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(54) **PRODUCTION OF METAL CASTINGS.**

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Production of metal castings

This invention relates to the production of metal castings, particularly steel castings, in sand or like moulds.

In order to produce a sound casting in any metal or alloy it is essential that the metal contained in the feeder solidifies at least at the same time or preferably after the last part of the casting to solidify and that there is a path for liquid metal from the feeder to all parts of the casting to compensate for the shrinkage contraction which occurs when liquid metals or alloys solidify. It is therefore, a requirement of sound castings production to promote progressive directional solidification from the point most remote from the feeder towards the feeder so that the feeder is the last section of the casting to solidify. Unfortunately, the required shape of many castings is such that without change to the design, directional solidification cannot be achieved.

As a result, the desired shape of many steel castings has to be altered in order to provide feed metal to those parts of the casting which are remote from feeder heads. The alteration generally takes the form of thickening up the metal at those casting sections where premature solidification would otherwise occur and thereby cause shrinkage cavities in isolated hot spots. This alteration in casting shape by the addition of extra metal is known as metal padding.

Typical of the types of casting which must be padded with metal in order to obviate internal shrinkage are gear wheel blanks, valve bodies and bonnets, H-arm wheels, idler wheels, pistons, rolls and turbine casings. In the basic shape of these and other castings there are heavy sections which are isolated from sources of feed metal. Metal pads are therefore positioned in such a way that they promote directional solidification throughout the casting.

In order to regain the casting shape originally required, the added metal padding must be removed after the casting and feeder have solidified. The removal of the metal pad can involve one or more of the following operations: flame cutting, sawing, grinding and machining. These are lengthy and expensive processes and often create bottlenecks in foundry production. Padding removal therefore is uneconomic in itself and metal padding involves melting additional quantities of metal to that required for the metal castings themselves.

The promotion of progressive directional solidification has already been achieved to some extent by replacing metal pads with pads of exothermic composition which, when located in the mould cavity in appropriate positions, ignite on contact with the molten metal and supply sufficient heat to prevent premature solidification of the casting sections with which the exothermic materials are in contact, and hence there use promotes the required directional solidification.

Alumino-thermic compositions which have been used for this purpose are well known and are described for example in British Patent Specification Nos. 971 749 and 808 400. They generally consist of finely divided aluminium, one or more oxidising agents for the aluminium such as an alkali metal or alkaline earth metal nitrate or perchlorate, iron oxide or manganese oxide, a fluoride such as calcium fluoride or sodium aluminium fluoride to initiate and control the exothermic reaction, one or more particulate refractory fillers such as sand, alumina, grog, chamotte or other refractory silicate known *per se*, and one or more binders such as starch, dextrin, sulphite lye, gum arabic, resins such as phenol formaldehyde resin, sodium silicate and clays. The quantity of oxidising agent is usually stoichiometrically insufficient to oxidise all the aluminium present.

Although pads of such exothermic compositions if correctly applied promote progressive directional solidification, their use in its turn produces new problems. Due to the exothermic reaction, gases are evolved from the exothermic composition and these must be vented to the atmosphere outside the mould to avoid casting defects such as blow holes or pinhole porosity. Sometimes, because of the location of the exothermic pad in the mould it is difficult if not impossible to find a path from the pad to the atmosphere for the escape of gases evolved during the exothermic reaction.

It has also been observed when using exothermic padding materials that the surface of the metal casting in contact with the exothermic pad is rough and/or has been contaminated by undesirable impurities such as aluminium and silicon originating from the exothermic pad itself. Such roughness and contamination is undesirable and whilst it may be reduced by the extra application of an inert mould coating, it cannot always be eliminated. As a result, although exothermic padding materials are well known their commercial application has been restricted because of the problems described above.

It has been proposed to overcome the problems associated with aluminothermic or other exothermic padding compositions by the use of heat insulating pads of refractory fibrous material. British Patent Specification No. 1 240 301 described the use of such padding material in the production of metal castings.

Such materials generally comprise a refractory mineral fibre of, for example, alumino-silicate or calcium silicate, a particulate refractory filler as previously described and a binder system such as colloidal oxide hydrosols and/or starch and/or phenol formaldehyde resin.

However, although these padding materials do not contaminate the metal casting with undesirable impurities and do not cause gas defects, such as blowholes and pinholes porosity, they are not as efficient thermally as exothermic padding materials in promoting progressive directional

solidification, and furthermore the surface finish of that part of the casting which comes into contact with the heat insulating pad is noticeably poorer than that in contact with the rest of the mould. Heat insulating pads therefore have only a limited application in commercial castings production.

It has now been found that the merits of both types of padding material can be combined in a single padding composition which is sufficiently exothermic to overcome the thermal inefficiency of a purely heat insulating padding composition but which surprisingly does not contaminate the metal casting with undesirable impurities such as aluminium, providing that the padding composition does not contain any fluoride salts and is within certain limits of density.

According to the present invention there is provided a process for the casting of molten metal in a sand or like mould in which there are provided at one or more locations in the mould where it is desirable to promote progressive directional solidification, lining pads located either to constitute or to support the metal contacting surface of the sand mould and to provide with the remainder of the sand mould a cavity of the desired shape and dimensions, the pads being formed of a composition comprising particulate refractory material, finely divided aluminium, an oxidising agent for the aluminium and a binder, characterised in that the composition is substantially free of fluoride salts and contains a fibrous refractory material known *per se* and the pads have a density of 0.3 to 1.1 g/cm^3.

According to a further feature of the invention there is provided a process for the production of a sand or like mould for casting molten metal in accordance with the above process in which a padding composition comprising particulate refractory material, finely divided aluminium, an oxidising agent for the aluminium and a binder is applied to those portions of a pattern at which it is desired to promote progressive directional solidification in a casting of the shape of the pattern, moulding sand is applied around the pattern and the composition, the composition is hardened to produce pads, and the resulting mould and pads are stripped from the pattern, characterised in that the composition is substantially free of fluoride salts and contains a fibrous refractory material known *per se* and the pads have a density of 0.3 to 1.1 g/cm^3.

According to a further feature of the invention there is provided a padding material, comprising particulate refractory material, finely divided aluminium, an oxidising agent for the aluminium and a binder, for promoting progressive directional solidification in a metal casting, characterised in that the material is substantially free of fluoride salts, contains a fibrous refractory material known *per se* and has a density in the range of 0.3 to 1.1 g/cm^3.

The pads may be preformed and dried before being located in a mould or next to a pattern or they may be produced from a composition in the form of a flexible mat which can be placed in position in a mould or around a pattern or in the form of a mouldable mixture which can be rammed into position around a pattern or into a cavity in a mould. The flexible mat or the mouldable mixture may be dried by the action of heat or hardened by chemical means. A flexible mat or mouldable mixture which can be hardened chemically is preferred.

Suitable fibrous refractory materials include alumina fibres, alumino-silicate fibres and calcium silicate fibres such as slag wool, rock wool or mineral wool.

Suitable particulate refractory materials include alumina, mullite, sillimanite, chamotte, grog, calcined fireclay, calcined flint clay, silica expanded vermiculite, expanded perlite, calcined rice husks and crushed coke. It is important that the particulate refractory material contains no more than traces of fluoride salts otherwise metal castings produced using the pads are likely to be contaminated with aluminium.

Suitable oxidising agents include alkali metal nitrates, alkaline earth metal nitrates, alkali metal perchlorates, iron oxide and manganese oxide.

Suitable binders include organic binders such as resins dextrin, starch, sulphite lye, gum arabic and/or inorganic binders such as alkali metal silicates, colloidal oxide hydrosols and clays such as kaolin clays or ball clays.

The composition may also contain a small proportion of organic fibre, such as rayon fibre, particularly when the composition is to be used in the form of a flexible mat.

The preferred pad compositions are (percentages by weight):—

Fibrous refractory material	5—70
Particulate refractory material	5—70
Aluminium	4—30
Oxidising Agent	1—20
Binder (solids content)	2—20

In order to achieve good thermal insulation properties it is desirable that the density of the pads is as low as possible and in practice pads having a density of 0.3—1.1 g/cm^3 are satisfactory. Within this range the optimum density for a particular material will depend on the composition of the material because with most compositions refractoriness also decreases as density decreases.

As mentioned earlier the pads according to the invention may be manufactured and used in one of a number of ways. For example, the individual ingredients may be mixed in one of a number of suitable mixing machines and moistened with water until a rammable consistency is achieved. The mixture may

than be rammed into a cavity in a sand mould or core or laid against a casting pattern or compacted in a core box and hardened chemically or dried by the application of heat in, for example, an oven or by gentle application of a gas flame.

Alternatively, the ingredients may be mixed with water into a slurry which is then dewatered by connecting to vacuum a suitable shape mesh former immersed in the slurry in order to produce the required shape, in general as taught by British Patent Specification No. 1 204 742. It may be desirable to include a dispersion agent such as aluminium sulphate to aid in the dispersion of the ingredients in the slurry. The green shape may be dried in, for example, an oven or hardened chemically either separately or as an integral part of a core or mould. Pads made by the manufacturing method described, have a density when dried in the range 0.3 to 1.1 g/cm^3 and usually in the range 0.45 to 0.95 g/cm^3.

When pads are produced from a flexible mat or a mouldable mixture by chemical hardening the preferred method is to apply an alkaline substance to a few points on the surface of the mat or moulded mixture as described in British Patents 775 380 and 808 400. Suitable alkaline materials include hydroxides, carbonates and aluminates of alkali metals such as sodium and the materials are preferably applied to the pads as aqueous solutions. For the chemical hardening process to take place the presence of a water-soluble nitrate such as an alkali metal nitrate is essential. The alkali metal nitrate may be dissolved in the aqueous solution of the alkaline material or included in the composition of the flexible mat or mouldable mixture as at least a proportion of the oxidising agent present in the composition.

In order to delay commencement of the chemical hardening reaction it may be desirable to include in the composition forming the flexible mat or mouldable material a small proportion of a compound such as boric acid which will passivate the aluminium as described in British Patent 775 380.

The invention is illustrated by way of example with reference to the accompanying drawings in which Figures 1 to 3 are each a sectional view of a casting mould according to known practice and Figures 4 and 5 are according to the invention.

Referring to the drawings:

In Figure 1 a steel casting 1 having dimensions 110 mm×110 mm×110 mm is produced in a sand mould 2. The casting 1 is separated from a cylindrical feeder 3, 100 mm in diameter and 150 mm high by a plate 4, 220 mm high, 110 mm wide and 55 mm thick. The cylindrical feeder is lined by a refractory insulating sleeve 5. Without the use of metal padding as traditionally practised or without the use of some other form of padding material the casting 1 is unsound in the area 6.

Figure 2 illustrates the traditional steel foundry practice of utilising metal padding and the portion 7 of the plate 4 indicates the minimum possible additional metal needed to make casting 1 sound. The dotted lines indicate the amount of cutting and machining which would be needed to produce the required casting shape. The use of metal padding also requires an increase in the diameter of the feeder 3 from 100 mm to 125 mm.

Figure 3 illustrates an alternative prior art method of applying metal padding and the portion 8 of the plate 4 indicates the minimum metal needed in order to make casting 1 sound. Again it is necessary to increase the diameter of the feeder from 100 mm to 125 mm, and to remove a considerable quantity of metal in order to produce a casting of the required shape.

Figure 4 illustrates the use of a preformed and dried pad according to the invention. In the production of the mould 2 a preformed and dried pad 9 was placed against the pattern in the position indicated. The composition of the pad was:

	Percent by weight
Aluminium silicate fibre	26.0
Aluminium powder	10.0
Calcined alumina	38.0
Iron oxide	2.0
Colloidal silica sol (solids content)	12.0
Phenol-formaldehyde resin	10.0
Aluminium sulphate	2.0

and the pad had a density of 0.47 g/cm^3.

The casting 1 produced using the pad 9 was sound and was not contaminated by aluminium.

Figure 5 illustrates the use of a pad formed from a mouldable mixture according to the invention. A composition was produced as follows:

	Percent by weight
Alumino-silicate fibre	50.9
Aluminium powder	23.0
Colloidal silica sol (solids content)	2.0
Sodium nitrate	12.0
Calcined chamotte	9.0
Ball clay	3.0
Boric acid	0.1

60 parts by weight of water were added to 100 parts by weight of the composition to produce a mouldable mixture, and the mixture was rammed into a cavity in the mould 2 at the position indicated 10. After removal of the pattern a few spots of an alkaline solution were applied to the exposed face of the moulded mixture. The composition of the alkaline solution was:

	Percent by weight
Sodium nitrate	10
Sodium hydroxide	10
Water	80

As a result of the ensuing chemical reaction the moulded mixture hardened to form a pad. Previous tests using the same composition had produced pads having a density of 0.90 g/cm^3. Two hours after application of the alkaline solution molten steel was poured into the mould 2 and the resulting steel casting 1 was sound and was not contaminated by aluminium.

As a further illustration of the invention the following compositions were compared using preformed pads and sand moulds as shown in Figure 4.

(1) An exothermic composition according to British Patent No. 971749 containing sillimanite as refractory filler, 1% by weight potassium cryolite and 1% by weight sodium fluoride.

(2) An exothermic/heat-insulating composition consisting of 97.0% by weight of the composition shown on page 10 and 3.0% by weight calcium fluoride.

(3) A composition exactly as stated on page 5, i.e. containing no fluoride salts.

The density of each of the pads was recorded and casting soundness and aluminium pick-up in the casting face in contact with the pad were determined.

The following results were obtained:

Composition	Pad density (g/cm^3)	Casting soundness	Aluminium pick-up
1	1.51	SOUND	0.063%
2	0.47	SOUND	0.070%
3	0.47	SOUND	0.002%

As the table shows the pad according to the invention made from composition 3 was sufficiently exothermic even in the absence of fluoride and had sufficiently good heat insulation properties to produce a sound casting and did not cause the casting to pick up aluminium. In contrast the use of the exothermic composition 1 and the exothermic/heat-insulating composition 2, both of which contained fluoride, resulted in aluminium pick-up by the casting.

Claims

1. A process for the casting of molten metal in a sand or like mould in which there are provided at one or more locations in the mould where it is desirable to promote progressive directional solidification, lining pads located either to constitute or to support the metal contacting surface of the sand mould and to provide with the remainder of the sand mould a cavity of the desired shape and dimensions, the pads being formed of a composition comprising, particulate refractory material, finely divided aluminium, an oxidising agent for the aluminium, and a binder, characterised in that the composition is substantially free of fluoride salts and contains a fibrous refractory material known *per se* and the pads have a density of 0.3 to 1.1 g/cm^3.

2. A process for the production of a sand or like mould for casting molten metal in accordance with the process of claim 1, in which a padding composition comprising particulate refractory material, finely divided aluminium, an oxidising agent for the aluminium and a binder is applied to those portions of a pattern at which it is desired to promote progressive directional solidification in a casting of the shape of the pattern, moulding sand is applied around the pattern and the composition, the composition is hardened to produce pads and the resulting mould and pads are stripped from the pattern, characterised in that the composition is substantially free of fluoride salts and contains a fibrous refractory material known *per se* and the pads have a density of 0.3 to 1.1 g/cm^3.

3. A padding material for use in the process of claim 1 comprising particulate refractory material, finely divided aluminium, an oxidising agent for the aluminium and a binder, characterised in that the material is substantially free of fluoride salts, contains a fibrous refractory material known *per se* and has a density in the range of 0.3 to 1.1 g/cm^3.

4. A padding material according to claim 3 characterised in that it contains, by weight:—

Fibrous refractory material	5—70%
Particulate refractory material	5—70%
Aluminium	4—30%
Oxidising agent	1—20%
Binder (solids content)	2—20%

Patentansprüche

1. Verfahren zum Vergießen von geschmolzenem Metall in eine Sandform oder eine ähnliche Form, worin an einer oder mehreren Stellen in der Form, an welchen die Förderung der fortschreitenden gerichteten Verfestigung erwünscht ist, Auskleidungskissen vorgesehen sind, die so angeordnet sind, um entweder die Metall-berührende Oberfläche der Sandform zu bilden oder diese zu tragen und um mit dem übrigen Teil der Sandform einen Hohlraum von gewünschter Gestalt und gewünschten Abmessungen zu ergeben, wobei die Kissen aus einer Zusammensetzung gebildet sind, die ein teilchenförmiges feuerfestes Material, feinteiliges Aluminium, ein Oxidationsmittel für das Aluminium und ein Bindemittel umfaßt, dadurch gekennzeichnet, daß die Zusammensetzung praktisch frei von Fluoridsalzen ist und ein faseriges feuerfestes, an sich bekanntes Material enthält und daß das Kissen eine Dichte von 0,3 bis 1,1 g/cm^3 aufweist.

2. Verfahren zur Herstellung einer Sandform oder einer ähnlichen Form zum Vergießen von geschmolzenem Metall nach dem Verfahren gemäß Anspruch 1, wobei eine Kissenzusammensetzung, die ein teilchenförmiges feuerfestes Material, feinteiliges Aluminium, ein Oxidationsmittel für das Aluminium und ein Bindemittel umfaßt, auf solche Teile eines Gußformmodells aufgebracht wird, an welchen eine Förderung der fortschreitenden gerichteten Verfestigung in einem Gußstück mit der Gestalt des Modells erwünscht ist, Formsand um das Modell und die Zusammensetzung herum aufgebracht wird, die Zusammensetzung zur Bildung von Kissen gehärtet wird und die sich ergebende Gießform und Kissen von dem Formmodell abgestreift werden, dadurch gekennzeichnet, daß die Zusammensetzung im wesentlichen frei von Fluoridsalzen ist und ein faseriges feuerfestes, an sich bekanntes Material enthält und daß die Kissen eine Dichte von 0,3 bis 1,1 g/cm^3 besitzen.

3. Kissenmaterial zur Verwendung bei dem Verfahren von Anspruch 1, welches ein teilchenförmiges feuerfestes Material, feinteiliges Aluminium, ein Oxidationsmittel für das Aluminium und einen Binder umfaßt, dadurch gekennzeichnet, daß das Material im wesentlichen frei von Fluoridsalzen ist, ein faserförmiges feuerfestes, an sich bekanntes Material enthält und eine Dichte im Bereich von 0,3 bis 1,1 g/cm^3 aufweist.

4. Ein Kissenmaterial nach Anspruch 3, dadurch gekennzeichnet, daß es ausgedrückt in Gew.-%, enthält:

Faseriges feuerfestes Material	5—70%
Teilchenförmiges feuerfestes Material	5—70%
Aluminium	4—30%
Oxidationsmittel	1—20%
Binder (Feststoffgehalt)	2—20%

Revendications

1. Procédé pour la coulée de métal en fusion dans un moule en sable ou analogue dans lequel il est prévu en un ou plusieurs endroits du moule où il est souhaitable de favoriser une solidification direction-nelle progressive des tampons de garnissage positionnés de manière à constituer ou bien à supporter la surface du moule en sable en contact avec le métal et à créer avec le reste du moule en sable une cavité de la forme et des dimensions désirées, les tampons étant formés d'une composition contenant une matière réfractaire en particules, de l'aluminium finement divisé, un agent oxydant pour l'aluminium et un liant, caractérisé en ce que la composition est essentiellement exempte de sels de fluorure et contient une matière réfractaire fibreuse connue en soi et en ce que les tampons ont une densité de 0,3 à 1,1 g/cm^3.

2. Procédé pour la production d'un moule en sable ou analogue pour la coulée de métal en fusion conformément au procédé de la revendication 1, dans lequel une composition de garnissage comprenant une matière réfractaire en particules, de l'aluminium finement divisé, un agent oxydant pour l'aluminium et un liant est déposée sur les parties d'un modèle où on désire favoriser une solidification directionnelle progressive lors de la coulée du profil du modèle, du sable de moulage est déposé autour du modèle et de la composition, la composition est durcie pour produire des tampons et le moule et les patins résultants sont éjectés du modèle, caractérisé en ce que la composition est essentiellement exempte de sels de fluorure et contient une matière réfractaire fibreuse en soi et en ce que les tampons ont une densité de 0,3 à 1,1 g/cm^3.

3. Matière de garnissage utilisable dans le procédé de la revendication 1, comprenant une matière réfractaire en particules, de l'aluminium finement divisé, un agent oxydant pour l'aluminium et un liant, caractérisée en ce que la matière est essentiellement exempte de sels de fluorure, en ce qu'elle contient une matière réfractaire fibreuse connue en soi et a une densité comprise entre 0,3 et 1,1 g/cm^3.

4. Matière de garnissage selon la revendication 3, caractérisée en ce qu'elle contient, en poids,

Matière réfractaire fibreuse	5—70%
Matière réfractaire en particules	5—70%
Aluminium	4—30%
Agent oxydant	1—20%
Liant (teneur en solides).	2—20%

FIG.1.

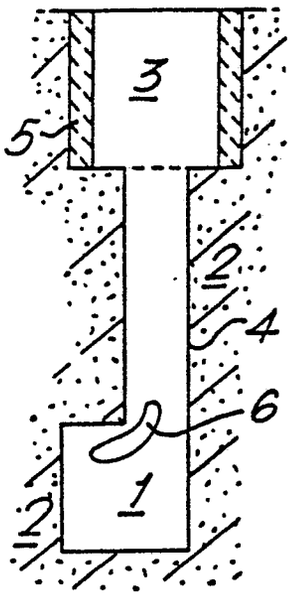

FIG.2.

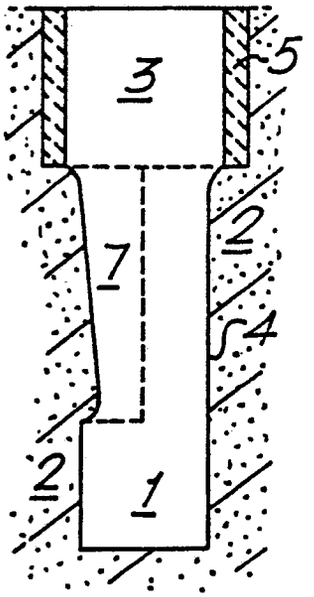

FIG.3.

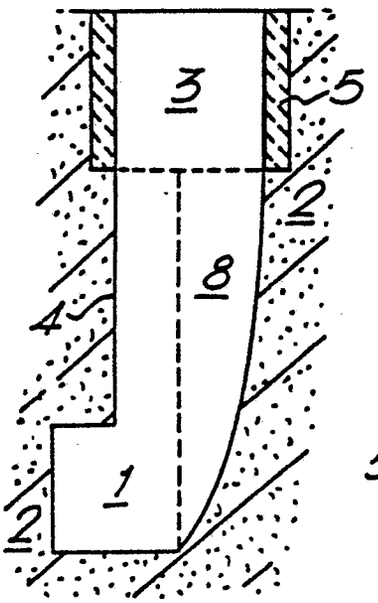

FIG.4.

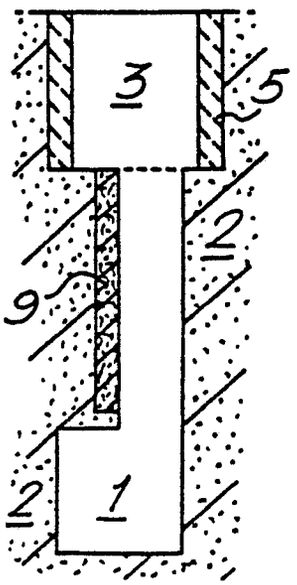

FIG.5.