研究速報

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MANUFACTURING OF MOLDING DIE BY CASTING INTO CERAMIC PERMEABLE MOLD

——Report 4：High-tensile Brass Molding Die and Others——

通気性セラミック型への鋳造による金型の製造

——第4報：高力黄銅型とその他——

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1. Introduction

High-tensile brass has been used in very extensive industrial field for its excellent wear resistivity, corrosion resistivity, thermal-conductivity and mechanical properties, but it has never been used as a kind of material for dies. Recently, we tried to use it to make molding die for injection by casting it into the ceramic permeable mold—as a kind of new technology this peocess has been successfully used to make zinc or aluminium alloy dies for small or middling lots production—and has a satisfactory result.

2. Experimental method

The experimental method and casting mold, device used in this experiment are basically the same with the experiments so far[1)~3)]. The high-tensile brass used are specially ordered from Kyowa Gokin Ltd.. It has not only the advantages mentioned above, but also has good casting attribute, such as lower melting point (875～900°C), more narrow solidifying range (18～30°C), better fluidity and dezincification resistivity, which make the precision sucked casting easier.

3. Results of experiments

3.1 General casting condition

The general casting condition is as follows:

Drying of casting mold:
  Vacuum drying (100°C,3h) as soon as formed
Material of casting mold frame:
  Steel with insulating material at the upper part of inner wall.
Weight of molten alloy:
  5Kg (Area of base＝180×80)
Temperature of casting mold:
  Room temperature
Pouring Temperature:
  950°C
Sucking pressure:
  ＞50cmHg (On meter)
Sucking timing:
  2～5sec. before pouring
Cooling condition:
  Cooling naturally
Some details for above conditions:

The ceramic permeable casting mold is only vacuumdried instead of sintering at high temperature to make the casting mold excellent thermal shock resistivity and collapsibility. And this kind of casting mold has good permeability and enough strength for handling.

Using insulating material at the upper part of inner wall of steel frame is to form a temperature gradient in molten alloy, i.e., the molten alloy near the transprinting surface solidifies earlier than that at the upper part. As the result of this, defects are concentrated to the upper surface which will be cut away and elaborate patterns can be perfectly transprinted.

The weight of molten alloy is related to both saving material and avoiding affection from defects like shrinkage cavity, micro-porosity and shrinkage strain to the transprinting surface. An optimum point is necessary because the both are contradictory. In our experiments, the thickness of castings is determined to about 40mm and then the weight of molten alloy is calculated.

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The temperature of casting mold is feasible in room temperatur. Preheating is unnecessary because sucked casting produces excellent fluidity and trermal shock resistivity of the mold is enough.

The pouring temperature can be lower than traditional casting for the sucked casting can effectively improve the fluidity and filling ability. Generally, the pouring temperature can be determined from following formula:

$$Tp = 1.08 \sim 1.10 \times Tl$$

where Tp : Pouring temperature

Tl : Liquidus temperature of alloy

The sucknig pressure is mainly dependent on the shape and size of transprinted pattern if the surface tension of molten alloy is given. This has been reported in detail before[2]. On the other hand, there are a great number of pores on the surface of casting mold, so the molten alloy will get into the pores if the sucking pressure reaches a given value. It results in that transprinting and mold releasing will be interfered. Therfore, casting mold which has finer pores has to be used as higher sucking pressure is necessary in order to transprinting more eleborate pattern. The relation between the sizes of pores and transprinted pattern is suggested as follows:

$$D_h \leq 0.5 \sim 0.8 \times Dp$$

where D_h : Diameter of pores

Dp : Size to be transprinted pattern

The sucking timing is very important when green mold is used to cast the alloys with high melting point (higher than 700°C). Because the ethyl silicate binder still remains in the mold as a form of macromolecular matter consisted of C, H, O and Si even though the alcohol has almost been drawn away during vacuum-drying. And it will be resolved under higher temperature. Gas produced from the resolving reacts with molten alloy immediately so that defects, such as flow marks, dark skin, occur and affect the transprinted elaborate pattern seriously. Therefore, sucking has to be started just before pouring and a larger flow pump is recommended for drawing the gas away promptly.

The cooling condition is set to "cooling naturally" as it is the simple way and has no obvious problem in our experiments. But it is significant that using perheating reduces heat shock to casting mold and using cooling improves quality of castings or production cycle, when bigger molding dies are cast.

3.2 Effect of sucking

3.2.1 Transprinting of patterns

The transprinting attribute is mainly dependent on the sucking pressure as other parameters are given. Fig. 1 is the photograph of natural leather patterns and contours of triangle waves pattern under sucked and non-sucked conditions respectively. On the sucked occasion, all of the patterns are transprinted clearly and have very good sense of reality. But on the non-sucked occasion, the transprinting attribute is quite poor for air and gas at interface are not drawn away, especially the back skin pattern (right side) which is finer than other patterns is alomst not transprinted. And the air and gas also reacts with molten alloy at interface so that defects like flow marks and dark skin occur and injure the patterns.

3.2.2 Roughness of plane

The effect of sucked casting on roughness of plane is also obvious. Fig. 2 is the photograph and measured roughness. Defects, like pinhole and gas porosity which are resulted from air and gas at interface, appear under the condition of non-sucked. But the

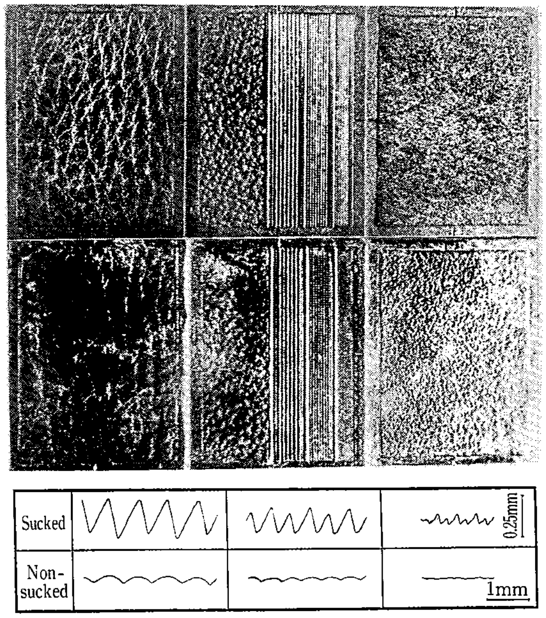

Fig. 1 Comparison between sucked and non-sucked on transprinting of patterns

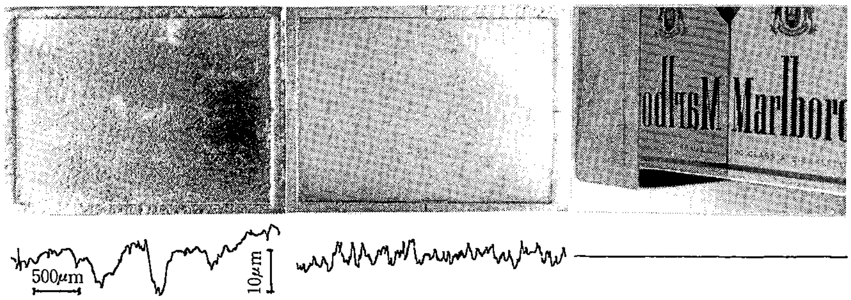

Fig. 2 Comparison between sucked and non-sucked on surface roughness of plane

above defects can not be observed on the sucked occasion. It also can be testified with the measured contours. A lot of valleys that depth is more than 15 μm shows that the defects exist on the non-sucked occasion, but no deep valley is recognized on the sucked occasion. The values of roughness (Rmax, Rz) also attested this fact. Therefore, a mirror surface can be obtained with polishing in a short time. This is attractive to large-scale free curved surface of molding dies.

4. Various kind of molding dies sucking casted so far

Fig. 3 shows various kind of molding dies sucking cast so far. Every alloy here can be cast successfully and each kind of patterns here can be transprinted perfectly. The size of finest triangle wave is that angle=102°, pitch=88μm, which is near the groove of music record. Comparision of the used alloys on mechanical and other properties is shown in Table 1. These alloys can cover a wide range of molding die from trial-producing, small lots to middling, large lots and possess their own features respectively.

Fig. 4 is the photograph of patterns from a genuine model, via silicone master, ceramic casting mold, alloy molding die, to plastic injection product. And the schematic of process, delivery, dimension change, material and equipment used in each course are also shown in it. In general terms, using this process enables molding die to be finished in a week if a genuine model has been prepared and no expensive equipment has to be used. The dimension change can be controlled in a range by requlating the ceramic mold's backing temperature and the materials blending condition. It is evident that molding die having patterns can be produced with high quality and precision at low cost for rapid delivery in this process.

Table 1 Main properties of alloys used in experiments

Itemis / Data / Alloy		Zn alloy (ZAS)	Al alloy (AC4D)	High-tensile brass
Tensile strength	(kg/mm^2)	22~30	20~31	50~80
Persentage elongation	(%)	2.0~3.3	2.0~7.0	39~12
Surface hardness	(HB)	90~100	75~105	100~200
Shock strength	(kgm/cm^2)	1.7~1.8		4.4~1.9
Heat conductivity	(Cal/sec°C)	0.2	0.3	0.21~0.83
Solidifying contraction	(%)	4.0	3.0	2.1
Casting temperature	(°C)	420	680	950~1000
Specitic gravity	(g/cm^3)	6.75	2.7	8.3~7.8

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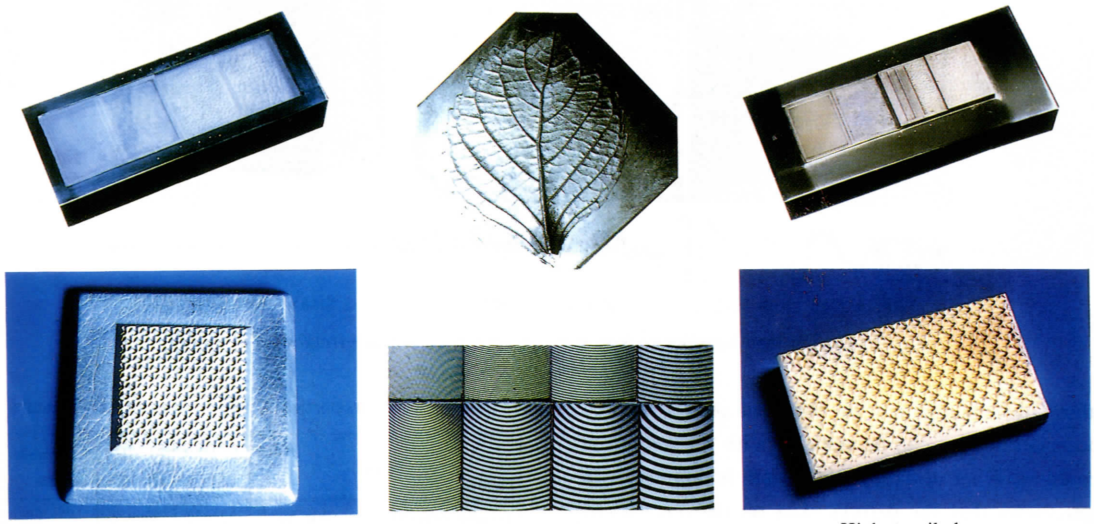

Zinc alloy　　Aluminium alloy　　High-tensile brass

Fig. 3 Various kinds of patterns sucking casted with various alloys

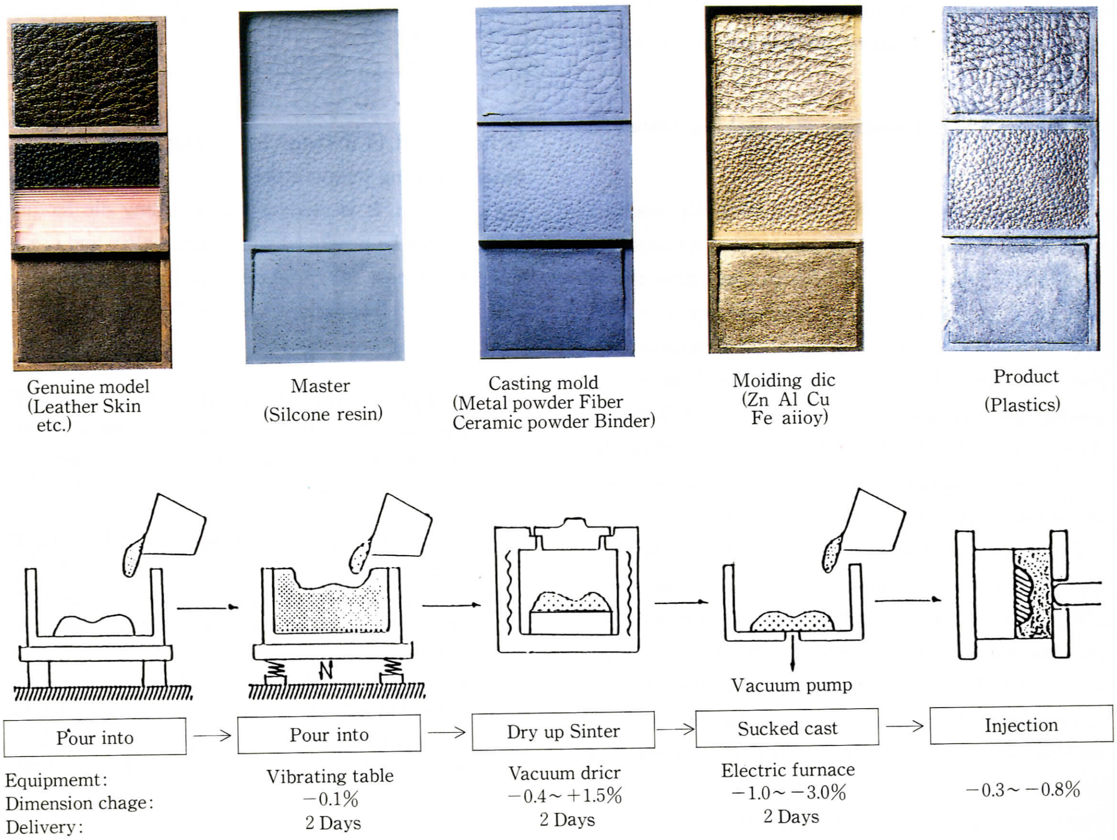

Fig. 4 Transprinting attribute, dimension change, delivery, material and equipment of the process