This is an English Report on the Japanese powder metallurgy industries and our association's activities for those interested in the PM industries overseas. We would like to receive the same kind of news and data from foreign countries on their PM industries.
1. Production in Japan

(1) PM Products

Table 1 shows the production volume of PM products item by item. The total production volume in 2007 was 121,153 ton (metric ton), 4.0% increase over the previous year. In this report, we will describe about the production conditions of Machine parts and Bearings that are the component parts for automobile and other machines which show high productivity. Fig.1 shows the production volume change of Machine Parts and Bearings for the period from 1997 through 2007.

<table>
<thead>
<tr>
<th>Kind of Products</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>07/06(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearings</td>
<td>8,011</td>
<td>7,964</td>
<td>7,954</td>
<td>99.9</td>
</tr>
<tr>
<td>Machine Parts</td>
<td>102,503</td>
<td>106,103</td>
<td>110,665</td>
<td>104.3</td>
</tr>
<tr>
<td>Friction Materials</td>
<td>773</td>
<td>726</td>
<td>788</td>
<td>108.5</td>
</tr>
<tr>
<td>Electric Contacts</td>
<td>105</td>
<td>99</td>
<td>93</td>
<td>93.9</td>
</tr>
<tr>
<td>Miscellaneous*</td>
<td>1,343</td>
<td>1,555</td>
<td>1,653</td>
<td>106.3</td>
</tr>
<tr>
<td>Total</td>
<td>112,735</td>
<td>116,447</td>
<td>121,153</td>
<td>104.0</td>
</tr>
</tbody>
</table>

(Source: METI)

*Including Electric Collectors and Refractory metals, except Magnetic materials and Cemented carbides

![Fig.1 Production of Machine Parts and Bearings](image-url)
**1. Machine parts**

The production volume was 110,665 ton, 4.3% increase over the previous year showing the positive growth for consecutive 6 years and the record high volume for consecutive 5 years. This is because the economy in Japan has kept the strong trend thanks to the export of vehicles etc.

The quarterly trend over the same period of the previous year showed 3.4% increase for January through March period, 6.6% increase for April through June period, 1.9% increase for July through September period and 5.7% increase for October through December period. Production volume in each quarter exceeded that in the same period of previous year steadily.

The production amount, which is not shown in the table, was 135.0 billion yen that was 5.9% increase over the previous year.

The trend of production volume by user industry was as follows. (Table 2)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>07/06(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Vehicles</td>
<td>93,745</td>
<td>97,690</td>
<td>101,386</td>
<td>103.8</td>
</tr>
<tr>
<td>For Others</td>
<td>8,758</td>
<td>8,413</td>
<td>9,280</td>
<td>110.3</td>
</tr>
<tr>
<td>Total</td>
<td>102,503</td>
<td>106,103</td>
<td>110,666</td>
<td>104.3</td>
</tr>
</tbody>
</table>

(Source: METI)

The major part for vehicles in this table is for automobile usage which is the biggest user of sintered machine parts. The production volume was 101,386 ton that was 3.8% increase over the previous year making a new record for the consecutive 6 years. That is because of the production volume of automobile was 11,600,000 units that was 1.0% increase over the previous year. (according to the statistics of Japan Automobile Manufacturers Association, Inc.) As factors for it, we can point out that the growth of eco-friendly parts because of the increase of cars which are loaded variable valve timing system parts (VVT and VVC) and the fuel injection related parts of diesel engine showed big increase, and engine parts, transmission parts, shock absorber parts and electric power-steering parts etc. showed steady increase. The composition rate was 91.6% (92.1% in 2006) representing the continuous high dependence on automobile industry by PM industry.

The use of machine parts for other than vehicles was 9,280 ton, 10.3% increase over the previous year, this means the first increase for these 3 years. By the statistics of JPMA, the use for industrial machines showed 4.7% increase and the use for electric machines showed 16.7% increase. Both showed the positive growth. In the industrial machine sector, the use for construction machine parts and general-purpose engine parts were increased. In the electric machine sector, the parts for cellular phone was good condition, and the compressor parts for refrigerator and air-conditioner are increased in spots.

For your information, we will refer to the following two points respect of the data of sintered parts used for automobiles, the main user, like the last year.
1) Weight (unit consumption) for sintered parts used for one car
According to the figures in 2006, the weight of sintered parts used for one car was 8.6 kg in Japan (8.7 kg in 2005), 19.5 kg in the U.S. (19.8 kg in 2005) and 9.3 kg in Europe (8.7 kg in 2005). Compared with Japan and Europe, the unit consumption in the U.S is outstanding. This is mainly because in the U.S, the large parts like connecting rod and bearing cap are already changed to sintered parts from other production method but not yet in Japan. This suggests that PM industry in Japan will be expected to grow more.

2) Composition of PM machine parts broken down by applied parts of automobile
Fig.2 shows the composition rate of production volume of sintered machine parts applied to respective section of automobile in 2006 based on the demand structure survey by JPMA. This figure shows that 51.1% of total use is for engine parts (51.5% in 2005), 24.0% for drive train parts (24.5% in 2005) and 14.2% for chassis parts (14.0% in 2005). The production volume of engine parts which effects to environment and safety of automobile, showed the positive growth. This shows that the sintered machine parts are highly evaluated both in quality and reliability.

![Pie chart showing composition rate of production volume of sintered machine parts applied to respective section of automobile in 2006]

A: Engine 51.1%  B: Drive Train 24.0%
C: Chassis 14.2%  D: Electrical 5.0%
E: Body 1.3%  F: Fuel 1.4%
G: Others 2.4%

**Fig.2 Breakdown of Machine Parts for Automobile (2007)**

**Bearings**

The production volume of Bearings was 7,954 ton, almost same as the previous year (0.1% decrease). The quarterly trend over the same period of the previous year was 5.3% decrease for January through March, 0.2% increase for April through June, 1.7% increase for July through September and 3.7% increase for October through December. After the decrease for the first quarter, from the second quarter trend changed to positive. And finally, total showed the almost same as the previous year.

The production amount, which is not shown in table, was 15.8 billion yen that was 7.8% increase over the previous year. The complicated products that are required high reliability are increasing.

The trend of production volume by user industry was as follows (Table 3).
Table 3 Analysis of Demand for Bearings (Calendar Year) (Metric Tons)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>07/06(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Vehicles</td>
<td>4,247</td>
<td>4,371</td>
<td>4,620</td>
<td>105.7</td>
</tr>
<tr>
<td>For Others</td>
<td>3,764</td>
<td>3,592</td>
<td>3,335</td>
<td>92.8</td>
</tr>
<tr>
<td>Total</td>
<td>8,011</td>
<td>7,964</td>
<td>7,955</td>
<td>99.9</td>
</tr>
</tbody>
</table>

(Source: METI)

The major part of vehicles was for automobile usage. The production volume was 4,620 ton that was 5.7% increase over the previous year. This was continuous 4 years increase. Bearings for electric motors for miller and door lock related to automobile were good condition. The composition rate was 58.1% that was 3.1% increase over the previous year.

The production volume for other use was 3,335 ton that was 7.2% decrease over the previous year. This means the consecutive 3 years decrease.

According to JPMA statistics, the use for industrial machines was 22.5% decrease over the previous year and the use for electrical machines was 7.7% decrease over the previous year. The use for industrial machines showed decrease because of production transfer to overseas. The use for electric machines showed some increase for bearings for spindle motor of light media, but overall same as industrial machines, because of production transfer to overseas, the production amount was decreased.

(2) Powder Shipment

Table 4 shows Shipment of Metal Powders.

The shipment of iron powder in 2007 was 228,624 ton that was 2.0% increase over the previous year. Among them, the domestic shipment for PM use was 131,869 ton that was 3.9% increase over the previous year.

The shipment of copper powder in 2007 was 8,939 ton that was 6.8% increase over the previous year. Among them, the shipment for PM use was 6,691 ton that was 6.2% increase over the previous year.

The domestic shipment of stainless steel powder for PM use was increasing year by year until 2004 more than 10% increase every year. (2,680 ton in 2001, 2,949 ton in 2002, 3,263 ton in 2003, 4,090 ton in 2004) But 4,718 ton in 2005 was only 3.6% increase over the previous year, then 4,104 ton in 2006 was 3.2% decrease over the previous year. The domestic shipment of powder for MIM was 346 ton in 2004, 420 ton in 2005 and 507 ton in 2006 that means 20.7% increase over the previous year. The shipment volume in 2007 is not available yet.
Table 4 Shipments of Metal Powders (Calendar Year)
(Metric Tons)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>07/06(%)</th>
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<tbody>
<tr>
<td>Iron Powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For PM Use</td>
<td>123,104</td>
<td>126,927</td>
<td>131,869</td>
<td>103.9</td>
</tr>
<tr>
<td>For Other Use</td>
<td>58,314</td>
<td>66,994</td>
<td>62,081</td>
<td>92.7</td>
</tr>
<tr>
<td>Export</td>
<td>29,584</td>
<td>30,188</td>
<td>34,674</td>
<td>114.9</td>
</tr>
<tr>
<td>Total</td>
<td>211,002</td>
<td>224,109</td>
<td>228,624</td>
<td>102.0</td>
</tr>
</tbody>
</table>

(Metric Tons)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>07/06(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For PM Use</td>
<td>6,305</td>
<td>6,298</td>
<td>6,691</td>
<td>106.2</td>
</tr>
<tr>
<td>For Other Use</td>
<td>1,326</td>
<td>1,362</td>
<td>1,465</td>
<td>107.6</td>
</tr>
<tr>
<td>Export</td>
<td>624</td>
<td>710</td>
<td>784</td>
<td>110.4</td>
</tr>
<tr>
<td>Total</td>
<td>8,255</td>
<td>8,370</td>
<td>8,939</td>
<td>106.8</td>
</tr>
</tbody>
</table>

(Source: JPMA)
2. Japan Powder Metallurgy Association

(1) Members as at the end of March, 2007

Present Member Constitution

Total members: 80 Companies & 2 Associations

- Regular member
  - Product manufacturers: 25 Companies
  - Powder manufacturers: 15 Companies
  - Equipment manufacturers: 7 Companies

- Special member: 1 Companies
- Associate member
  - Domestic: 26 Companies
  - Overseas: 6 Companies
- Complimentary member: 2 Associations

(2) Organization of JPMA

1) General meeting was held 2 times.
2) Board meeting was held 1 time.
3) Permanent Board meeting was held 5 times.
4) Committees were held 58 times.
(3) Board Members (at the end of March, 2008)

**President:**
Mr. Isamu Kikuchi (Chairman, Porite Corporation)

**Permanent Board Members:**
Mr. Takayoshi Sugiyama (Corporate Advisor, Sumitomo Electric Industries, Ltd.)
Mr. Hiroshi Fujinami (President, Hitachi Powdered Metals Co., Ltd.)
Mr. Yutaka Mizuno (President, Fine Sinter Co., Ltd.)
Mr. Masafumi Koga (Director, Mitsubishi Materials PMG Corporation.)
Mr. Naofumi Ohde (Vice President, JFE Steel Corporation.)

**Board Members:**
Mr. Masakazu Achikita (General Manager of Sagami Plant,
Sumitomo Metal Mining Co., Ltd.)
Dr. Shiro Nakazawa (General Manager, Friction Material Dept.,
Materials & Components Div., Tungaloy Corporation)
Mr. Ryoji Murota (Managing Executive Officer, Friction Materials Dept.,
Tokai Carbon Co., Ltd.)
Mr. Kiyotaka Matsukawa (President, Nippon Kagaku Yakin Co., Ltd.)
Mr. Minoru Nishimura (President, Fukuisinter Co., Ltd.)
Mr. Shinsuke Asai (Senior General Manager, Steel Powder Division, Kobe Steel, Ltd.)
Mr. Naruhiito Shimizu (General Manager, Metal Powder Division, Daido Steel Co., Ltd.)
Mr. Kiyotaka Notomi (Director General Manager, Advanced Fine Materials Business
Unit, Dowa Electronics Materials Co., Ltd.)
Mr. Hideaki Fukui (President, Nippon Atomized Metal Powders Corporation)
Mr. Yasuhiko Hayashi (President, Fukuda Metal Foil & Powder Co., Ltd.)
Mr. Carl-Gustav Eklund (President, Höganäs Japan K.K.)
Mr. Junichirou Tanaka (Executive General Manager of
Engineered Metal Powder Division in Engineered Materials Sector,
Mitsui Mining & Smelting Co., Ltd.)
Mr. Akira Kawaguchi (General Manager, Tamagawa Machinery Division,
Mitsubishi Materials Techno Corporation)

**Executive Director:**
Mr. Tohru Sakurai

**Auditor:**
Mr. Kazuhide Kikuchi (General Manager, Friction Materials Dept.
Friction Materials Div., Tokai Carbon Co., Ltd.)
Mr. Hideo Kato (Managing Director, Fukuda Metal Foil & Powder Co., Ltd.)

(4) JPMA Secretariat Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tohru Sakurai (Mr.)</td>
<td>(Executive Director)</td>
</tr>
<tr>
<td>Hiroaki Itabashi (Mr.)</td>
<td>(Secretary General)</td>
</tr>
<tr>
<td>Kazunori Arai (Mr.)</td>
<td>(Staff from January, 2008)</td>
</tr>
<tr>
<td>Yusuke Watanuki (Mr.)</td>
<td>(Staff from January, 2008)</td>
</tr>
<tr>
<td>Emi Sasaki (Ms.)</td>
<td>(Staff)</td>
</tr>
<tr>
<td>Mikie Kuwabara (Ms.)</td>
<td>(Staff)</td>
</tr>
</tbody>
</table>
(5) Activities of Committees

The main activities of various committees in 2007 are as follows.

1) Selection Committee for Award Prize
   *Selection of JPMA Award (Development Prize)

2) Committee for Administration
   *Planning and operating of the PR meeting “JPMA Awards Special Session” at JSPM Spring Meeting in June
   *Publication of the report “Analysis of investigation results of sintered parts demand structure 2006” in June
   *Edition of the brochure “2006 JPMA Annual Report (English)” in April
   *Planning and operating of “the 5th Research Promotion Program”
   *Planning and operating of “PM Information Exchange Meeting” among PM related companies
   *Planning and operating of “the Technical Information Meeting”
   *Planning of establishment for the Asian PM Association
   *Planning and operating of “the 12th Case Studies on New Products Development Seminar”
   *Planning and operating of the “Case Studies on Improving Production Efficiency Meeting” as the 25th memorial meeting
   *Follow-up of the action plan of “the Vision for PM Industry”
   *Planning of renewal for JPMA Website
   *Making of the education institution tool
   *Publication of monthly JPMA News “Funmatsu Yakin” (No.331-342)

3) Technical Committee for Sintered Parts
   *Discussion of the matter for ISO/TC 119/SC3 and SC5
   *Cooperation of “the 5th Research Promotion Program”
   *Information Exchange Program with Technical Committee for Metal Powders and Press Machine
   *Discussion of the test method of fatigue strength
   *Establishment of Sectional Committee for Sintered Bearings

4) Technical Committee for Sintered Friction Materials
   *Inserting an environmental activities of member companies in JPMA Website

5) Technical Committee for Press Machine
   *Information Exchange Program with Technical Committee for Sintered Parts and Metal Powders

6) Technical Committee for Metal Powders
   *Discussion of the point to notice for powder handling
   *Study on "New Evaluation Items for Powder Characteristics"
   *Discussion of the matter for ISO/TC 119/SC2
   *Information exchange about "REACH"
   *Introduction of topics about "Metal Powder" by Committee members and exchange of views
   *Information Exchange Program with Technical Committee for Sintered Parts and Press
7) **Committee for Metal Injection Molding**
*Planning and operating of “the 6th MIM Lecture Meeting for Users” in June*
*Discussion of the standard “MIM Materials Specifications” (ISO Draft)*
*Exhibiting to the Mechanical Components & Materials Technology Expo 2007*
*Planning of "New Evaluation Items for Characteristics of MIM Materials"*
*Investigation of the Japanese MIM market*

8) **Marketing Committee**
*Edition of “the future PM market demand”*
*Introduction of the topics of Committee members' company by Committee members and exchange of views*
*Introduction of "overseas information" by Committee members*

9) **Committee for International Standardizations**
*Participating to 2007 ISO/TC119 Conference at Toulouse, France*
*Planning to participate in 2008 ISO/TC119 Conference in USA*
*Discussion of related matters for TC119, SC2, SC3 and SC5*
*Discussion of the future GPMD program*

10) **Committee for Environment**
*Discussion of environmental matters for PM industries*

(6) **Events**

1) **Gathering of New Year Greeting and Ceremony of Awarding Various Honors 2006 of the Association**
*(January 10, at Tokyo Garden Palace)*

   Participants: 247.

2) **The 3rd PM Information Exchange Meeting (February 15, at Kikai Shinko Bldg.)**
   This meeting was opened for members and non-members for information exchange of PM related subjects.
   Participants: 55

3) **The 14th Technical Information Meeting (March 15, at Kikai Shinko Bldg.)**
   This meeting was held in order to promote cooperation of industrial, administrative and academic sectors.
   Presentation: 4 research reports by winners of the 4th Research Promotion Program and the latest governmental measure by METI
   Participants: 52

4) **2007 General Assembly (May 16, at Tokyo Garden Palace)**
   The 2006 Report of Activities and Settlement of Accounts were approved.
   The 2007 Working Plans and Budget of JPMA were approved.
5) JPMA Award Special Session at the JSPM Spring Lecture Meeting
(June 5, at Waseda University)

This special session was opened for end-users and researchers. This session has been held with the help of the JSPM since 1995 to strengthen the cooperation between the JPMA and the JSPM.

Presentation: 10 new products (2006 prize-winners)
Participants: Over 200

6) The 6th MIM Seminar for Users (June 28, at Tokyo Fashion Town Bldg.)

This seminar was opened for end-users for promotion of MIM technology and products.
Participants: 90

Same time, 8 MIM manufacturing member companies exhibited at the 11th Mechanical Components & Materials Technology EXPO.

7) The Joint Meeting for Information Exchange by Three Committees
(October 12, at Tekko Kaikan)

This meeting was planned by Technical Committee for Sintered Parts, Technical Committee for Metal Powders, and Technical Committee for Press Machine.
Participants: 22

8) The 12th Case Studies on New Products Development Seminar
(November 7, at Employees’ Aitetsuren Employees’ Pension Fund Bldg.)

This seminar was opened for end-users for promotion of PM parts.
Presentation: 7 case studies by member companies and 10 VA cases by the Technical Committee for Machine Parts
Participants: 134
9) The 5th Research Promotion Program 
(November 19, at Kyoto Institute of 
Technology)
This program aimed at promotion of 
research of ferrous PM at universities 
and research institutes.
17 Research Reports were presented 
with posters, and 5 Reports were 
elected for encouragement prize.

10) The 26th Case Studies on Improving Production Efficiency Meeting and The 12th 
Metal Powder and Equipment PR Meeting (November 21, at Kikai Shinko Bldg.)
Presentations: 9 (5 case studies and 4 PR reports), Participants: 97
*Case Studies on Improving Production Efficiency
This is the annual meeting for members’ plant workers and engineers. The results of 
work on process efficiency using various ideas and methods were reported, and 
discussion was held to assist in the further development of process engineering.
* Metal Powder and Equipment PR Meeting
Since 1989, this meeting has been held annually to address the sintered product 
manufacturers from Powder and Equipment manufactures.

(7) International Communications

1) Asian PM Association Meeting
This meeting was held on April 18, at Tokyo Garden Palace.
Agreement of the five basic points for establishment of APMA (Asian Powder Metallurgy 
Association)
Participants: 23 (KPMI, CPMUA, PMA of ROC, JSPM, JPMA)

2) General Assembly, PMA of ROC
This meeting was held on August 24 and 25, at Shandori Chinatrust Hotel, Taiwan.
Mr. Kikuchi, President of JPMA, participated in this meeting and demanded the 
cooperation in PM2012 Japan.
3) ISO/TC119 (Powder Metallurgy)
   This conference was held on October 18 and 19 at Toulouse, France.
   5 representatives of JPMA took part in the conference for ISO/TC119, SC2, SC3 and SC5.

4) Preparation Meeting for Organizing Asian PM Association
   This meeting was held on October 31, at Tokyo Garden Palace.
   Agenda: 1. The host country for PM2012 World Congress, 2. Establishment of APMA
   Participants: 16 (KPMI, PMA of ROC, JSPM, JPMA)

5) Annual Report (English)
   Issued JPMA 2006 Report (English) in April and distributed it to the overseas PM related
   associations and persons.
   Contents: Statistics, JPMA Activities, etc.

6) JPMA Statistics
   PM Statistics were exchanged each other, MPIF, EPMA and Asian PM related
   Associations.

(8) Awards

1) Association Prize
   a) Personal Prize (for distinctive merit to PM industry)
      No Entry
   b) Development Prize (see page 15-22, abstracts and photos)

2) Prize for Distinguish Service on the Committee Activities
   *Ms. Seiji Ishihara (Former Mitsubishi Materials Techno Corporation)

3) Recognition of Superior Employees
   Recognition of superior employees is a system that recognizes employees who have been
   engaging in manufacturing products related to powder metallurgy. The system was started
   in 1995.
   2007 prizewinner numbered 20 persons (15 member companies).
(9) Publications

1) PM GUIDE BOOK 2004 “PM Parts”
   This is the revised edition.
   Published by the Committee for Administration (98 pages/Japanese)

2) Summary of the 12th Case Studies on New Products Development
   This booklet was published as the textbook for the 12th Case Studies on New Products
   Development (76 pages/Japanese).
   Published by the Committee for Administration

3) The 28th Investigation Collection Results of Sintered Parts Demand Structure
   Achievements in 2005 were published. In order to seek for the trend in developing sintered
   parts market in future, perform it every year.
   Published by the Committee for Administration (13 pages/Japanese)

4) JPMA Report, 2006
   This report is recording the activities of the JPMA and the present situation of PM industry
   in Japan.
   44 pages for Japanese version (including advertisements), 20 pages for English version
   Published by the Committee for Administration

5) JPMA News “Powder Metallurgy (Funmatsu Yakin)”
   12 publications, monthly, Total 126 pages (Japanese)

2012 POWDER METALLURGY WORLD CONGRESS

PM2012 YOKOHAMA, JAPAN
October 14 (Sun.) – 18 (Thu.), 2012
Japan Powder Metallurgy Association (JPMA)
Japan Society of Powder and Powder Metallurgy (JSPM)

PACIFICO YOKOHAMA
A. NEW DESIGN

A-1 Development of a 4WD Part with High Density & Complicated Shape

Torque of an input shaft is transferred to an output shaft by inserting an output gear shaft into an internal spline of a planetary career in a 4WD transfer unit. Size of an output shaft is different depend on maximum output torque of unit. Since size of low torque output shaft is much smaller than that of high torque unit, a career of low torque unit with direct connecting to an output shaft needs to have complicated shape and is difficult to make. This part is developed for connecting a career designed similar in high torque unit to low torque output gear shaft.

This part has outside spline on the flange and this spline is inserted into internal spline of a career and the flange has nine holes for weight reduction located near the boss. Boss has an internal spline and an output gear shaft is inserted into this spline for torque transfer to an output shaft. Internal spline has back taper for compaction to have smooth insertion of this shaft. Shape of this part is complicated for these functions and original shape is designed for cold forging.

Discussion with customer for design in could make it possible for P/M production and realized 6% weight reduction of original forging design.

Compaction with machining-less process is realized by designing compacting tool structure and improved ejection process. Internal spline of the boss requires impact strength and hertzian fatigue strength. These strength are achieved by density 7.0g/cm³ Min. and induction hardening. Density of compaction process is 6.9g/cm³ because of the position of the internal spline. Back taper and density more than 7.0g/cm³ are achieved by sizing process and sizing process and material shape are optimized by FEM analyzation.

As a conclusion this P/M part realized common use of input side design for high and low output shaft with weight and cost reduction and customer’s satisfaction.

A-2 Development of Highly Efficient P/M Internal Gear Pump Rotors with Newly Developed Teeth Profile

These products are P/M internal gear pump rotors which are used for automotive oil pumps for engines, Automatic Transmissions and Continuously Variable Transmissions and fuel feed pumps of diesel engines.

In spite of a recent strong demand for low fuel consumption of automobiles, energy loss of oil pumps is so large that about 10% of energy loss is that of engine oil pumps, and about 20-30% is that of automatic transmission oil pumps. Thus, customer’s demand for highly efficient oil pumps to improve fuel consumption is very strong.
Energy loss of geared oil pumps depends on friction loss which is influenced by the side face of rotors and outside surface of an outer rotor. Therefore, in order to reduce its loss, new teeth profiles are developed to increase the theoretical discharge volume from the same outside diameter of an outer rotor.

The conventional teeth profile of inner rotor has one base circle, and displacement distance which relates to discharge volume is decided by the base circle and the number of teeth. As the theoretical discharge volume depends on displacement distance and one base circle, newly developed inner rotor’s profile has two base circles to enlarge displacement distance, and profile between these circles are involute curve. Outer rotor profile is generated from inner rotor profile. Optimization of design parameters is done by theoretical calculation and evaluating sample test. As mentioned above, the new teeth profile internal gear rotors which have large displacement distance are established.

As a result, theoretical discharge volume of the newly developed internal gear rotors is 12% higher than that of the same size conventional rotors (actual discharge volume is about 10% higher.) Consequently as long as required actual discharge volume stays constant, downsize of the rotor and reduction of the energy loss are realized. Moreover, this downsizing enabled the drive torque of a newly developed oil pump to reduce about 10% of conventional one.

A-3 Development of PM Sprocket combined with Housing Body for Electro Magnetic Actuated Variable-Cam-Timing Systems

Variable Cam Timing (VCT) System is used for almost all new model vehicles, and generally actuated by oil hydraulic system. However, recently, according to market demands such as high engine performance, low fuel consumption, and low emission, Electro Magnetic actuated VCT is newly developed.

This PM Sprocket consists of timing sprocket and housing body. Since this new part has such a complicated shape to satisfy its functions, the sprocket and housing have to be made separately by conventional process and joined by screw bolts. This newly developed housing sprocket is compacted in one compacting stroke, in result; this assembly process in customer was omitted. CNC Multi-level compacting press is developed for making complicated shapes and required dimensional tolerances are achieved without sizing operation.
A-4 Development of Sintered Parts Possessing Many Teeth for Steering Tilt

Mitsubishi Materials PMG Corporation

Sintered parts are developed for steering tilt of automobile, consist of Tooth Lock A, Cam A and Cam B.

These products are developed to increase the expansion and contraction holding power due to the connection mechanism of the gear which satisfies collision safety level, in order to develop the new steering column.

This system consist of Tooth Lock A which possesses 22 teeth and Cam A whose surface form differs and surface has unevenness. Tooth Lock A was required for form of tooth, high strength and flatness. Cam A was required for unevenness accuracy.

Form and flatness guaranty for Tooth Lock were achieved by optimization of die form and rationalization of operation. And, the improvement of powder filling up method and the adoption of the quenching private jig is conducted. Level precision guaranty and density equalization of Cam A were achieved by die constitution such as unification of upper punch and the rationalization of operation.

As a result, the mass production technology of high accuracy and the high intensity part were achieved. Sintered part for steering wheel tilt where reliability is strongly required was actualized.

A-5 Development of the Overload Clutch Parts for Hammer Drill

Porite Corporation

This product is a guide plate of overload clutch for hammer drill.

Such a product was complex shape, so it was produced by metal injection molding (MIM). But owing to the cost merit, we considered producing it by powder metallurgy.

This product requires that size accuracy of the groove to control idle torque during the overload, height accuracy of the groove to keep spring and roller, the equal strength as the MIM product.

The same shape as the MIM product is too complex to produce with high accuracy by powder metallurgy. Therefore, we reviewed the shape of this product in consideration for requirement specifications with user since the development phase.

We improved the tooling structure and all the groove were pressed by the same punch for the size accuracy of the groove. The number of the groove was changed from 8 to 10 for dispersion of the groove load. Keyway was added to the inside for torque transmission. In addition, we added machining process to keep height accuracy of the groove.

As a result, we’ve realized that complex shape such the MIM product has produced by powder metallurgy and so we cut down the cost of this product by 40%.
A-6 Development of the Long Thin-wall Helical Gear Parts with Non-regular Shape on the Inside

This product is a planet gear for the gear box to revolve the washing drum of automatic washing machine. It has involute serration on the inside and helical gear on the outside.

Such a product was produced by broach processing for the inside and by gear cutting for the outside in the past. But this product can be produced by powder metallurgy without post-processing now.

Because we considered it with user and have completed the suitable shape for powder metallurgy.

This product requires quiet operation. Therefore, in order to get product accuracy, we reviewed tooling structure, material and press work. And we’ve realized that density distribution between ups and downs is 0.03〜0.04Mg/m³, runout accuracy is under 0.025mm and helix deviations is the JIS 2nd class.

In addition, this product also requires that tolerance width to press in resin bush is 0.08. We process sizing for this product to satisfy it.

As a result, long thin-wall complex shape like this product has come to be manufacturable. We contributed lightening, low cost and improvement in the freedom of user design.

B. NEW MATERIALS

B-1 Powder Magnetic Core Materials with Low Iron Losses Equivalent to Steel Plates

Iron losses of conventional powder magnetic cores of insulated iron powder with phosphate coating are large at low frequencies. This material have achieved low iron losses with distinction of the conventional powder core by development of new insulation material and coating technology, they are used for magnetic sensors.

This development has four essentials : (1) Adoption of gaseous reaction method possible to form uniform insulation film on the atomized iron powder with irregular surface because of obtaining thin films with no prevention against iron powder compressibility, (2) Film structure having compositional gradient continuous to iron oxide on the powder surface because of securing adhesion to the powder particles, (3) Selection of film materials with thermal expansivity similar to iron substrate to prevent the occurrence of crack by heat cycle, (4) Selection of more thermostable materials than iron oxide of powder surface to prevent the composition and structure change above 600°C.

Standing on these four development essentials, we noted that the vapor pressure of magnesium
metal is high at relative low temperature, so that we adopted Mg-Fe-O heat-resisting insulation coating made by magnesium vaporization. We settled the condition of the film formation and developed the binder for this insulation coating.

Consequently, the powder magnetic cores of this developed insulation coating powders have lower iron losses than the steel plate at every frequency so that the cores are been able to use at wide frequency range.

B-2 High Wear Resistant Valve Seat Material for CNG Engines

Hitachi Powdered Metals Co., Ltd.

This valve seat material has very high wear resistance; it has been utilized for valve seats in CNG engines. The material makeup is 50% hard particle (Co-50-9Cr-3Si), which was recently developed; dispersed into a 5% Mo Steel matrix, with precipitated CrS solid lubricant.

The study of alternative fuels for vehicles has been progressing recently, due to the rising price of gasoline and environmental concerns. This surge in alternative fuels has increased the demand for CNG engines; these engines are interpreted as clean engine because it can achieve reducing the amount of CO\textsubscript{2} and other harmful gases in the emissions.

However CNG engines require valve seat materials to have very high wear resistance, this is due to the environment being drier than gasoline or diesel engines. In these dry conditions, metal on metal contact occurs between the valve seat and valve, leading to increased adhesive wear.

For the new valve seat material the 5% Mo Steel base matrix was chosen due to its superior hardness from room temperature to high temperature, which prevents adhesive wear. Additionally, the 50% high performance hard particle is dispersed in the matrix to improve overall wear resistance. Also the precipitation of the CrS solid lubricant into the matrix aids the wear resistance through lubricity.

This new material shows the highest level of wear resistance in the world, and it can be adopted for the latest CNG engines; which are prone to high wear due to insufficient wear resistance of current materials.

This material was introduced into the market in 2006, and it has contributed to both an increase in engine durability and a decrease in maintenance frequency for engine manufacturers.

B-3 High Performance of Sinter Forged Aluminum Alloy

Hitachi Powdered Metals Co., Ltd.

This material is Al-Zn-Mg-Cu alloy that gives improve the tensile strength. It is applied to connecting rods of a general-purpose engine by the sinter-forged method.

Generally sintered aluminum parts that made by extrusion method or sinter-forging method that using rapidly solidified Al-Si alloy powder have been produced. However, the extrusion material had the problem of low yields and long processes. On the other hand the sinter-forged material had insufficient in tensile strength.
The other hand, a new original pre-mix powder was developed. This aimed at the substitution of connecting rods made of the aluminum-forged alloy that had already been put to practical use along with the development of a new engine. This powder is based on general alloy and have been improved for optimization about mixing methods, the composition, the combination of the powders aiming to control the element segregation in compacting and the element change of sintering. High strength is achieved in the Al-Zn-Mg material of the base, and wear resistance is achieved by adding CrB hard particle and the improvement of plasticity is achieved by adding the pure aluminum powder.

As a result, the product has improved lowering the cost simultaneously with the fatigue strength of 18% or more compared with a general aluminum-forged material. And 20% higher engine out put has got.

**B-4 Oil-impregnated Sintered Bearing for EGR used under High Temperature Corrosion Environment**

Mitsubishi Materials PMG Corporation

This material is Cu-Ni-Sn-C-P system with the improved corrosion resistance, heatproof, and abrasion resistance by adding Ni and P compared with the current materials, and it is applied as a bearing of the flow regulating valve of the gas in the EGR unit with which the usage environment is severe.

EGR comes to be adopted from an environmental side widely as part of the exhaust gas measures of the engine, and the demands from a high power and low-fuel consumption of the engine to a light compactification of the system are strong. Therefore, exhaust gas pressure and an environmental temperature of the system increase, and high abrasion resistance and corrosion control against the high temperature exhaust gas are required for the bearings with this usage.

Free graphite is distributed to solid solution blanks of Cu-Ni-Sn-P system as a solid lubricant, and corrosion control by Ni, strength improvement by P, and securement of abrasion resistance aimed at by developing impregnated oil that has the excellent high temperature lubricity are performed for a realization of the application to a severe condition in this development.

As a result, the oil-impregnated sintered bearing with the characteristics surpassing Cu-Sn-C system dry bearing for a conventional high temperature sliding was achieved, and substituting for expensive Carbon Bush requiring the machining for the accuracy securing became possible.
D. NEW POWDERS

D-1 Mo Hybrid-alloyed Steel Powder to Improve Fatigue Strength of Sintered Parts

JFE Steel Corporation / Toyota Motor Corporation / Fine Sinter Co., Ltd.

This featured alloyed steel powder gives sintered parts with improved fatigue strength by a conventional belt furnace sintering at a temperature of 1200 °C or less.

To obtain high fatigue strength of sintered parts, it is effective to decrease the amount and size of pores, which act as causes of fatigue crack initiation and propagation. Double-pressing and double-sintering method or high temperature sintering method has been conventionally applied for this purpose. However, the productivities of these methods have been lower than that of the belt furnace sintering, resulting in high production costs.

This developed powder gives a higher green density due to its lower Mo content of a prealloyed steel powder. At the same time, Mo-rich regions bonded on the surface of the powder particle exist as the alpha-iron phase during sintering and promote sintering efficiently.

A warm compacted, mesh-belt sintered and CQT treated specimen shows a higher fatigue strength than that made of the conventional Mo prealloyed steel powder through the same process. This is also the same as or more than that of a high temperature sintered specimen made of the conventional diffusion-alloyed steel powder.

A sintered parts manufacturer has already been applying this developed powder as a raw material of a high strength part for automotive engines with advantages of sintering cost, productivity improvement and enhanced flexibility in manufacturing process. This powder also gives an advantage over the conventional diffusion-alloyed steel powder in terms of raw material cost reduction.

F. EFFORT PRIZE

F-1 Sintering of Low Cost Variable Cam Timing Rotor by means of Machining at Green Stage

Fine Sinter Co., Ltd.

This product is a rotor of hydraulic actuator for automotive engine variable cam timing system.

For sintering of the actuator, a rotor has following angle oil path slits and a sprocket has proceeding angle oil path slits. A design that each of whose oil paths can be functioned without additional machining is required at assembly process for cost performance. Recently, with trend toward compact system, formation of not only following angle oil path but also proceeding oil path for the rotor is required.

In this product, the design of oil path is optimized and the following angle path side and the proceeding angle side totaling to 7 oil paths are formed with green machining and compacting as
a concurrent manufacturing line.

As a result, in comparison with machining as sintered, cutting speed became approximately 5 times faster and machining expense was 60% reduced.

In this green machining, prevention from burr occurrence and invasion of foreign materials such as swarfs are important points. However, selection of cutting tools that has less burr occurrence or has less its detachment and collection of swarfs with air blow to cutting portion are carried out, a machining technique that controls remained foreign materials after sintering to be under standard level is ensured and mass production is realized.

**F-2 Low Cost Sintered Oil Impregnated Bearing with Superior Low and High Temperature Properties for In-car Motor**

Porite Corporation

A Fe-Cu-Sn-Zn-C type material with lower amounts of non-ferrous constituents compared to presently available copper based materials was developed. By using optimum impregnated oil with this material, similar or better properties compared to conventional materials were realized at a lower cost. This material is used for in-car motors due to its high reliability over a wide temperature range.

A 43% reduction in the raw material cost was achieved by using this material. Due to the finer air pockets of this raw material, the permeability of the bearing was improved by 20% resulting in augmentation of the oil film formation and lowering of the friction coefficient. Moreover, the oxide film formation due to addition of Zinc improved the corrosion resistance. In addition, a reduction in the formation of hard ferrous impurities to 1/3 improved the sliding contact properties with respect to the shaft.

From the results it can be said that, compared to the present use of ball bearings and separate sintered bearings for low and high temperature applications respectively, this research makes it possible to use a single material in oil impregnated bearings under various conditions.
ANNEX (2): PM PRODUCTION IN ASIA

1. PM Production

<table>
<thead>
<tr>
<th>AREA</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>07/06(%)</th>
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<tbody>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron-base</td>
<td>107,100</td>
<td>110,500</td>
<td>115,180</td>
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<tr>
<td>Copper-base</td>
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<td>3,430</td>
<td>3,440</td>
<td>100.3</td>
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<tr>
<td>Total</td>
<td>110,550</td>
<td>113,930</td>
<td>118,620</td>
<td>104.1</td>
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<tr>
<td>China</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron-base</td>
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<td>73,586</td>
<td>91,707</td>
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<tr>
<td>Copper-base</td>
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<td>4,444</td>
<td>5,838</td>
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<td>Total</td>
<td>67,917</td>
<td>78,030</td>
<td>97,545</td>
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<tr>
<td>Korea</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>*Iron-base</td>
<td>43,475</td>
<td>46,507</td>
<td>46,743</td>
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<tr>
<td>Copper-base</td>
<td>2,152</td>
<td>1,368</td>
<td>880</td>
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<tr>
<td>Total</td>
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<td>47,875</td>
<td>47,623</td>
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<td></td>
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<tr>
<td>Iron-base</td>
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<td>22,000</td>
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<td>1,900</td>
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<td>24,900</td>
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</tr>
<tr>
<td>India</td>
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<td></td>
</tr>
<tr>
<td>Iron-base</td>
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<td>21,000</td>
<td>22,000</td>
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<td>Copper-base</td>
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<td>10,210</td>
<td>28,000</td>
<td>31,000</td>
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<tr>
<td>Malaysia</td>
<td></td>
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<td></td>
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<tr>
<td>Iron-base</td>
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<td>6,556</td>
<td>6,668</td>
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<tr>
<td>Copper-base</td>
<td>137</td>
<td>126</td>
<td>158</td>
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<td>Total</td>
<td>6,480</td>
<td>6,682</td>
<td>6,826</td>
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<td>Singapore</td>
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<td></td>
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<tr>
<td>Iron-base</td>
<td>883</td>
<td>931</td>
<td>1,037</td>
<td>111.4</td>
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<tr>
<td>Copper-base</td>
<td>524</td>
<td>604</td>
<td>658</td>
<td>108.9</td>
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<tr>
<td>Total</td>
<td>1,407</td>
<td>1,535</td>
<td>1,695</td>
<td>110.4</td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron-base</td>
<td>7,702</td>
<td>7,706</td>
<td>8,673</td>
<td>112.5</td>
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<tr>
<td>Copper-base</td>
<td>36</td>
<td>60</td>
<td>44</td>
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<td>7,738</td>
<td>7,766</td>
<td>8,717</td>
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<td>Total</td>
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<td>288,786</td>
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<tr>
<td>Copper-base</td>
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<td>21,918</td>
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<td>Total</td>
<td>274,929</td>
<td>307,618</td>
<td>336,926</td>
<td>109.5</td>
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</table>

*Included “Others”
# 2. Application Field Ratio of PM Production (2007) (%)

<table>
<thead>
<tr>
<th>AREA</th>
<th>For Transportation Machines</th>
<th>For Industrial Machines</th>
<th>For Electrical Machines</th>
<th>For Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>91</td>
<td>5</td>
<td>3</td>
<td>1</td>
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<tr>
<td>China</td>
<td>58</td>
<td>1</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>Korea</td>
<td>87</td>
<td>0</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Taiwan</td>
<td>30</td>
<td>40</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>India*</td>
<td>78</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Malaysia</td>
<td>47</td>
<td>1</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Singapore</td>
<td>26</td>
<td>6</td>
<td>68</td>
<td>0</td>
</tr>
<tr>
<td>Thailand</td>
<td>87</td>
<td>5</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

*estimate

**Cooperated Organizations:**

China:  Powder Metallurgy Association of China General Machine Components Industry Association (PMA of CGMIA)
Korea:  Korean Powder Metallurgy Institute (KPMI)
Taiwan: Powder Metallurgy Association of R.O.C. (PMA of ROC)
India:  Powder Metallurgy Association of India (PMAI)

Many Thanks!