performance(latent heat), this model can provide efficient and comfortable dry function.

7. Conclusion

The energy saving type air-conditioner reduces annual electorate charge to half that of our previous model by both improvement of the hard ware and soft ware and is confirmed by field tests. The 1995 year model has heating performance of 4.65 at its rated operation and annual electricity charge of 27,900yen. Figure 1 shows the comparison of the performance of the conventional model and energy-saving type models.

◆ A METHOD OF MANUFACTURING HIGH-QUALITY, ECONOMICAL FRP PRODUCTS THAT CAN BE PLATED

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1. Introduction

Products made of glass-fiber reinforced plastics (FRP) are stronger and stiffer than all other plastic products, and are lighter and have longer life than comparable steel products. Thus, FRP is ideal for automotive exterior panels. Conventional FRP, however, has certain drawbacks:

a. Poorer than steel sheets in appearance, requiring excessive touch-up operation and thus higher cost, and
b. Does not accept decorative plating which is essential to automotive exterior panels, especially for trucks.

We have attempted to overcome these difficulties by developing new technology with primary emphasis on sheet molding compound (SMC) method. First, forming conditions have been optimized by improving in-mold coating (IMC) technology and introducing pressure control, which in turn helped eliminate pinholes and stabilize quality. Thus, significant saving in touch-up operation has been achieved. Second, we tried a new concept to apply plating to the surface of IMC. We succeeded in converting the IMC surface structure to that compatible with plating, and as a result an SMC plating technology has been accomplished for the first time in the world to make the plating on SMC look equal to that of steel.

2. Details of Technology

2.1 Technology for improving quality and reducing cost of coated SMC products

Major technological challenges in realizing better and cheaper coated SMC were to make the surface smoother and minimizing the surface discontinuities like pinholes. We focused our research efforts on IMC technology which applies coating inside the mold while products are being formed. In IMC, paint is injected at high pressure, while SMC material is being cured in the mold under heat and pressure, to coat the entire surface of the SMC, filling pinholes and other discontinuities and forming a smooth surface. The timing of paint injection is critical. Injection at a wrong time would leave the SMC surface partially uncoated. The paint would also form humps on or near the ribs or bosses provided on the back of a product to increase rigidity or to seat other parts. These ribs or bosses could also cause dents or sink marks. We observed the curing behavior of SMC material in the mold and thus determined the best timing of IMC paint injection to minimize those humps and dents. The results of these studies were reflected on mold design and forming conditions.

1) Mold design improvement

a. The IMC injector is slanted for easy injection of IMC paint.
b. A pressure sensor is installed in that part of the lower mold where SMC material is placed. It helps determine the optimum paint injection timing and thus prevent paint from leaving part of the product uncoated.

2) Forming conditions

Multiple-step control of in-mold pressure was introduced after analysis of in-mold pressure data.

a. Molding pressure is reduced before the SMC material heats and expands, thus preventing sink marks in rib or boss area.
b. IMC paint is injected while the SMC material is being cured and shrinking.
c. 3-step pressure control is conducted after injecting IMC paint to prevent the paint from flowing or forming humps on bosses or ribs.

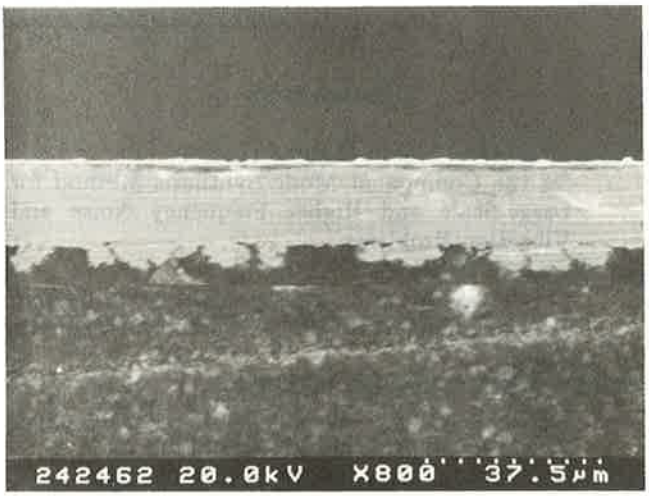


Fig. 1 Sectional view of electroplated surface

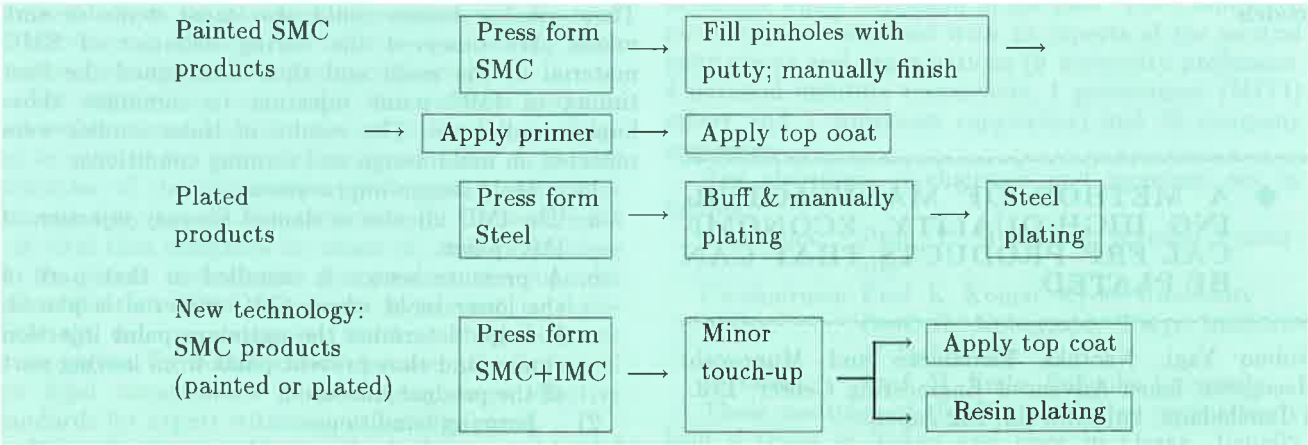
2.2 Development of IMC paint compatible with decorative plating

We attempted to apply plating to the surface already coated with IMC paint rather than directly to SMC surface. Our research objective was set to develop IMC paint that would accept not only plating but also top-coating. The basic mechanism of ABS resin plating, which is already on the market and is well proven, was used to make sure that paint flow is smooth during SMC molding while achieving neat plating appearance and high degree of adhesion. IMC paint was converted into 2-component structure: One easily soluble, or non-refractory, the other not easily soluble, or refractory, in chemical etching fluid. The non-refractory components are used as inorganic filler for which small particle size objects are selected for better painted surface quality, while the refrac tory component are resins with high acid resistance. The microscopic appearance of the converted and resin-plated IMC paint surface shows irregular holes like those on ABS surface, serving as anchorage, and the sectional view of Fig. 1 shows that the plating is firmly enmeshed with the IMC paint coating.

2.3 Achievements

As shown below, the new technology has made it possible to reduce the number of processes required for paint touch-up on SMC-formed products and to apply decorative plating to such products. This has eliminated the need of making new investment in steel mold tooling.

Conventional method (a reported example):



3. Conclusion

Practically feasible SMC plating technology has been established for the first time in the world and has been applied to front exterior panels of new medium- and heavy-duty trucks. This technology is expected to be useful not only in automotive industry but a lso in other industries as well.

JSME AWARD FOR YOUNG ENGINEERS

[Research]

Tetsuji Ichikawa, Nissan Motor Co., Ltd.
for the Component Mode Synthesis Method for Large-Scale and Higher Frequency Noise and Vibration Problems

Jun Ishimoto, Tohoku University
for the Study on an Energy Conversion System Using Boiling Two-Phase Flows of Magnetic Fluid

Hiroshi Okuda, University of Tokyo
for the Study on Efficient Finite Element Analysis of Incompressible Viscous Fluid

Hidenori Kosaka, Tokyo Institute of Technology
for the Studies on the structure of transient sprays and spray flames

Masaharu Komiyama, Osaka University
for the Measurements of Temperature and Concentration by Laser Scattering and Induced Fluorescence and Application to Diffusion Flames

Katsuhiko Sasaki, Hokkaido University
for the Research on Cyclic Inelastic Deformation and Constitutive Equation

Kaiji Sato, Tokyo Institute of Technology
for the Integration of Functions for Precision Mechanisms

Hideaki Sato, Musashi Institute of Technology
for the Removal of Ceramic Swarf from Grinding Fluids

Shuichi Sakamoto, Niigata University
for the Research work of method of detecting number of sheets using sound

Masahiro Suetsugu, Suzuka College of Technology
for the Application of the Caustic Method to the Dynamic Fracture Problems of Structural Ceramics at Elevated Temperatures

Hiroshi Tanaka, Nagoya University
for the Fracture Mechanics Approach to Fatigue and Fracture of Graphite Fiber-Reinforced Plastics

Mamoru Tanahashi, Tokyo Institute of Technology
for the Structure Analysis of Turbulence and Chemically Reacting Turbulence by Direct Numerical Simulation

Mitsuhiro Tsue, Osaka Prefecture University
for the Combustion of Fuel Droplets under Super-critical and Microgravity Conditions

Hoshio Tsujita, Hosei University
for the Numerical Calculation of Viscous Flow within Turbomachine by Boundary-Fitted Coordinate System

Yuji Hamai, Mazda Motor Corporation
for the Numerical Study of Flowo Field Inside Rotary Engine

Keijiro Masui, Tohoku University
for the Active Flatness Control of a Large-Scale Silicon-Wafer Slicer Cutting a Crystal Ingot

Fumihiko Mikami, Chiba University
for the Control of Non-Spherical Microparticles with Center of Gravity Offset by a Shear Flow

Masahiro Mizuno, Iwate University
for the Theoretical Analysis of Blade Behavior in Outer-Blade Slicing

Tomohiro Yamasaki, Osaka University
for the Study on Nodestractive Residual Stress Measurement Using Interaction between Magnetics and Ultrasonics

[New Technology]

Toshikatsu Akiba, Toshiba Corporation
for the Development of a Magnetically Suspended Mirror Scanning Mechanism

Yasunori Itou, Nippon Steel Corporation
for the Development of a Robot System for Converter Relining

Noriyuki Imada, Babcock-Hitachi KK
for the Measurement of Gas Temperature Distribution in Boilers Using Acoustic CT Method

Shintaro Kitade, Ishikawajima-Harima Heavy Industries Co., Ltd.
for the Study of the Non-Destructive Evaluation Techniqe of Composite Laminates Using Fiber Optic Sensors

Noboru Konda, Sumitomo Metal Industries, Ltd.
for the Development of Evaluation Method for Life Prediction under Corrosive Environments

Yusuke Tanaka, Kobe Steel, Ltd.
for the Structure and Properties of Ti-Al-N Coatings for Cutting Tools

Naohiko Takahashi, Hitachi, Ltd.
for the Applications of Magnetic Bearings to Centrifugal Compressors

Nakamura Keiji, Mitsubishi Electric Corp.
for the Development of Twin Lens Optical Pick-up for DVD

Naoki Matsumoto, Nippondenso Co., Ltd.
for the Dynamics and Control of a Holonomic Omnidirectional Vehicle

Masashi Yamanaka, Toyoda Machine Works, Ltd.
for the Development of CNC Gear Grinding Machine Using Threaded Vitvified-bounded CBN Wheel

DIVISION AWARDS IN 1995

部門名（英文）	賞名（英文）	受賞者名（英文）	勤務先（英文）
Computational Machanics	Computational Mechanics Award	Toshiro Miyoshi	Tokai University
	Computational Mechanics Award	Brian Launder	University of Manchester
	Computational Mechanics Achievement Award	Hiroshi Kitagawa	Osaka University
Bioengineering	Seguchi Award	Hiroshi Yamada	Nagoya University
	Bioengineering Award	Kiichi Tsuchiya	Waseda University
	Bioengineering Achievement Award	Toshiaki Hara	Niigata University
Materials & Mechanics	Materials and Mechanics Award	Eiryo Shiratori	
	Materials and Mechanics Award	Osamu Tamate	
	Materials and Mechanics Award	Arthur J. McEvily,Jr.	University of Connecticut
	Materials and Mechanics Award	Keith John Miller	University of Sheffield
	Materials and Mechanics Achievement Award	Ryuichi Ohtani	Kyoto University
Materials & Processing	Materials and Processing Award	Satoshi Somiya	Keio University
Fluids Engineering	Fluids Engineering Award	Ichiro Ariga	Chiba Institute of Technology
Thermal Engineering	Thermal Engineering Award for Outstanding Leadership	Ryoji Ishiguro	Hokkaido University
	Thermal Engineering Award for International Activity	Ichiro Tanasawa	University of Tokyo
	Thermal Engineering Award for International Activity	Chang Lin Tien	University of California at Berkeley
	Thermal Engineering Award for Outstanding Academic/Technical Contribution	Ryozo Echigo	Tokyo Institute of Technology