Feb. 25, 1969 KAZUO TACHIMOTO ETAL 3,429,362

PROCESS OF MANUFACTURING SMALL CASTINGS OF FERROALLOY

Filed Dec. 20, 1965

FIG. 1

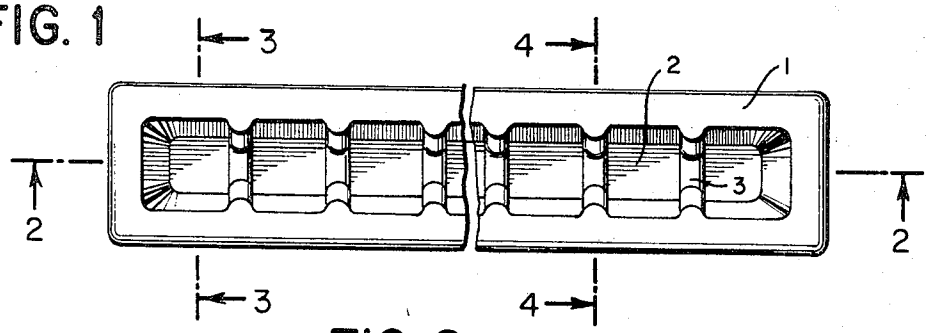


FIG. 2

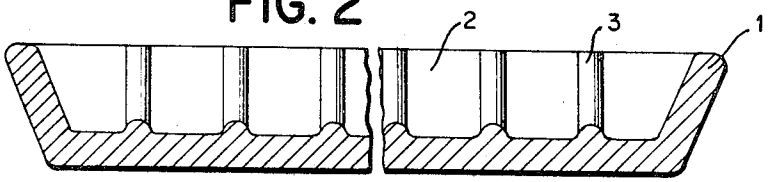


FIG. 3

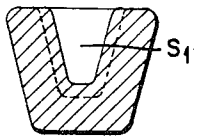


FIG. 4

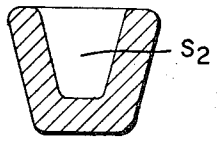
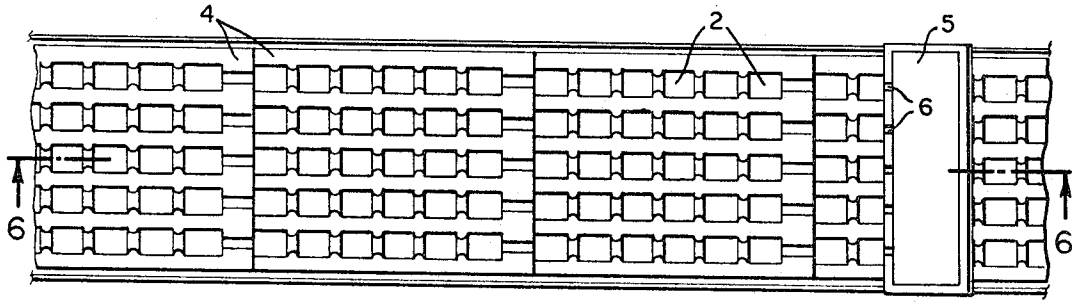


FIG. 5



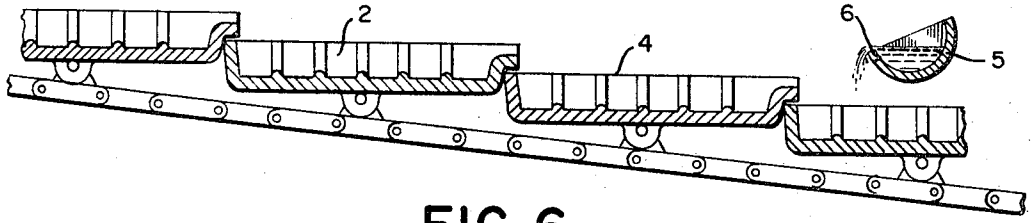


FIG. 6

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PROCESS OF MANUFACTURING SMALL CASTINGS OF FERROALLOY

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U.S. Cl. 164—70 10 Claims
Int. Cl. B22d 31/00, 27/04; B28b 11/12

ABSTRACT OF THE DISCLOSURE

A method of casting large numbers of metal bodies which tend to crack during cooling, the bodies having a size of, for example, 20–50 mm. The molten metal from which the bodies are to be formed is poured into a mold wherein a row of the bodies are integrally cast with necks which extend between the bodies of the row with the ratio of the cross section of each neck to the cross section of each body being in the range of 0.25 to 0.90. The thus-cast metal is cooled in the ambient atmosphere and when the metal has solidified, but is still at a substantially high temperature, the casting is removed from the mold and cooled further. A row of such interconnected bodies is then broken at the necks of the row so as to achieve the separate bodies.

This invention relates to the process of manufacturing small castings of ferroalloy.

With the recent mechanization of steel making operation, a certain size has come to be required for the ferroalloys to be added for deoxidation or alloying. For instance, many steel makers prefer ferromanganese that had been sieved to a range of 20 to 40 mm. or 20 to 50 mm. in size and of 100 to 250 grams per piece to lumps that had been obtained by breaking larger castings into more irregular shape, size and weight.

However, as is widely known, ferroalloys, especially ferromanganese or silicon-manganese, are liable to crack during cooling after casting. Thus it is extremely difficult to cast the metal in a certain size, for instance, 20 to 40 mm. as mentioned above. Accordingly, these ferroalloys have been cast in, for example, metal mould about 200 mm. deep, 800 to 1000 mm. wide and 800 to 1000 mm. long. In this method, the cast metal must be crushed either by machine or manual labour after solidification and cooling, and then sieved into the lumps of desired size. However, this method is very uneconomical because many undersized fragments are produced in the process of crushing, and moreover, manual crushing itself involves considerable expense.

For these reasons, a great advantage in the production of ferroalloy will be realized if (a) ferroalloy lumps of desired size can be obtained simply by casting, or (b) the yield, or the ratio of that part of the product which fell within the allowable range to that which was fragmented and became the undersize, can be improved by simple means after casting.

But many attempts for (a) have failed because of easy cracking of those ferroalloys during cooling after solidification. As for an attempt for (b), a method has been proposed in which the metal is cast into ingots of a shape generally similar to those of pig iron except a number of lateral grooves are so provided that they will break from those grooves into small lumps of more or less uniform size and shape. However, those pig iron-shaped ingots, even with the lateral grooves, do not ensure the cracks to occur exclusively at the grooved parts, and therefore a considerable number of undersized fragments form in the process of crushing.

The purpose of this invention lies in the removal of such defects. This invention relates to the process of manufacturing small castings of ferroalloy consisting in (a) preparing casting mould from any metallic substance such as cast iron; (b) providing plural number of ribs to protrude at an equal interval into the casting cavity so that said casting cavity be divided in effect into a number of portions of the equal volume and shape except those at both ends of the casting cavity; (c) making the ratio of the cross sectional area of the casting cavity at ribs to that of the cavity proper be 0.25 to 0.9; (d) pouring the metal into said mould; (e) solidifying the metal and forming an ingot of such shape as a number of equal-sized and equal-shaped portions (excepting those at both ends) are mutually connected by narrower neck parts that correspond to the ribbed parts of the casting cavity; (f) cooling the ingot in air before separating from the mould; (g) taking the ingot out of the mould at a temperature not lower than 700° C. or at a time not longer than six minutes since the pouring; (h) cooling the ingot further in natural air; (i) separating the connected portions of thus formed ingot by dropping it onto a hard object at a temperature between aforesaid take-out temperature and the room temperature; and (j) obtaining small castings of ferroalloy of required size. Hereinafter, the ingots thus prepared are said to be composed of "portions" and "necks" for the sake of simplicity, whereby the portions are the small castings that are to be ultimately recovered as the final product.

Next, examples of this inventive process will be explained.

FIGURE 1 presents a plan view of an example of the metal mould design suited for the process of this invention.

FIGURE 2 presents a sectional view along the line **2**—**2** of FIGURE 1.

FIGURE 3 presents an enlarged sectional view along the line **4**—**4** of FIGURE 1.

FIGURE 4 presents an enlarged sectional view along the line **3**—**3** of FIGURE 1.

FIGURE 5 presents a plan view which shows the state of interlinking of the metal moulds.

FIGURE 6 presents a sectional view along the line **6**—**6** of FIGURE 5.

1 of FIGURES 1 and 2 shows a metal mould, **2** of FIGURES 1 and 2 is a cast cavity, **3** of FIGURES 1 and 2 is a rib, **4** of FIGURES 5 and 6 are metal moulds, **5** of FIGURE 6 is a ladle and **6** of FIGURE 6 shows a spout.

(a) *Example for ferromanganese.*—Into the cast cavity

2 of metal mould 1 (FIGS. 1 and 2) was poured the molten ferromanganese having the chemical composition as shown in Table 1. The row entitled "before dropping" of Table 2 shows the state in which the portions were connected to each other at the moment when the ingot was taken out from the metal mould two minutes after the pouring. The rows entitled "after the first dropping" and "after the second dropping" of Table 2 show the result of the repeated drop from the height of 1500 mm. upon the steel plate which was 10 mm. thick. Thus, after the material was dropped twice, no two portions were found connected to each other any longer, and of the thus broken ingot, 97.7% was accounted for by the individually separated portions and fragments of over 20 mm. sieve, 2% by fragments under 20 mm. sieve, and only 0.25% by useless fragments under 4 mm. sieve.

(b) *Example for silicon-manganese.*—Into cast cavity 2 was poured the molten silicon-manganese having the chemical composition as shown in Table 3. The row entitled "before dropping" of Table 4 shows the state in which the portions were separated at the moment when the ingot was taken out from the metal mould three minutes after the pouring. The rows entitled "after the first dropping," "after the second dropping" and "after the third dropping" of Table 4 show the result of the repeated drop of this material from the height of 1500 mm. upon the steel plate 10 mm. thick.

In the Table 4, the heading "train of more than 2 portions" means not only those lumps composed of two or more whole portions, but also those which are composed of one or more whole portions and a partial portion that was broken at midway between necks. In this case, the unseparated partial portion was counted as one half portion.

In this example, most of the portions were separated from one another after two operations of dropping, and further repetition of dropping resulted in the increase of breakage of individual portions themselves. Therefore, in such case, it is recommended to sieve the material after each dropping so that after each operation of dropping only those lumps composed of two or more portions may be left over. In the test as shown in Table 4 wherein all of those portions and fragments of over 20 mm. sieve were subjected to further droppings, the result of three dropping operations reveals that 97.5% of the resultant material was accounted for individual portions and fragments of over 20 mm. sieve, 1.4% by those under 20 mm. sieve and only 1.10% by those under 4 mm. sieve which were written off as loss.

As clearly shown in the examples above, the ingots break up or separate into individual and whole portions or castings of predetermined size and some fragments, simply by dropping; there being no need to apply additional mechanical or manual means in obtaining the small castings except perhaps an aid of a sieve which in some cases may be recommendable. As shown in Tables 2 and 4, the yield, or the percentage of the individually separated small castings and fragments, for example, those that are over 20 mm. sieve, can become better than 97% (Table 2) or 92% (Table 4) by repeating the dropping a few times. It can be over 99% if those of sizes over 4 mm. sieve are included, the useless loss being then only less than 0.5% (Table 2).

In another experiment, is was found that the percentage of undersized fragments resulted from dropping changes but a little even if the dropping is done from the height of 1800 mm.

This means that the method of dropping can be varied according to convenience, provided that such factors as the narrowness of the neck, namely the severity of notches, the brittleness of the material, the desired size of the individual portions or small castings or the allowance therefor, or the weight of the ingot are properly taken into account. For example, the ingot may simply be dropped onto concrete floor, or trommel or tumbler of corresponding diameter can be used to advantage. In particular, the use of trommel brings about further convenience, for then the sieving of broken or separated pieces is automatically carried out.

The important conditions in practicing the process of this invention are: (a) the shape of the metal mould, (b) the method of cooling after casting, and (c) the temperature of ferroalloy ingot at the time to be taken out of the metal mould. These conditions have great effects on the occurrence of undersized fragments.

The following is the explanation of the conditions mentioned under (a), (b), and (c):

(a) *The shape of the metal mould.*—The ratio of the area of the cross section of the connecting part (neck) to the area of the cross section of the portion of ferroalloy ingot to be cast, or the casting cavity proper, is important. The portions are liable to crack if the ratio S_1/S_2 is large, wherein S_1 stands for the area of the cross section of the cast cavity at the rib, namely of the neck, as shown in FIGURE 3, and S_2 stands for the area of the cross section of the cast cavity proper as shown in FIGURE 4. In that case, the individual portions themselves are apt to crack rather than the connecting necks during cooling, resulting in less small castings with predetermined size. In case S_1/S_2 is too small, on the other hand, the occurrence of undersized fragments increases upon dropping. After all, the essential condition is:

$$S_1/S_2=0.25-0.9$$

(b) *The method of cooling after casting.*—It requires the natural air-cooling, since the forced air-cooling or water-cooling increases the occurrence of undersized fragments.

(c) *The take-out temperature of the ferroalloy ingot from mould.*—The length of time between casting (pouring) and the removal of the ingot from the metal mould should be varied depending on the size of the portions. Usually a good result is obtained when it is not longer than 6 minutes. This means that the ingot, or the portions, should not be cooled to lower than 700° C. If this time or the temperature limit is exceeded, the percentage of undersized fragments increases.

In addition to the above-mentioned (a), (b) and (c), there is a requirement of height for the dropping operation. The most desirable value is in the vicinity of 1500 mm. If the height is too great, the percentage of undersized fragments increases, and if too small, the efficiency of the separation of the portions decreases.

The optimum combination of those conditions is to be determined within respective ranges specified on such considerations as the size of the small castings to be required, the kind of the ferroalloy, or the allowance for occurrence of undersized fragments.

FIGURES 5 and 6 show an example of a continuous process to which this invention is applied. A number of metal moulds 4 having a multitude of casting cavities 2 are interlinked to form an endless chain or train circulating in one direction. The ladle 5 placed thereabove has the same number of spouts 6 as the said cast cavities 2. The train of the metal moulds 4 is moved while molten ferroalloy is being poured in through the spouts 6. Here, the distance traveled by the individual mould to the end of the upper side of the endless chain, or the time spent between pouring and flip-over of the mould, must be designed to conform to this invention's principles. By supplying the ladle 5 with molten metal from, for instance, another ladle continuously, the process can be carried out to make it possible to manufacture the ferroalloy castings of desired size on the industrial mass-production basis.

According to this invention, a large quantity of small castings of ferroalloy of predetermined size, for instance, from 20 mm. to 40 mm., is obtained with great ease, the manufacture of which was heretofore regarded as highly difficult. Moreover, it is the advantageous feature of this

invention that very few undersized fragments are produced, while the extremely simple process of this invention reduces the working expense, consequently the manufacturing cost of the small size ferroalloy by castings.

Table 1.—Chemical composition (percent)

Mn	74.30
C	6.78
Si	0.24
Fe*	Remainder

*Includes P, S, and other impurities.

5. The method of claim 4 and wherein the bodies have a weight in the range of 100–250 grams.

6. The method of claim 1 and wherein the solidified metal is removed from the mold at an elevated temperature which is at least 700° C.

7. The method of claim 1 and wherein the solidified bodies are removed from the mold within six minutes after the pouring of the molten metal into the mold, to provide said elevated temperature at which the bodies are removed from the mold.

8. The method of claim 1 and wherein the bodies are broken apart from each other by being dropped onto a surface of suitable hardness.

9. The method of claim 8 and wherein the interconnected rows of bodies are dropped from a height of approximately 1500 mm.

10. The method of claim 1 and wherein the bodies are broken apart from each other by being tumbled.

TABLE 2.—DROP TEST (HEIGHT OF DROPPING 1,500 mm.)

	Separation of individual portions										
	Train of more than 2 portions		Individually separated portions		Total number of portions	Weight percent of fragments exceeding 20 mm.	Weight percent of fragment less than 20 mm.	Total weight		Loss (under 4 mm. sieve)	
	Number of portions	Weight percent	Number of portions	Weight percent				(G.)	Weight percent	Weight (g.)	Weight percent
Before dropping	40	66.0	20	34.0	60	0	0	5,940	(100)	0	0
After 1st dropping	8	15.2	52	84.7	60	0	0	5,935	99.91	5	0.09
After 2nd dropping	0	0	57	94.6	57	3.1	2.0	5,925	99.75	15	0.25

Table 3—Chemical composition (percent)

Mn	61.20
Si	15.53
C	2.37
Fe*	Remainder

*Includes P, S, and other impurities.

TABLE 4.—DROP TEST (HEIGHT OF DROPPING 1,500 mm.)

	Separation of individual portions										
	Train of more than 2 portions		Individually separated portions		Total number of portions	Weight percent of fragments exceeding 20 mm.	Weight percent of fragment less than 20 mm.	Total weight		Loss (under 4 mm. sieve)	
	Number of portions	Weight percent	Number of portions	Weight percent				(G.)	Weight percent	Weight (g.)	Weight percent
Before dropping	27	71.7	25	28.3	52	0	0	8,450	(100)	0	0
After 1st dropping	18	24.1	64	72.9	72	2.1	0.5	8,452	99.7	25	0.30
After 2nd dropping	5.5	6.8	72	84.5	77.5	7.0	0.8	8,380	99.2	70	0.80
After 3rd dropping	3.5	5.1	68	78.4	71.5	14.0	1.4	8,357	98.9	93	1.10

What we claim is:

1. A method of manufacturing relatively large numbers of relatively small bodies of a metal which tends to crack during cooling, comprising the steps of casting the metal while in molten condition in a mold wherein a row of the cast metal bodies are integrally interconnected by necks which in cross section have a ratio to the cross section of said bodies which is in the range of 0.25 to 0.9, cooling the thus-cast metal in the ambient atmosphere, until it solidifies, removing the thus solidified metal from the mold while the metal is still at a substantially elevated temperature, further cooling the thus-removed metal, and then breaking the bodies apart from each other at said necks.

2. The method of claim 1 and wherein the metal is silicon-manganese.

3. The method of claim 1 and wherein the metal is ferromanganese.

4. The method of claim 1 and wherein said bodies have a size range of approximately 20–50 mm.

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U.S. Cl. X.R.

164—78, 129, 262, 279, 329; 249—52