JSME AWARDS IN 1994

JSME DISTINGUISHED ENGINEERS AWARD

Yoshiki Kawasaki, Isuzu Motors Ltd.
for Quality Improvement of Automobile Manual Transaxle and Transmission

Norio Komoda, Toyota Motor Corporation
for Research and Development on Intelligent Vehicle Drive and Transport Systems

Tatsuo Shibata, KRT Co., Ltd.
for Enhancement of the Design Engineering of the Railway Freight Cars

JSME MEDAL for the Best Papers

Microscopic Behavior of Ice Crystals and Biological Cells during Directional Solidification of Solutions with Cells
Hiroshi Ishiguro, University of Tsukuba and Boris Rubinsky, University of California.

Influence of Long Seal on the Stability of Fluid Machineries
Yuji Kanemori, Torishima Pump Mfg. Co., Ltd., and Takuzo Iwatsubo, Kobe University.

Theoretical Analysis of Rotating Cavitation in Inducers
Kenjiro Kamijo, National Aerospace Laboratory, Yoshinobu Tsujimoto, and Yoshiki Yoshida, Osaka University.

Numerical Simulation of Stress-Induced Failure in Aluminum Conductors of a Microelectronic Package based on Surface and Grain Boundary Diffusion
Takayuki Kitamura and Ryuichi Ohtani, Kyoto University, Tetsuya Yamanaka, Toshiba Corporation.

Development of Mechanical Testing Machine for Microelements and Fracture Strength Evaluation of Single-Crystalline Silicon Microelements
Kenjiro Komai, Kohji Minoshima, Kyoto University, Hideo Tawara, Sumitomo Electric Industries, Ltd., Shigemichi Inoue, Kyoto University and Katsuyoshi Sunago, Sumitomo Electric Industries, Ltd.

Polygonal Deformation of Roll-Covering Rubber
Atsuo Sueoka, Takahiro Ryu, Kyushu University, Takahiro Kondou, Fukuoka Institute of Technology, Yoshihiro Tsuda, Ohita University, Keiichi Katayama, Katsuaki Takasaki, Masahiro Yamaguchi, Hideki Hirooka, Mitsubishi Heavy Industries, Ltd.

Swirling Flows in a Circular-Sectioned 90° Bend
Kouzou Sudou and Toshihiro Takami, Hiroshima University.

3-D Mesomechanical Analysis of Brittle Microcracking Solids and Improvement of Damage Mechanics Models
(1st Report, Isotropic Damage Mechanics Model)
Yutaka Toi and Takanori Kiyosue, University of Tokyo.

Mixture Formation Process in a Diesel Spray with High Injection Pressure
(Behavior of Spray Injection into a Model Combustion Chamber)
Hiroyuki Hiroyasu, University of Hiroshima, Mamoru Suzuki, Idemitu Kosan Co., Ltd., and Keiya Nishida, University of Hiroshima.

Reduction Gear System with Inclined Pinion
(1st Report, Theoretical Analysis)
Koro Yaejima and Muneharu Morozumi, Shinshu University.

A Study on Run-out Characteristics of Externally Pressurized Gas Journal Bearing
(2nd Report, Rotor Run-out Characteristics)
Hiroshi Yabe, Kyoto University.

Optimum Design Using Fuzzy Numbers as Design Variables
(3rd Report, Determinations of Fuzzy Sets and Discussion)
Hiroshi Yamakawa and Masao Arakawa, Waseda University.

JSME MEDAL for the Development of New Techniques

◆ Development of hydrostatic stern bearing for contra-rotating propeller system

Sadao Asanabe, Kunio Saki, Susumu Matsumoto, Kazuyuki Araki and Tetsuzo Ohta, Mitsubishi Heavy Industries, Ltd.

The idea of contra-rotating propeller (CRP) originated about 150 years ago. Though its excellent energy saving effects have long been recognized, however due to the technical barrier that sufficient lubrication between the inner shaft and its bearing rotating with the outer shaft in reverse direction could not be secured, the practical application of CRP system to merchant ships had not been brought to reality.

Therefore we have developed a new type of hydrostatically lubricated plain bearing and have confirmed that this bearing ensures sufficient performance as stern bearing for CRP.

Uniqueness of counterrotating bearing Two stern bearings are necessary for CRP. One is the inner shaft bearing to support the inner shaft with after propeller, and the other is the outer shaft bearing to support the outer shaft with forward propeller.

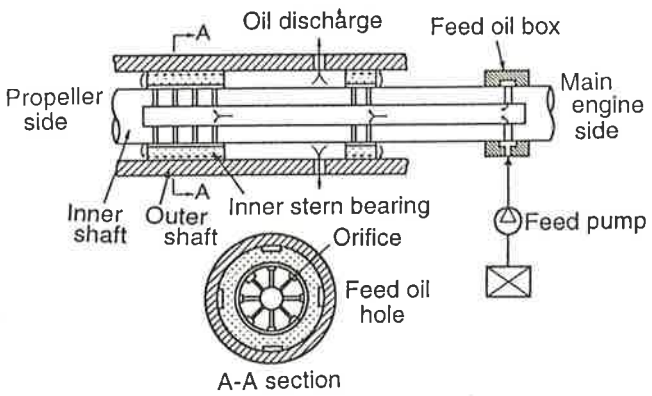
The inner shaft bearing operates in different lubrication principle from the outer one, because the inner shaft bearing is fitted inside the outer shaft and rotates in opposite direction to the inner shaft. In such a situation, conventional plain bearing has problems that load carrying capacity based on the hydrodynamic pressure generation would not be very large. Because the lubricant oil carried by rotation of the inner shaft is carried away by the counterrotation of the bearing, so that net pressure generation would not be very large. If the rotational speeds of inner and outer shaft are equal, no pumping action occurs and no load carrying capacity is available.

This is one of the major difficulties that have prevented large sized CRP system to be realized for a long time.

Newly developed plain bearing Tapered land bearing and floating bush bearing are thought to be among the candidates for CRP bearing. But these bearing were not adopted in our development, because they do not have enough reliability against severe misaligned situation.

So we contrive rather new structure, where externally pressurized oil is utilized. Highly pressurized oil is fed into the rotating inner shaft and is directed through the axial center hole up to where the inner bearing is positioned.

Eight equally spaced oil holes with flow compensator (orifice) in several axial locations direct oil to the sliding surface itself.



Newly developed hydrostatic bearing for CRP system

View of contra-rotating propellers fitted on the 4200 GT car carrier

The newly developed bearing is much superior in carrying not only force but also moment which causes the shaft to misalign and contacts the bearing at its edge. So it can minimize the relative inclination between shaft and bearing.

Another feature of this special hydrostatic bearing is asynchronous counterrotation.

The weakest point of hydrostatic lubrication is loss of high pressure source such as in case of blackout.

In asynchronous counterrotation, net flow of oil would not be zero and produce oil film pressure hydrodynamically, therefore failure could be prevented in spontaneous loss of high pressure oil.

This load carrying capacity in asynchronous counterrotation were confirmed in full scale stand test on land, and also the safe operation after blackout was confirmed in sea trial of full scale ships.

Full scale ship application Newly developed CRP systems were successfully installed in a 4200 GT car carrier in 1988 and in a 258000 DWT tanker in 1993.

Full scale measurements of oil film thickness and bearing temperature showed how well the bearings operate and confirmed the reliability of them.

◆ The Development of Automotive Miller Cycle Gasoline Engine

Tatsuji Ikeda, Koichi Hatamura, Takao Nogami, Mazda Motor Corp., Hideki Matsuoka and Yuichi Iguchi, Ishikawajima-Harima Heavy Industries Co., Ltd.

1. INTRODUCTION

With growing concern to the global environment, the reduction of CO_2 emission becomes one of the most important problems in automobile technology. So Mazda has developed Miller Cycle gasoline engine and successfully realized the high quality performance required for upper grade vehicle and low fuel consumption.

2. MAJOR TECHNOLOGICAL ASPECTS

"Miller Cycle" is an air-charged combustion cycle with an intercooler introduced by R. H. Miller in 1947 ASME. Since an intake valve closes before the bottom dead center ('early closing timing'), the effective expansion stroke is longer than the effective compression stroke. High torque output was realized by 'early closing timing', a compressor and an intercooler without raising combustion temperature. Mazda's Miller Cycle engine is characterized by the "late intake valve closing timing system" and "Lysholm compressor".

(1) Late intake valve closing timing system — As for the 'early closing timing', the charging efficiency decreases and required intake pressure increases at high engine speed. On the other hand, 'late closing timing system' prevents the charging efficiency decreases at high engine speed, being suitable for automobile gasoline engines.

Late close timing system have the following two typeical features.

i) The later the intake valve closing timing becomes, the better the combustion will be even under the high charging efficiency condition. Much larger torque is generated by increasing the intake pressure within the limitation of knock and exhaust gas temperature.

ii) As the later intake valve closing timing is adopted, the higher intake pressure is required to obtain the same torque; Therefore, a compressor with higher intake pressure ratio is indispensable.

(2) Lysholm compressor — A compressor generating high intake pressure without throttle response delay is inevitable to realize a higher torque with Miller cycle. To satisfy theses requirements, Lysholm compressor has newly been developed.

3. ENGINE SPECIFICATION

Miller cycle engine is characterized by its high nominal compression ratio of 10, though it is a supercharged engine, and by its late intake valve closing timing at 70 degree ABDC, later than the conventional engines by 30 degrees. Although the retarded intake valve closing timing reduces the effective compression ratio to 7.6, the ratio is still close to that of conventional supercharged engines.

4. MAJOR ENGINE PERFORMANCE

(1) Output performance and transient response performance — The V6 2.3 L Miller cycle engine torque is superior to that of V6 3.0 L NA engine over all speed range. A Lysholm compressor and an electrically controlled air bypass system achieve a linear acceleration performance from a low engine speed region. This differentiates Miller cycle engine from turbo-charged engines, making Miller cycle as a true alternative to larger displacement NA engines.

(2) Fuel consumption — From a viewpoint of supercharged engine, Miller cycle engine has the highest compression ratio (or expression ratio) of 10.

So high torque performance is achieved over all engine speed range with high thermal efficiency being kept. Miller cycle engine has lower fuel consumption owing to smaller frictional resistance because of smaller displacement, compared to a larger displacement engine with the same maximum torque. As a result, brake specific fuel consumption (BSFC) has been improved from conventional 3.0 L engines by 10–15% in partial load region. The BSFC is almost equal to that of a turbo charged IDI diesel engine with the same maximum torque.

5. FUEL ECONOMY IN PRACTICAL USE

Fig. 1 shows the comparison of fuel economy in practical use between EUNOS 800 with the Miller cycle engine and other conventional 2.0 L and 3.0 L passenger vehicles. The fuel economy equivalent to V6 2.0 L is achieved even in daily use, including engine warm up, air conditioning, etc.

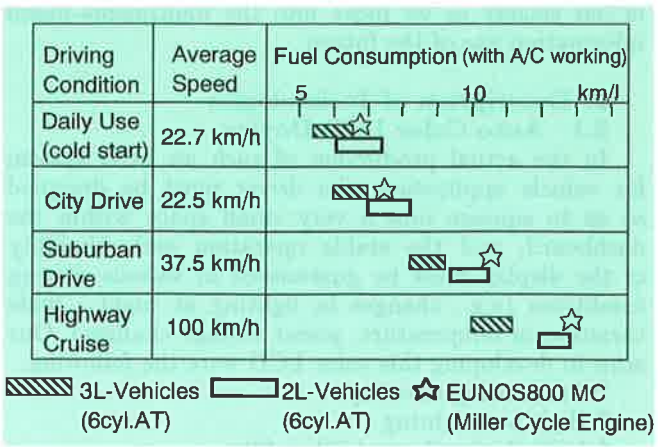


Fig. 1 Fuel Economy in Practical Use

◆ Development of High-Performance Auto Navigation System

Hiroshi Kondo, Shigetoshi Azuma, Kenji Kimura, Toyota Motor Corp., Takaaki Kato, Nippondenso Co., Ltd., and Koji Sumiya, Aisin AW Co., Ltd.

1. General

With each passing year, the kinds of information for display within the vehicle are increasing in terms of the changing needs as vehicle information become more diversified, and elderly and women drivers are increasing in number. Meanwhile, in many different nations,public and private sectors are attempting to alleviate traffic congestion and are thus conducting tests on actual systems to provide traffic information, along with public tests of the kind. In the days to come, as extra-vehicular information becomes more diversified and the vehicle traffic environment more complex, the prediction is there will be a greater need for all kinds of information to be used within vehicles.

Moreover, with such changes taking place in the road/traffic environment, auto navigation system will be extremely important from the standpoint of safety, economy and resource conservation. Thus, a number of features of great importance have been kept in mind in our development of a high-performance, next generation navigation system of breakthrough proportions: sure legibility/visibility, a switch arrangement with screen touch function, a downsized-type 6-inch crystal display with anti-window reflection for automobiles, GPS (Global Positioning System), speed and other sensors together with map matching techniques for a sophisticated auto location pinpointing technology and both digital and compression technologies to record vast amounts of map data on CD-ROMs. The new system will also come with a display system that will prevent mistaken operation/awareness and the like, along with a voice guidance function based on ergonomics. Such technologies will be the mainstream of our society as we move into the multimedia-based information age of the future.

2. Description of Technologies

2.1 Auto Color LCD Device

In the actual production of such an LCD system for vehicle application, the driver must be designed so as to squeeze into a very small space within the dashboard, and the stable operation and reliability of the display must be guaranteed in various driving conditions (e.g., changes in lighting at night , wide variation in temperature, power voltage changes). Our aims in developing this color LCD were the following.

* Pre-heating circuitry
* High backlighting
* LCF (Light Control Film) filter

This display device for vehicle use provides a large, brightly illuminated 6-inch screen equipped with infrared touch switch feature for "easy operation" and "excellent legibility." We consider the development targets were achieved.

2.2 High-speed Readout Memory CD-ROM Changer

The construction of the new CD-ROM changer is laid out like that of a music CD changer. It uses a high-speed motor drive, a rack-and-pinion system for greater durability, and for the pick feed motor a small cureless motor with low threshold and moment of inertia. For greater stopping accuracy, a rotary encoder is used. Figure 1 presents the construction used and a comparison of access time.

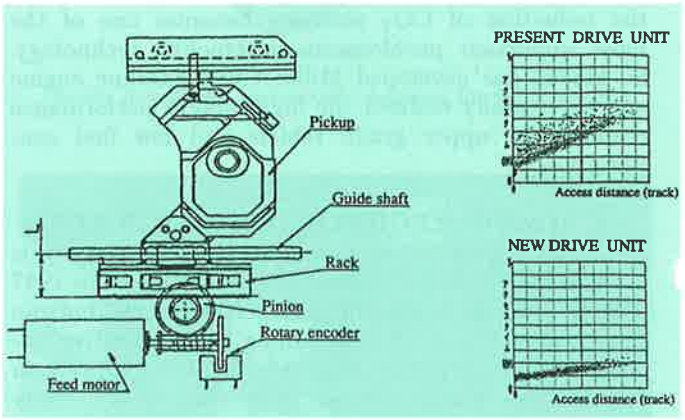


Fig. 1 Comparison of new CD construction & access time

2.3 Route Searching

In the system, a "Route Guidance" function was incorporated the first time ever for vehicle application. Route guidance is a function which calculates the recommended roads from point of departure to final destination on the basis of map database in the CD-ROM. In its development we attempted to realize a practical traffic flow control for an on-board system in combination with traffic information available. The system which eventuated uses a map database for route guidance, high-speed processing, and a new feature by which a pathfinding algorithm developed is shown on the map. The modified Dyksthod method was employed for pathfinding as far as the final destination, to shorten.

2.4 Voice Guidance

A new method was developed combining voice and enlarged views of intersections in order to assure better route guidance, driving safety, peace of mind and cost-effectiveness. The kinds of voice-over used are arranged for names of intersection, roads, interchanges, or road signs with destination names. As for the timing of the voice pronunciation, care is taken to consider the number of stripes on the road, the speed etc., in developing a new processing logic. The targets were achieved through lowering the heart beat, time and the number of times the driver has to glance at the display while driving.

3. Summary

In the new system an almost basic technology was developed for use in an automotive navigation system.

With the market expansion of the future, the combination of this system with the traffic information systems of the future promises to assure greater traffic safety.

◆ Development of A Flying Width Sizing Press of High Productivity

Nobuhiro Tazoe, Ken-ichi Ide, Ishikawajima-Harima Heavy Industries Co., Ltd., Masami Oki, Sumitomo Metal Industries Co., Ltd., Takahisa Kobuchi, and Hisaki Hatoko, Kashima Steel Works, SMI.

1. Synopsis

In the concatenation of steelmaking processes, the free sizing of slab width over a large range claims an indubitable importance for synchronizing hot strip rolling with steelmaking. Although sizing of slab width for a substantial reduction rate as called for by the hot strip mill is being accomplished today by using either the edger rolls or the start-and-stop action width sizing presses, neither can be said to be wholly satisfactory, for the former leaves much to be desired in the matter of yield because of the rather large crop loss, and the latter's productivity cannot be very high because of its intermittent operation.

This paper introduces a novel flying slab width sizing press we have developed and duly had commissioned in June, 1988 at the Hot Strip Mill, Kashima Steel Works, the Sumitomo Metals Industries Co. Our past experiences have proved clearly that its ability of processing slabs while moving them continuously down the line to very heavy width reductions not only makes it entirely compatible with any modern hot strip mill but positively helps to improve the productivity of the preceding line of continuous casters. Undoubtedly this is the reason for the quite a few orders that we are receiving from abroad these years.

2. Production Experience

Since its commissioning at the Hot Strip Mill (monthly production capacity of 360,000 tons), flying sizing press has processed 97% of the slabs, reducing their widths by 235 mm on average, and 350 mm maximum, not only keeping up with the hot strip mill's high productivity but positively improving that of the continuous casting line, thereby contributing to the further operation rationalization of entire works.

It is on these achievements, we like to believe, that contracts for technology exports have successfully been concluded with several foreign hot strip mills, with quite a few inquiries arriving every day.

3. Conclusion

A flying slab width sizing press has been developed leading the world. Working on the principle of eccentric sine motion mechanical crank shaft press, it develops productivity that is entirely compatible with that of modern hot strip mills. Production experiences acquired at the Hot Strip Mill, Kashima Steel Works, Sumitomo Metal Industries Co. have proved indubitably that the large freedom in sizing the slab our flying press affords has had a great deal to do with the productivity improvement achieved in the continuous casting line as well as in enlarging the scope of concatenation of continuous casting to hot strip rolling.

We trust therefore that efficacy of our technology will be recognized widely, and believe that it will come to be adopted by all hot strip mills the world over.

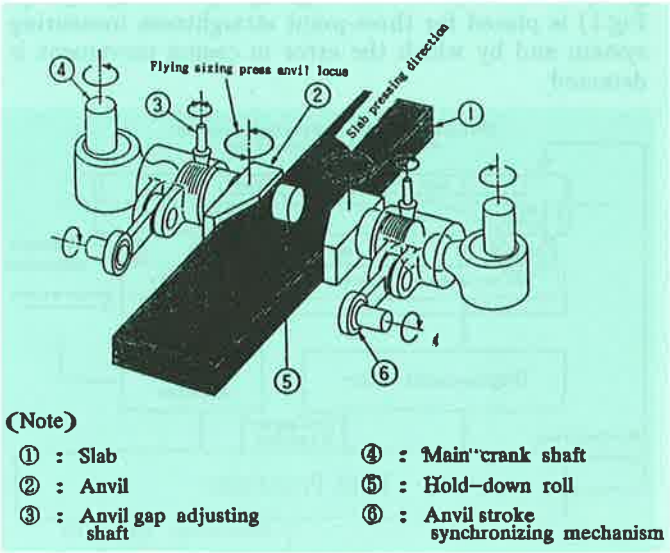


Fig. 1 Schematic view of flying slab width sizing press

Table 1. Major specifications of flying slab width sizing press

Type	Flying press with horizontally counter-moving anvils
Stroke drive	Mechanical crank upward drive system
Transfer drive system	Mechanical crank system with transfer speed adjusting mechanism
Width draft	350 mm (maximum)
Widthwise press capacity	2,700 tons
Slab feed amount	400 mm/stroke
Operating cycles	50 strokes/min (maximum)
Slab speed	20 m/min

◆ Development of On-Line Roll Profile Meter (OPM) and its application

Takehito Nakamura, Hiroshi Sekine, Shinji Okazaki, NKK, Corp., and Kouichi Takeno, Hiroaki Shimazutsu, Mitsubishi Heavy Industries, LTD.

1. Introduction

On-Line Roll Profile Meter (OPM) and application algorithm have been developed. OPM provides exact roll profile by measurement while rolling, which is much available for rolling process. This system has been applied for Hot Strip Finishing Mill at NKK KEIHIN WORKS.

2. Technical Details

2.1 Outline of OPM

OPM system configuration is shown in Fig. 1. Multiple ultrasonic displacement meters (probes) are placed along the casing to measure distance to the roll surface. As the casing moves along parallel to the roll shaft, the roll profile in a straight line on the roll barrel is measured over multiple segments in accordance with a trigger signal synchronized with roll rotation. At the left and right ends of the casing, a group of three probes (i.e., ①, ②, ③, and ⑧, ⑨, ⑩ Fig.1) is placed for three-point straightness measuring system and by which the error in casing movement is detected.

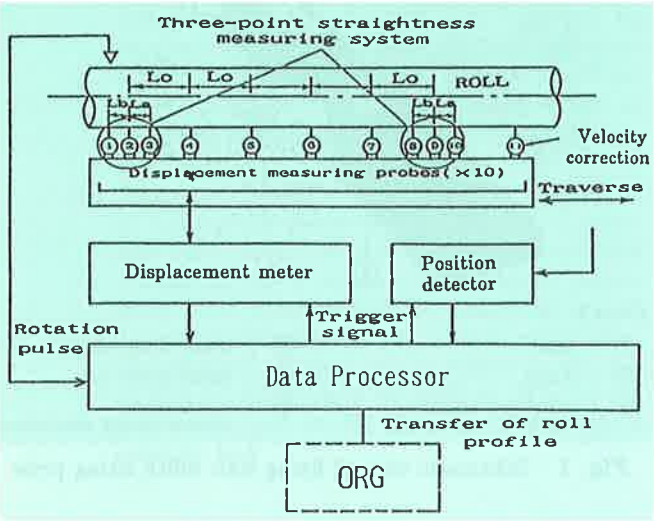


Fig. 1 Outline of OPM

2.2 Data processing procedure

Fig.2 shows the data processing procedure of this mesuring system.

(1) The displacement between roll surface and probe and position along roll shaft are measured.

(2) With the three-point straightness measuring system shown in Fig.1, the movement error of the casing as a rigid body can be calculated. On the basis of the results, the measurment values of step (1) are corrected to what they would be if the casing had moved perfectly straight, thereby partial roll profiles can be obtained.

(3) The partial roll profiles obtained in step (2) are linked together to form whole roll profile.

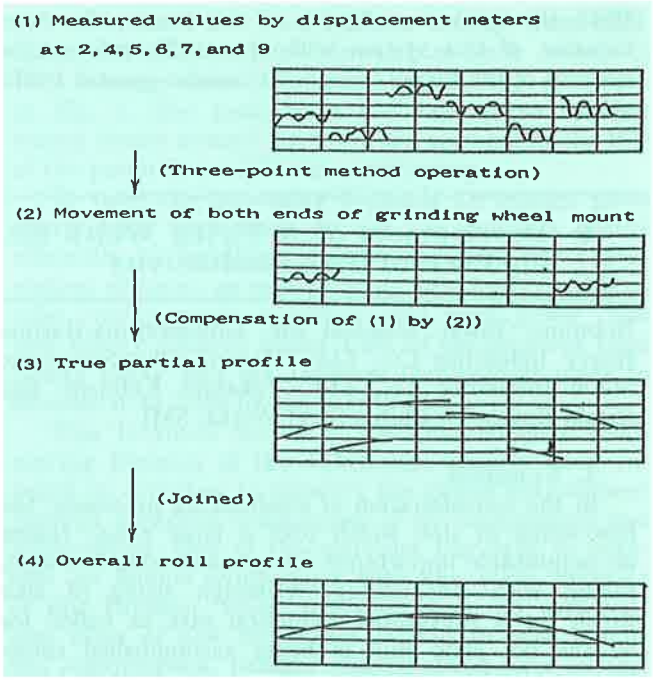


Fig. 2 OPM data processing procedure

3. OPM Application

3.1 Application for On-Line Roll Grinder (ORG)

A feedback grinding algorithm for ORG has been developed based on the roll profile measured by OPM. Roll grinding data is calculated at every rolling timing by the comparison between roll profile estimated by model and target profile. And roll profile model is automatically adjusted according to the exact roll profile measured by OPM at constant period (e.g. every 20 strip rolling) which enables us to compensate for roll wear and to remove surface roughness accurately by ORG. This leads to significant effects in productivity and energy saving because we can keep initial roll profile and extend roll changing period.

3.2 Application for Automatic Gauge Control (AGC)

Accuracy of strip thickness depends on the gap between top roll and bottom roll, which is controlled by AGC system. Roll profile model improved by OPM has been also applied for AGC system, and consequently the accuracy of strip thickness is dramatically improved.

4. Conclusion

OPM described here enables us to measure roll profile accurately even under the severe conditions of hot strip mill. Besides improving the accuracy of strip thickness, this system provides great amount of cost reduction by combining with ORG.

◆ Development of Low NOx Boiler by Low Temperature Combustion

Tamotsu Miura, Miura Co, Ltd., Yasutoshi Senoo, Miura Institute of Research & Development, Shigehiro Watanabe, Kazuhiro Ikeda, Seiji Tai, Miura Co., Ltd.

1. Design Concept

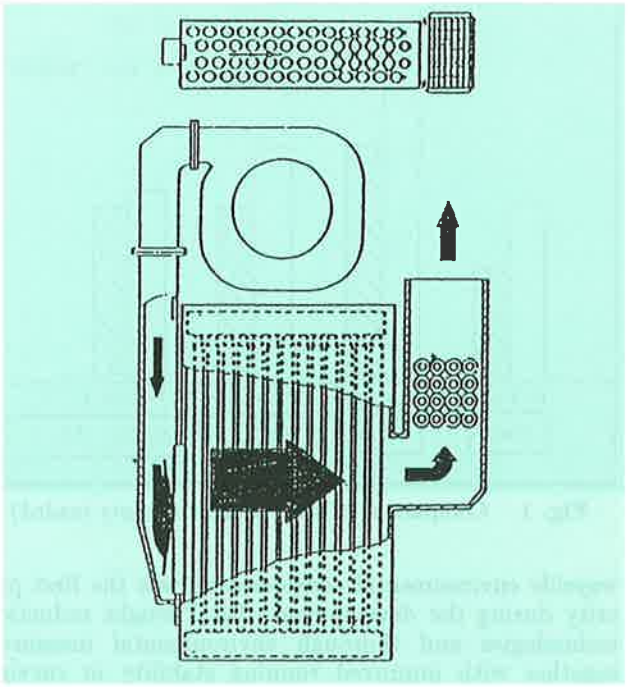
Envinomental problem is one of the most important matters throughout the world. As boilers are continous sources of exhaust gas, reduction of NOx emission exhansed out of boiler is an urgent problem especially in populated area. So far, reduction of NOx emission has been attained by technics such as circulation of exhaust gas in a combution chamber and/or adoption of various kinds of burner, so called, low NOx burners. As a result, NOx contents has been reduced about 50 percent at best.

NOx is mostly produced in the high temperature zone in the combustion furnace. In the present boiler, a bunch of water tubes are located very close to the burner so that the flame is quickly cooled and the burned gas passes through the relatively high temperature zone in a very short time. The design concept of the present boiler, which is called as integration of burner and water tubes, is successful in reducing gas temperature without harming combustion. Thus NOx is reduced drastically without increasing CO emission. In the present boiler, which is boiling capacity of 2000kg/hr with an area of heat transfer less than $10m^2$, the NOx concentration ratio in the exhaust gas is less than 30 ppm, which is about one quarter of that of conventional boilers. Furthermore, the space required for installation of the boiler is reduced to less than one half of conventional ones with the same boiling capacity, because it has no furnace. Based on these merits, installions and demand on boilers of this type are increasing in the market.

2. Component

Several rows of water tubes are placed in parallel so that tubes are diagonally arranged. The burner is located very close to the tubes at one end of rows and the other end of the row is opened to the exhaust duct. (as shown in drawing) During operation, combustion is kept in the space between several water tubes near the burner, where the gas temperature is relatively low in comparison with conventional combustion, and then it is reduced monotonically toward the exhaust duct. Fuel gas and air are mixed well before they are introduced to the burner. Unless they are mixed well, it is not possible to achieve stable combustion with low NOx and low CO in the exhaust gas. The flow rate of the fuel gas is controlled changing air flow, so that the fuel/air ratio is kept nearly constant in transient state when the load of the boiler is changed.

The burner is made of a honeycomb which consists of a pile of corrugated and flat thin metals. On the surface of the burner, which is the edge of corrugated



Dwg. Configuration of the burner and water tubes in the present boiler

sheet metals, several lines of flame divider is located. Due to the high opening ratio of the honeycomb, the heat release rate of the burner is as high as $14MW/m^2$. The flame dividers and the quenching effect of the honeycomb not only stabilizes the flame but also serves for preventing from flashback.

In conventional boilers, water tubes surround the furnace and require a large heat transfer surface. In our boiler, there is no furnace and the water tubes are distributed in a rectangular box.

Gas goes through the box in the longer path on, and is discharged from the backend of the boiler box. Therefore, heat transfer surface become small. A pump and a drain separator are assembled suitablly. The total width of our boiler is about 60% of that of conventional boilers because of better accessible for service.

◆ Development of the bullet train "NOZOMI"

Tsutomu Morimura, Central Japan Railway Company, Isao Okamoto Railway Technical Research Institute, Takashi Shimomura, Nippon Sharyo, Ltd., Kunio Koganemaru, Kawasaki Heavy Industries, Ltd. and Morinari Hattori Hitachi Ltd.

1. Introduction

The bullet train "NOZOMI" (Series 300) was developed aiming to connect Tokyo and Osaka within 2 and a half hours. For this purpose, the maximum speed was raised from 220km/h to 270km/h, and

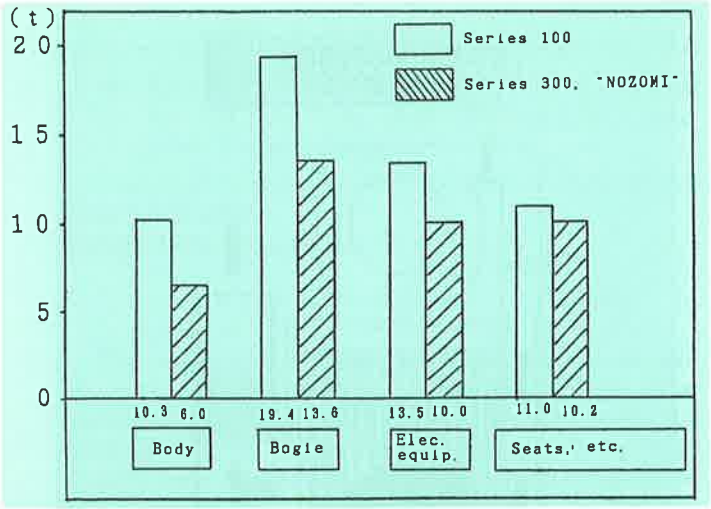


Fig. 1 Comparison of body weight (Empty loaded)

wayside environmental consideration was the first priority during the development. Total weight reduction technologies and thorough environmental measures, together with improved running stability in curving sections, raised its maximum speed by 50km/h, as a result, travel time was shortened successfully. R& D of a completely new traction system, braking system, running gear, and body structure realized the fully model change of the bullet train.

Features of the "NOZOMI" technology are described below.

2. Key technologies

2.1 Light weight technologies

The weight of the former types of bullet train was 60 ton (fully loaded) per car. By reviewing total weight of the car, "NOZOMI" weighed 45 ton (fully loaded), by 25% of weight reduction. (Figure 1)

For this weight reduction, aluminum alloy body, bolsterless bogie and resistorless regenerative brake system were adopted. In addition, optimizing weight balance measures, such as reviewing power unit composition of the trainset and placement of electric equipment, realized balanced axle load in a trainset as well as total weight reduction.

2.2 Light weight aluminum alloy body

The body of the bullet train has an air tightness structure to ease the effect of outside pressure variation of the car body, when the train goes through a tunnel. According to speed raising, variation of the outside pressure becomes larger. To deal with this problem and realize the weight reduction at the same time, optimized cross-sectional form of the beam, less molded long beam, and new aluminum alloy beam were applied to produce the light weight strong body. In addition, equipment on the roof, such as air-conditioner, was moved to the under floor, as a result, the center of gravity of the body was lowered and running stability in the high-speed region was improved.

2.3 Light weight bolsterless bogie

Former type of the bogie was equiped with a bolster between a bogie frame and a car body. "NOZOMI" adopted the bolsterless bogie first as a bullet train in Japan. To improve running stability in the high-speed region, bored axle and aluminum alloy parts were applied to reduce unsprung mass thoroughly. (Figure 2) The prototype of this bogie had been developed since Japan National Railway period. Central Japan Railway Company Central proceeded running test of the bolsterless bogie, together with the bench test up to 500km/h at the JR Railway Research Institute. As a result of these efforts, the bolsterless bogie was completed successfully.

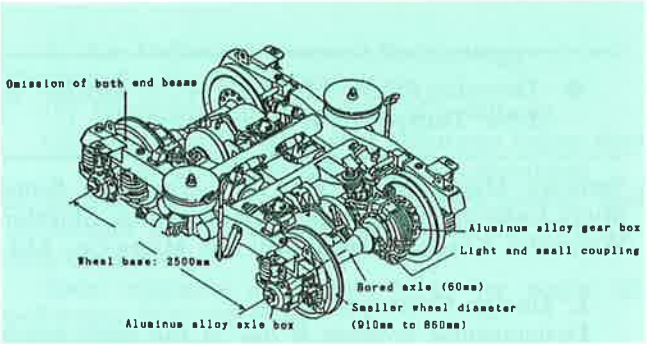


Fig. 2 Features of new Bogie

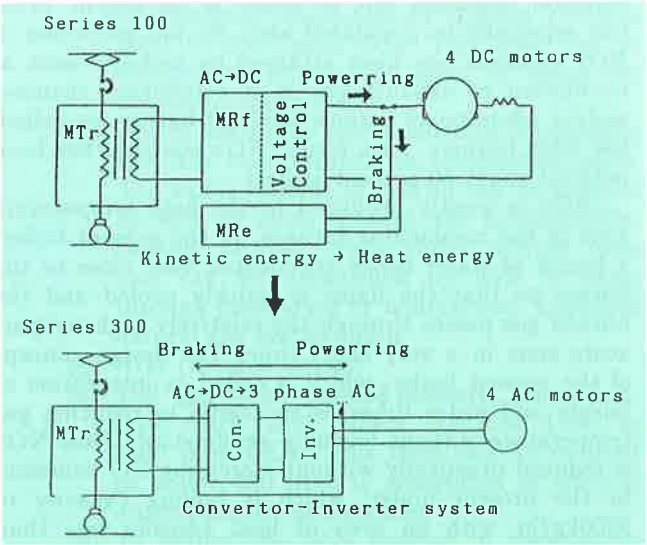


Fig. 3 Comparison of Traction system

< Notes >
MTr: Main Transformer
MRf: Main Rectifier
MRe: Main Resistor
Con.: Convertor
Inv. : Inverter

2.4 AC traction system

High power AC traction system with asynchronous traction motor, which is light and small and easy maintenance, were applied. Power electromic technologies, in particular power GTO and its control technology, contributed to this success. In braking, regenerative brake system returned generated power to the power line effectively. (Figure 3)

2.5 Environmental measures

Noise prevention has been attacked for years. In developing "NOZOMI", aerodynamic front shape, flash surface, and low body height are applied to prevent aerodynamic noise from the body and pantographs in the high-speed region. The number of pantograph has been reduced to relief noise, and so "NOZOMI" is equiped with 2 pantographs, while Series 100 has 3 pantographs. Light weight body contributed to reduce the vibration of ground and ground facilities, as a result, these realized the 270km/h operation of "NOZOMI".

3. Conclusion

The development of "NOZOMI" had solved environmental problems which was the most important to realize the speed raising. In the face of "NOZOMI" development, functional key technologies were reviewed totally and systematically. "NOZOMI" is the first train which adopted such innovative technologies as a bullet train, and it will be an original model for the future high-speed trains.

◆ Development of Aluminum-Titanium Nitride [(Al, Ti)N] Coated Carbide Endmills

Koichiro Wakihira, Takeo Komine, Masahiro Machida, Yasuyuki Yamada and Taiitsu Aoki, Kobe Steel, Ltd.

1. Introduction

For manufacturing of forming tools, such as dies and molds, improved productivity, higher accuracy and reduced production time are required. It has also become essential to machine forming tools at higher cutting speeds and to machine harder work-piece materials, such as heat-treated steels. In particular, since milling involves interrupted cutting, conventional TiN coated carbide endmill can not prevent microchipping and large wear at the cutting edge under such severe cutting conditions.

In order to improve milling performance, new composite (Al,Ti)N coatings have been developed for carbide endmills. The (Al,Ti)N coatings which are deposited by cathodic arc ion-plating exhibit higher film hardness, as well as higher oxidation resistance than conventional TiN. Consequently, these new hard-type profiles have resulted in improved chipping resistance.

The cutting performance of these newly developed endmills have been improved markedly. With these (Al,Ti)N coatings, the tool's life is two to five times longer than those of TiN coatings, and the cutting speeds can be high enough to machine hardened steels.

In addition to these new coatings, the newly developed profiles have enabled the machining of much harder (50 to 65 HRC) heat-treated die steels.

2. Technical Features

2.1 (Al,Ti)N Coating Technology

In the ternary system, the characteristics such as micro-hardness and oxidation temperature have been investigated. (Al,Ti)N coatings are stable below 840°C in the air (TiN coatings begin to oxidize at 620°C) and their hardness increases to 2,720 HV (1,930 HV for TiN).

In addition, for improving film adhesion to the carbide substrate, several types of fully-automatic control equipments for cathodic arc ion-plating have been developed for metal-ion bombardment.

2.2 New Profiles for Hard Workpieces

Two types are available: the sharp-edge type for general use, and the specially designed new type for hard workpiece materials. The new hard-type has a wide core, 6 teeth and chamfered negative edges to impove rigidity and edge-strength. The helix angle of this type has been increased to 45° to suppress increase in cutting force.

2.3 Cutting Performance

Figure 1 shows an example of cutting performance. When milling the heat-treated die steel SKD61, both uncoated and TiN coated carbide endmills generate a large wear in the early cutting stages. However, the (Al,Ti)N coated endmills produce only a small, constant wear and have life times more than five times longer than those of TiN coated endmills. In the case of carbon steel S50C, even with a high rigidity machining center, (Al,Ti)N coated endmills made it possible to increase the cutting speed, and to improve productivity.

The superb performance of the (Al,Ti)N coatings may be attributed to their higher oxidation resistance.

3. Advantages for the Manufacturing of Forming Tools

These endmills have resulted in numerous advantages. Since milling process could be done after heat treatment, it no longer requires electric-dischage

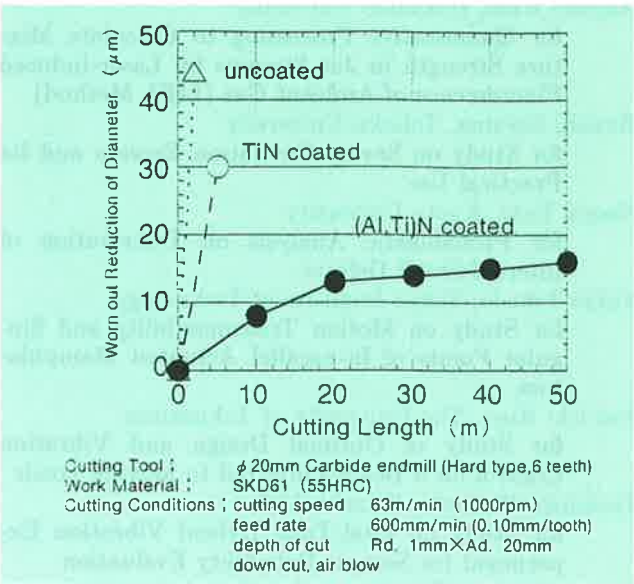


Fig. 1 Cutting performance of (Al, Ti)N and TiN Coated Carbide Endmills. (Hard type, work SKD61 55HRC)

machining and polishing (which was required in conventional finishing process), and production time and delivery time have been reduced by 30～50%.

4. Conclusion

The newly developed (Al,Ti)N cotead carbide endmills exhibit significant improvement in cutting performance, enabling machining of hardened die steels and thereby achieving higher speed milling. The (Al,Ti)N coatings provide superior characteristics, such as higher hardness and better oxidation-resistance. In addition, endmills with new profiles have been developed to improve chipping resistance,so that harder workpieces, up to 65 HRC, can be milled.

These endmills are able to improve the forming tool manufacturing process, as well as markedly increase cutting speed which will result in productivity increase and cost reduction.

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