

The latest technology of cast irons and melting processes in japan.

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1. The castings in Japan.

1) Production amount of castings, 1996.

Production 6,958,386 tons, 21,380 hundred million in value of Japanese yen.

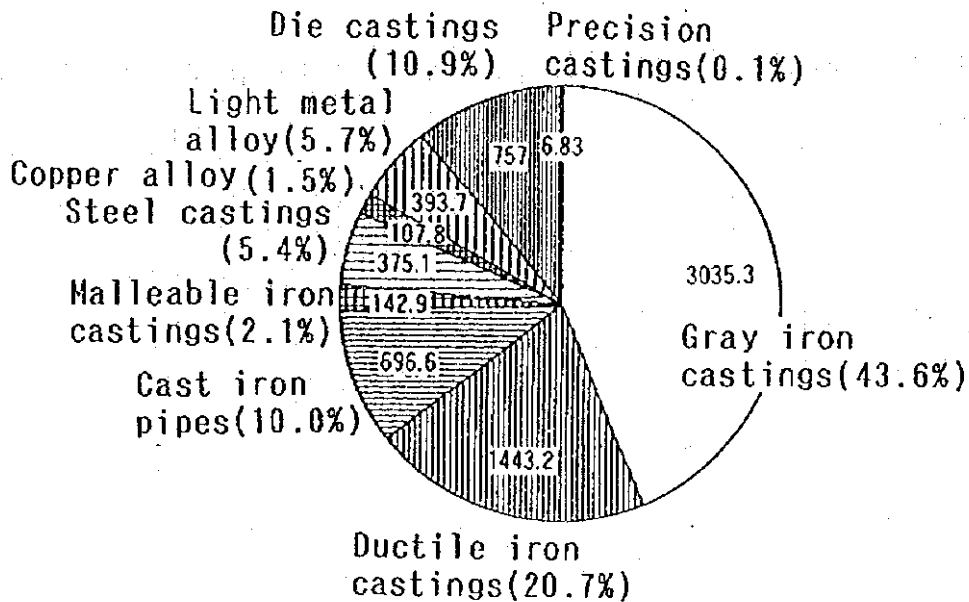


Fig.1 Production amount.

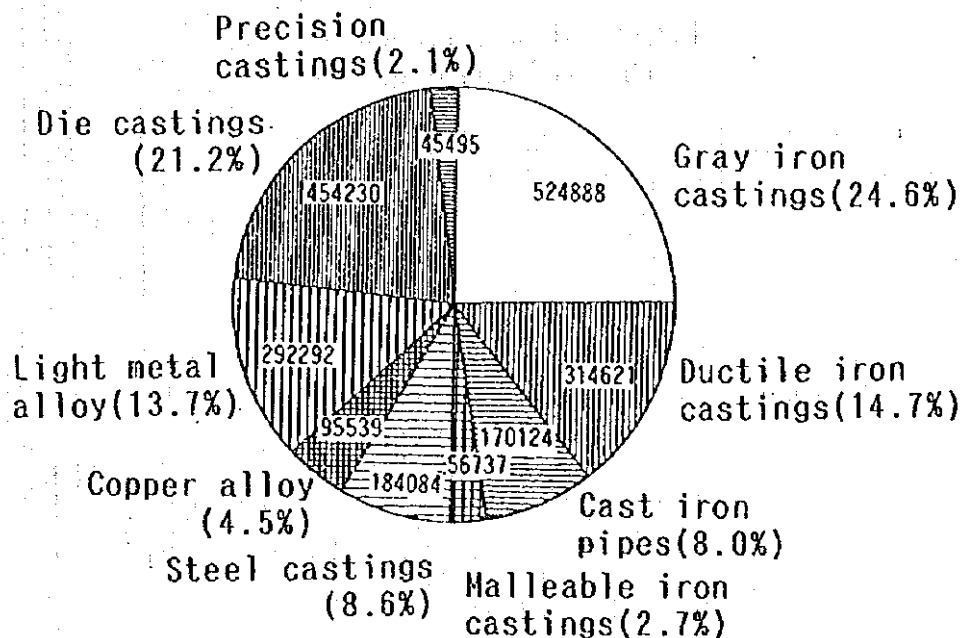


Fig.2 Production value.

Production of castings show no change for the last three years, however slight decrease year by year on total of castings.

Table 1 Production quantity of iron castings.

(Unit:tons)

| Year<br>Item   | 1991                     |                            | 1995                     |                            | 1996                     |                            | 1996 year Total<br>Gray & Ductile<br>iron castings |
|--|--------------------------|----------------------------|--------------------------|----------------------------|--------------------------|----------------------------|--|
|  | Gray<br>iron<br>castings | Ductil<br>iron<br>castings | Gray<br>iron<br>castings | Ductil<br>iron<br>castings | Gray<br>iron<br>castings | Ductil<br>iron<br>castings |  |
| Industrial machinery                                 | 504,548                  | 154,635                    | 527,936                  | 182,410                    | 511,835                  | 192,426                    | 704,261  |
| Machinery for mining, road<br>building & constructio | 65,883                   | 107,533                    | 63,913                   | 115,410                    | 63,637                   | 128,227                    | 191,864  |
| Metal working machinery<br>& machine tool            | 133,222                  | 9,244                      | 164,376                  | 10,302                     | 174,742                  | 12,196                     | 186,938  |
| Roller products, molds<br>& plate, ingot, holding    | 74,577                   | 32,649                     | 91,764                   | 25,394                     | 86,618                   | 23,571                     | 110,189  |
| Others   | 127,649                  | 32,402                     | 126,480                  | 40,630                     | 128,796                  | 38,568                     | 167,364  |
| Electric machinery                                   | 87,314                   | 16,536                     | 101,791                  | 19,407                     | 94,603                   | 20,558                     | 115,161  |
| Transportation vehicles<br>Automobiles               | 1,738,195                | 815,453                    | 1,707,449                | 827,451                    | 1,644,161                | 830,412                    | 2,474,573  |
| Others   | 161,253                  | 41,574                     | 189,465                  | 50,965                     | 182,860                  | 53,208                     | 236,068  |
| Others   | 142,538                  | 96,897                     | 144,803                  | 140,244                    | 148,039                  | 144,001                    | 292,040  |
| Total  | 3,035,179                | 1,306,923                  | 3,117,917                | 1,412,213                  | 3,035,291                | 1,443,167                  | 4,478,458  |

Use of gray iron castings(Previous grand total ratio)

Automotive industry :53.9%

Industrial machinery :16.8%

Metal working machinery: 5.7%

Use of ductile iron castings

Automotive industry :57.5%

Industrial machinery :13.3%

4) Products cost.

Gray iron castings :70~200yen/kg

Ductile iron castings :180~220yen/kg

Aluminum alloy castings:700~1,000yen/kg

5)Trend of industry

- Users(automobil,electric industry) are on the decrease of production because imported parts.
- Shortage of workers,(middle and upper age,unsecured young worker)
- Mechanization and automatization of production process for labor saving.
- Multikind, small production, small lot and short cycle.
- Low cost of products.
- Anti-environment in factory.
- Technical skill worker in short.
- To secure production by newly developed products.

## 2. The latest melting technology.

### 1) Product of ductile cast iron by the special arc furnace.

Melting practice by arc furnace, mixed charging with cast iron machining chips and CaO, desulfurization and deoxidation and conducted at the time when molten iron is passing through basic slug formed under electrodes, clean melts of high surface tension obtained.

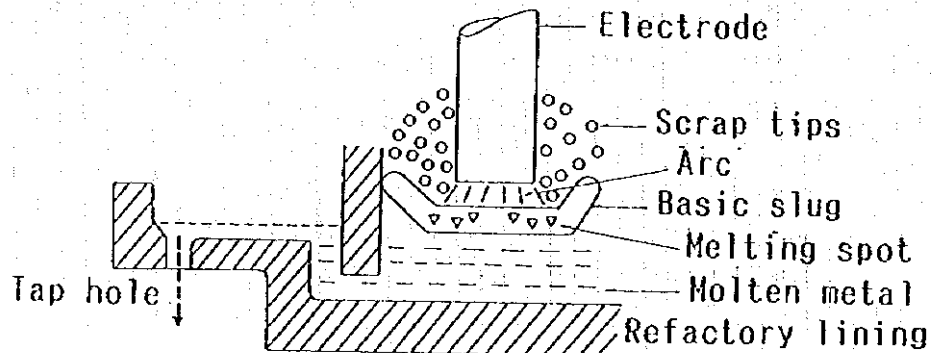
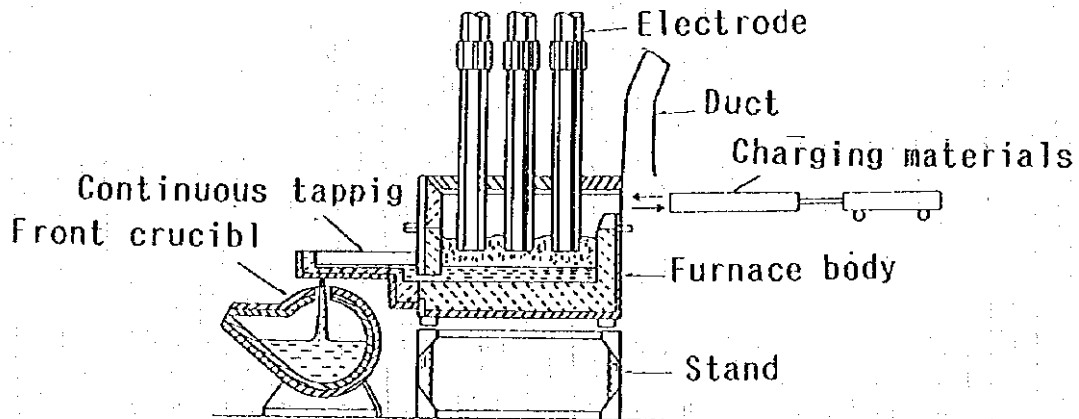


Fig. Schematic illustration of arc furnace.

### 【Characteristics】

- Molten metal of fine Spheroidal graphite obtained, with low remain Mg by refining of S, Si oxide.
- Possible at small shrinkage, nonriser system with cast yield ratio more than 90%.
- Possible non coating by high surface tension, a little sand burning.
- A little dross in molten metal.
- Less change rate of graphite spheroidization at after 30minute spherodized and a little Mg fading.
- Homogeneous quality of thick castings from surface to inner.
- Able of low cost casting.

2) A newly spheroidizing method of ductile cast iron.  
(Fume less process)

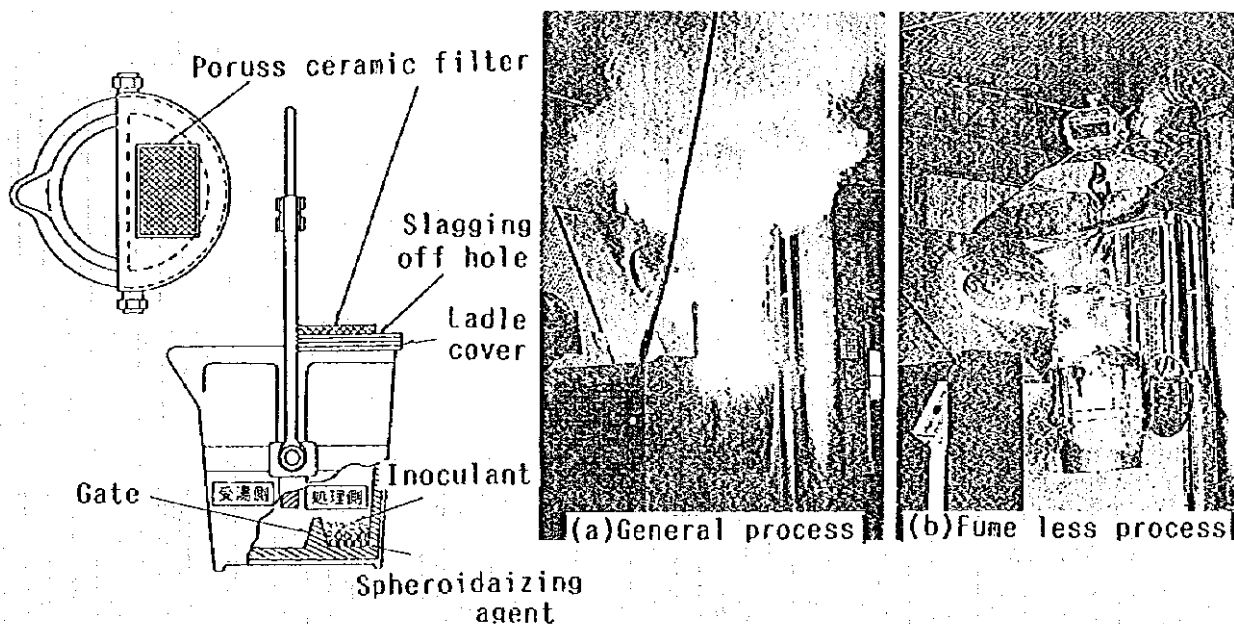


Fig. Schematic illustration of fume less process.

Table 2 Comparison of molten gas content and recovery Mg content.

|  | General method | Fume less process |
|--|----------------|-------------------|
| Spheroidizing agent addition(Fe-Si-Mg alloy) | 1.8%           | 1.3%              |
| Recovery Mg content (After 10 min)           | 0.048%         | 0.050%            |
| Yield rate of Mg (After 10 min)              | 58.0%          | 83.6%             |
| Gas content                                  |                |                   |
| Oxygen(After 10 min)                         | 4.6ppm         | 1.4ppm            |
| Nitrogen(After 10 min)                       | 48.1ppm        | 50.7ppm           |

**【Characteristics】**

- Safety to a little scattering of molten metal.
- A little change of molten metal in chemical compositions.
- Catch rate of MgO fume are 80%.
- Spheroidal graphite agent addition amount in comparison with general method, possible 0.5% decrease, improve yield rate at 30% of recovery Mg content.
- Able at low cost production.

### 3) Rotary furnace

It is a new type of furnace to melt cast iron and steel by rotating the furnace body, fired by liquid propan gas with mixed injection of pure oxygen.

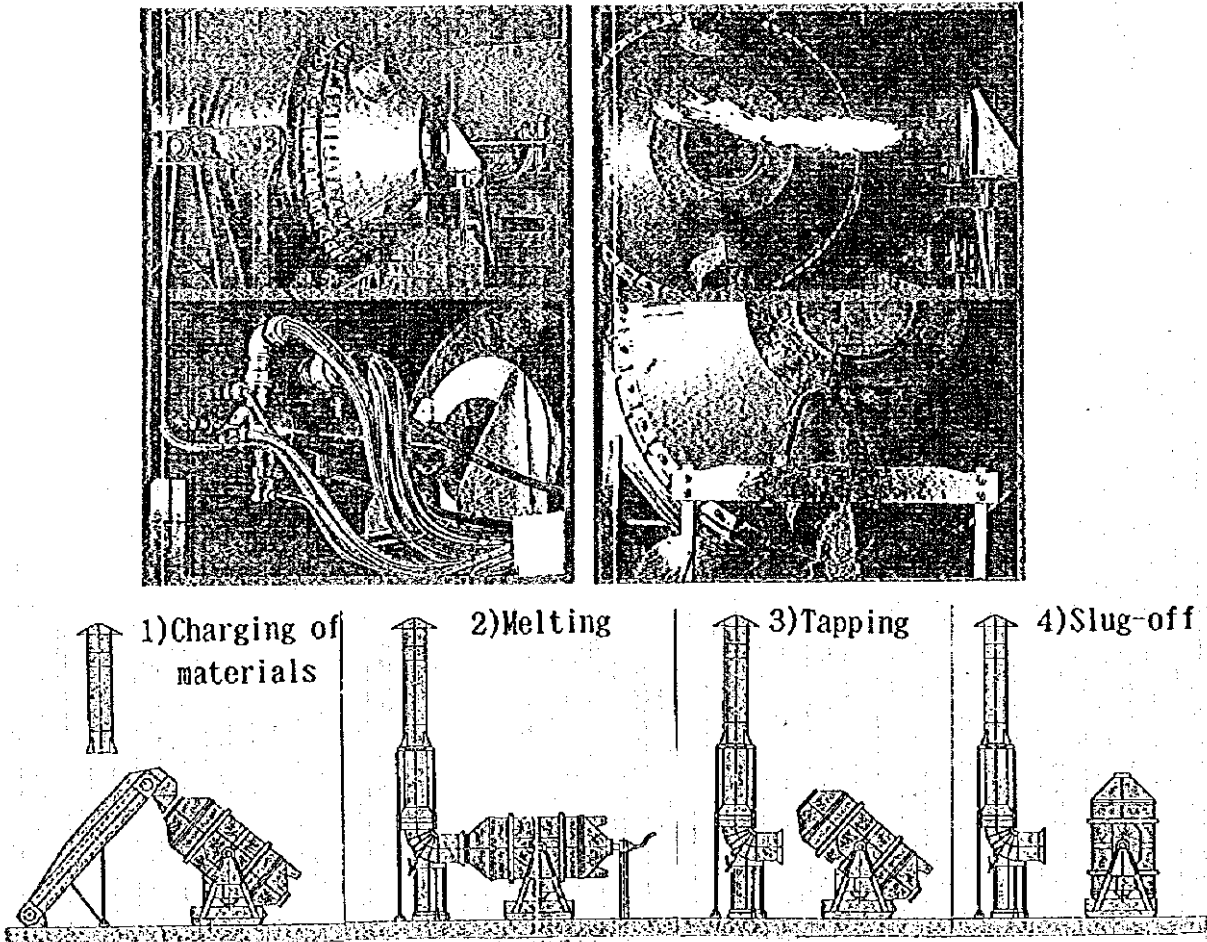


Fig . Operation connditions

| Capacity                                      | 3ton | 5ton | 8ton |
|---|------|------|------|
| Charging time(min)                            | 10   | 10   | 15   |
| Melting time(min)                             | 90   | 105  | 120  |
| Tapping time(min)                             | 10   | 10   | 10   |
| Total time(min)                               | 110  | 125  | 145  |
| Propan gas(Nm <sup>3</sup> /hr)               | 60   | 75   | 95   |
| Fuel spending<br>Oxygen (Nm <sup>3</sup> /hr) | 300  | 375  | 475  |
| Tapping temp.(°C)                             | 1480 |      |      |

#### 【Characteristis】

- The molten metal quality be good to homogenize furnace temperature distribution, also for scrap meltings.
- Maximum melting temperature is 2,800 °C.
- This furnace is able to decrease exhaust gas amount (the furnace comparsion with cupola at 1/10)to high melting efficency.
- Facility cost low in the furnace in comparsion with electric furnace.

#### 4) Gas shaft furnace for melting iron castings.

This type of furnace is similar to cupola furnace in construction, cupola uses coke as a fuel but this furnace uses natural gas.

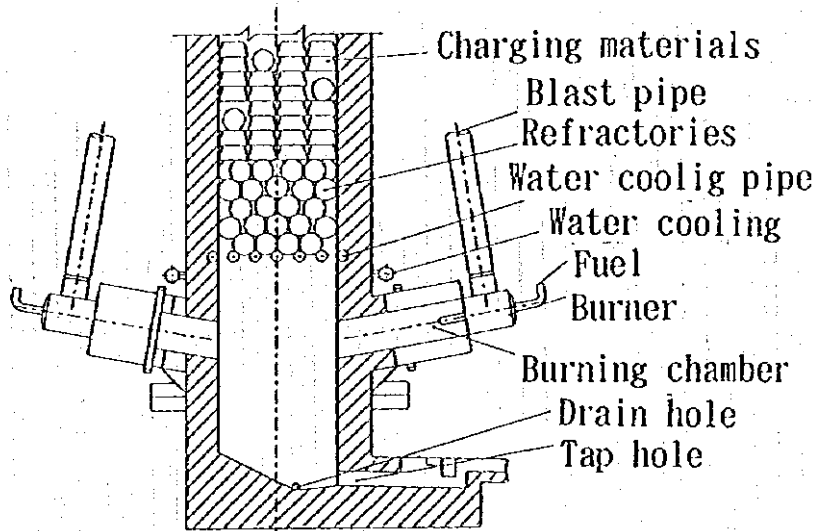


Fig Schematic illustration of gas shaft furnace.

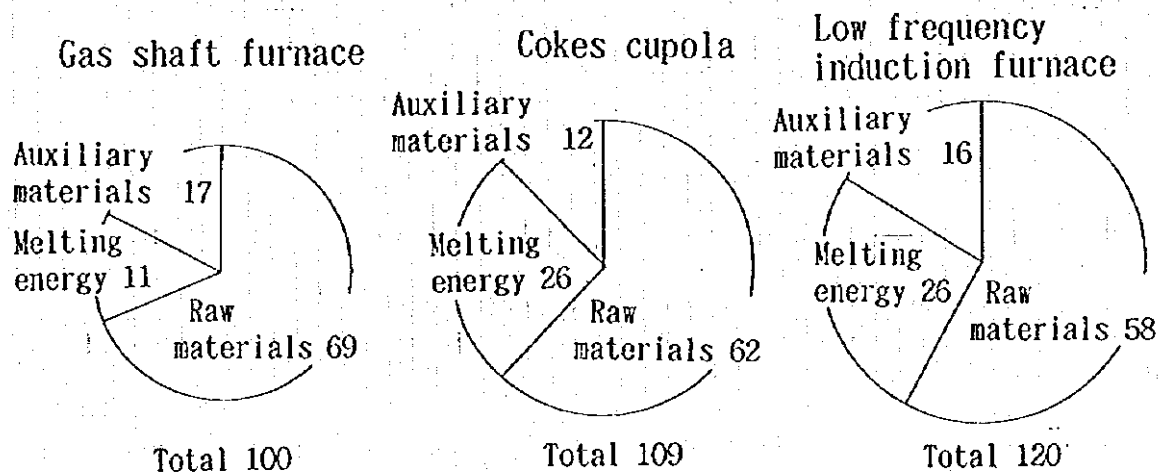


Fig Comparison of cost on the various melting process.

#### 【Characteristics】

- Exhaust gas in high cleanness. (decrease of  $O_2, SO_2$ )
- The molten metal is fit to produce ductile cast iron for because desulfurization of molten metal is not necessary.
- Burning control is easy by gas fuel. (possible to computer control, saving man power)
- The running cost in comparison with low frequency electric furnace is at 15 to 20%, coke cupola at 8 to 10%.

3. Newly used examples of the spheroidal graphite cast iron. The spheroidal graphite cast irons are more flexible in shape compared to steel, and its characteristic 10% less weight than steel, more demand on the automobile parts by thin casting technology. The improved spheroidal graphite cast iron are developed in elongation toward strength, that at lower stage of strength more than 20% in elongation, that at high strength available at 1000N/mm<sup>2</sup> tensile strength, more than 10% elongation.

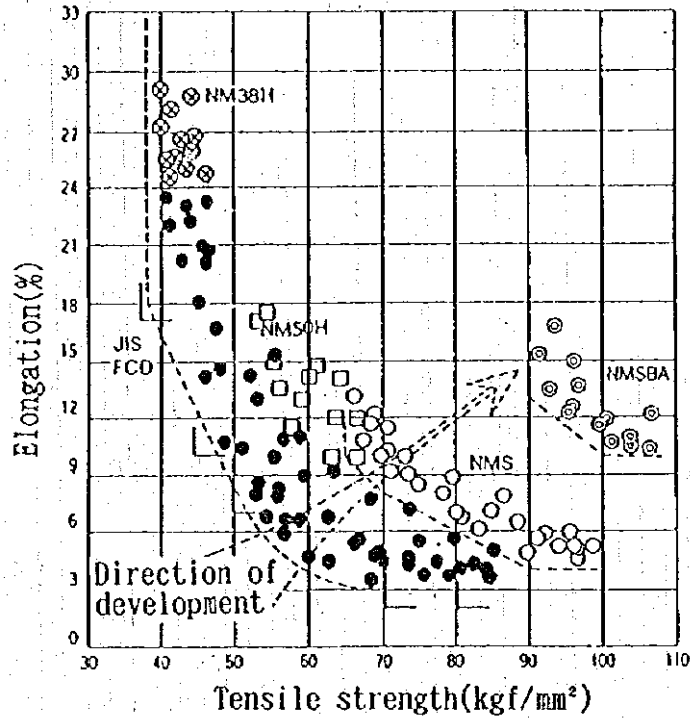


Fig. An improvement of the spheroidal graphite cast iron.

1) Ferrite type, high ductility spheroidal graphite cast iron. The cast iron are high in ductility of complete ferritic matrix by lowering Si content.

Table Properties of ferrite type, high ductility spheroidal graphite cast iron.

| Material No.  | 0.2% Yield strength (N/mm <sup>2</sup> ) | Tensile strength (N/mm <sup>2</sup> ) | Elongation (%) | Hardness HBS | Fatigue strength (N/mm <sup>2</sup> ) | Elastic coefficient (GPa) |  |
|---------------|--|---------------------------------------|----------------|--------------|---------------------------------------|---------------------------|--|
| HM 38         | >230                                     | >380                                  | >18            | <170         | 230~260                               | 170                       |  |
| J FCD370<br>I | >230                                     | >370                                  | >17            | <170         | 180~220                               | 160~170                   |  |
| S FCD400      | >250                                     | >400                                  | >12            | <201         | 190~240                               |                           |  |

**【Application】**

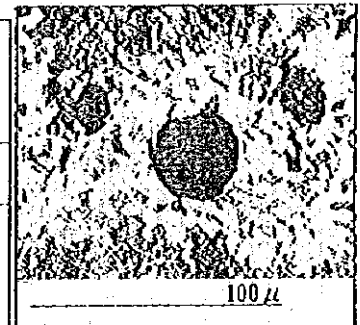
- Torquerod of truck suspension.
- Lower arm of automobile suspension (minimum thickness at 2.5mm)



2) Ferrite,pearlite type,high toughness sphroidal graphite cast iron. Uses in high strength and toughness through necessary more than 50N/mm<sup>2</sup> in tensile strength. Obtained by heat treatment cooling after heating ferrite,austenite mixture stractur zone. Diffrent from bu'ls eye type and pearlite type so that toughness at lower temperature and fatigue stregth rather high even thou at high hardness.

Table Properties of ferrite,pearlite type,high toughness sphroidal graphite cast iron.

| Material No.  | 0.2%Yield strength (N/mm <sup>2</sup> ) | Tensile strength (N/mm <sup>2</sup> ) | Elonga-tion (%) | Hardness HBS | Fatigue strength (N/mm <sup>2</sup> ) | Elastic cofficient (GPa) |
|---------------|---|---------------------------------------|-----------------|--------------|---------------------------------------|--------------------------|
| HNM 50H       | >340                                    | >500                                  | >10             | 163~217      | 260~310                               | 174                      |
| J FCD150<br>I | >280                                    | >450                                  | >10             | 143~217      | 200~290                               | 164~174                  |
| S FCD500      | >320                                    | >500                                  | > 7             | 170~241      | 220~300                               |                          |



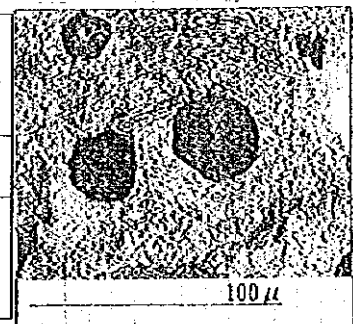
**【Application】**

Axle wheel parts, Spring sheet, Front drive axle housing.

3) Pearlite type,high strength sphroidal graphite cast iron. This cast iron developed requires high strenth, wear resistance with complete pearlitic structure with increase graphite number in matrix.

Table Properties of pearlite type,high strength sphroidal graphite cast iron.

| Material No.  | 0.2%Yield strength (N/mm <sup>2</sup> ) | Tensile strength (N/mm <sup>2</sup> ) | Elonga-tion (%) | Hardness HBS | Fatigue strength (N/mm <sup>2</sup> ) | Elastic cofficient (GPa) |
|---------------|---|---------------------------------------|-----------------|--------------|---------------------------------------|--------------------------|
| HNM 80        | >400                                    | >800                                  | > 3             | 248~311      | 300~340                               | 176                      |
| J FCD700<br>I | >420                                    | >700                                  | > 2、            | 229~302      | 200~290                               | 167~176                  |
| S FCD800      | >480                                    | >800                                  | > 2             | 248~352      | 220~300                               |                          |



**【Application】**


Crank shaft, gear for moter cars.

4) Austenite, bainite type spheroidal graphite cast iron.

The cast iron can be obtained austenite, bainite mixture structure by the austempering heat treatment.

The austempering treatment requires rapid cooling into 250~400°C salt bath with that after 900°C heating.

Table Properties of austenite, bainite type spheroidal graphite cast iron.

| Material No. | 0.2%Yield strength (N/mm <sup>2</sup> ) | Tensile strength (N/mm <sup>2</sup> ) | Elongation (%) | Hardness HBS | Fatigue strength (N/mm <sup>2</sup> ) | Elastic coefficient (GPa) |  |
|--------------|---|---------------------------------------|----------------|--------------|---------------------------------------|---------------------------|---|
| Upper ba     | >600                                    | >900                                  | >10            | 269~321      | 360~400                               | -                         |   |
| Lower ba     | >900                                    | >1300                                 | > 2            | 352~429      | 250~340                               | -                         |   |

ADI is obtained in high wear resistance, high fatigue strength, 10% elongation and 1000 N/mm<sup>2</sup> strength, however a little product amount in Japan at present.

**【Application】**

Nucle spindle of front wheel axle of truck.  
Gear(Timing gears),Crank shaft for large load.

**【Problem】**

Cutting is not good(Hob machining of gear is not good)  
Fatigue strength is unstable.(250~500N/mm<sup>2</sup> )  
High notch sensitivity.

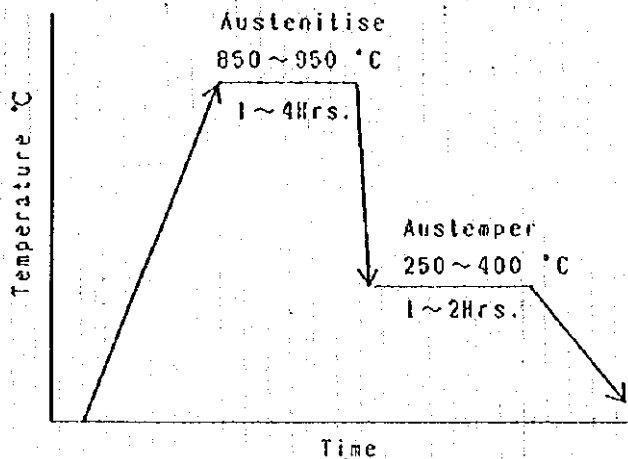


Fig. Schematic time-temp. program pattern of austempering heat treatment.

4) Introduce of the other product technology.

1) Semi solid die casting.

Flake graphite were diecast by the reocasting, thixocasting method.

It was successful to obtain the casting iron product, in 3mm thickness, 100mm width, 150mm height.

Microstructure show eutectic of austenite-cementite at as cast, those obtained eutectic of austenite-cementite, cementite fine massive graphite structure.

Strength obtained 400MPa for 240MPa of show flake graphite cast iron, elongation of 3% for 0%.

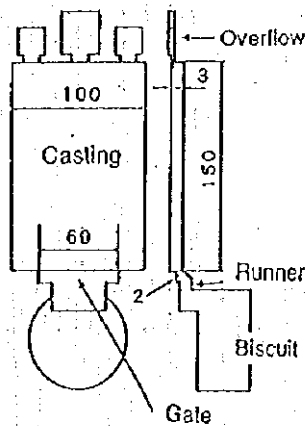


Fig. 8 Geometry of flat plate produced by horizontal die casting machine

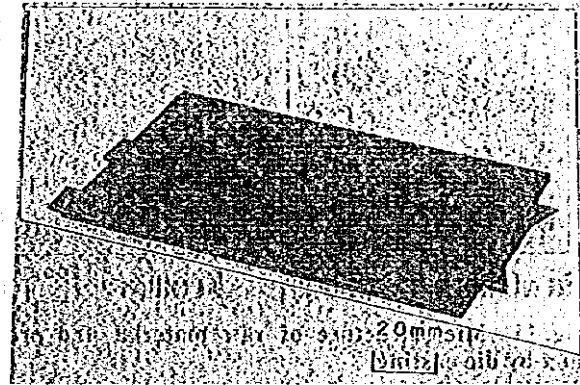


Fig. 9 Surface appearance of cast iron product by die casting

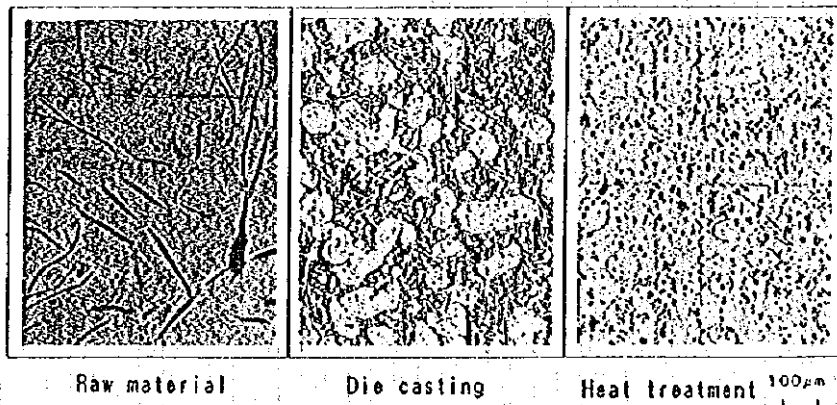


Fig. The structure of semi solid die casting.

## 2) Product of spheroidal graphite casting by metal mold casting process.

Honda engineering Ltd. produces chasis parts as axle wheel etc. by development of water cooling copper dies production system for spheroidal graphite cast iron. The system introduces by integrated straight line, from in gates cutting off, straightening for strain, continuous annealing at high temperature, and obtainable of fine graphite with ferritic structure. It excels in fatigue strength, impact toughness, far superior than sand castings. And also it saves floor area for production into 1/2 compared to conventional processes.

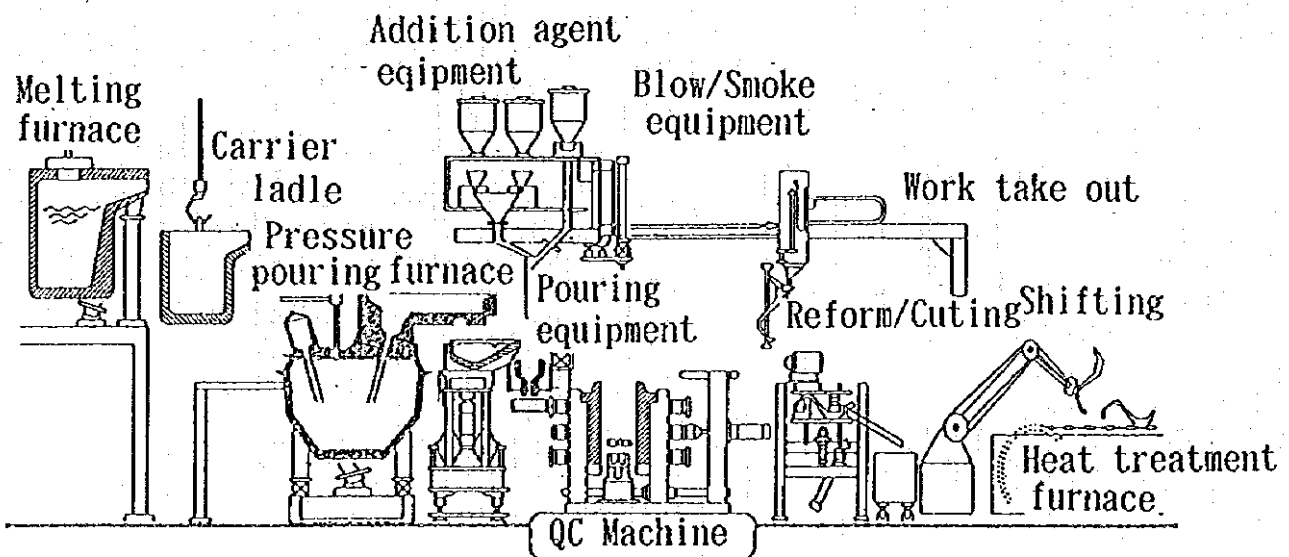


Fig. Full automatic metal mold iron casting system.

### 【Characteristics】

- The line able to full automatic line, saving space, large saving comparison with sand mold casting process.
- The system improves work shops surroundings with a few dust, waste.
- Castings obtainable enough strength, graphite spheroidization with low Mg recovery (0.008%).
- Mechanical properties increasable in fatigue strength in comparison with sand castings, 650MPa in strength, 20% elongation, 14J/cm<sup>2</sup> impact vale.

## 3) Newly using for the development example of casting irons.

Casting puroducts are being tried for application field, new puroducts development to make small and midle foundry factories survive in japan.

- Development of casting puroducts for better appearance.  
(Exterior, Monument, Fence, Light colum, Bench etc.)
- Development of a man-made gathering-place to live for fish.

