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GB-A-1 278 265

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**GIESSEREI-PRAXIS, no. 23-24, 1979, Berlin, J.B.
v. NESSELRODE "Gusseisen mit
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Zylinderköpfe", pages 445 to 449**

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Description

This invention relates to a process for the manufacture of cast iron with vermicular graphite.

In U.K. Patent No. 1,278,265 a process for the production of nodular or spheroidal graphite cast iron castings in which untreated molten grey cast iron is introduced into the mould cavity by way of a conventional pouring system which additionally includes one or more intermediate chambers containing a nodularising agent in an amount sufficient to convert the graphite to nodular or spheroidal form is described.

It has now surprisingly been found that the pouring system described in the said prior patent enables castings of cast iron with vermicular graphite to be produced without the use of a nodular graphite inhibitor as mentioned below.

Vermicular graphite is a name given to flake graphite which has become rounded, thickened and shortened compared with the normal elongated flakes commonly found in grey cast irons. This modified form of graphite is known by several other names including "compacted", "quasi-flake", "aggregate flake", "chunky", "stubby", "up-graded", "semi-nodular", "P-type" and "floccular" graphite.

Most cast irons have elongated flake graphite structures and such irons are comparatively weak and brittle, but have good thermal conductivity and resistance to thermal shock. It is known however, that it is possible to produce cast irons having a nodular or spheroidal, graphite structure and these are ductile and comparatively strong. However, in some circumstances these nodular or spheroidal graphite structures have lower thermal conductivity and sometimes also poorer resistance to thermal shock. Irons with vermicular graphite structures combine the high strength and ductility often associated with nodular graphite irons whilst retaining good thermal conductivity and resistance to thermal shock.

The manufacture of cast iron containing vermicular graphite has been well known for many years by alloying the iron with magnesium. Various investigators have devised systems in an attempt to control the magnesium content. A narrow range of magnesium content is required to produce a vermicular structure and close control of the process necessary to achieve this has been difficult. One proposed method of control involves the addition of an alloying agent, normally magnesium, and an inhibiting or suppressing agent. The major problem with such two-part systems, e.g. magnesium alloying agent and a nodular graphite inhibitor is that, in practice, it is difficult to make accurate additions at the required levels, e.g. 0.015%. One part addition agents are known, that is agents comprising a combination of a suppressing agent and magnesium. However, in practice, it is difficult to achieve the correct balance of the two components.

In GB—PS—1,427,445 there is described a method of treating molten carbon-containing iron to produce cast iron with a compacted graphite structure comprising adding to the molten iron in a single step a quantity of an alloy containing silicon, magnesium, titanium and a rare earth, the balance being iron. The titanium acts as a nodularization inhibitor.

In DE—A—2,705,630 there is described a method similar to that described in GB—PS—1,427,445 in which the alloy also contains calcium.

The art therefore teaches the necessity of using a nodularization inhibitor when producing compacted vermicular graphite.

Iron inherently contains titanium to a certain extent that is up to about 0.015%. The presence of titanium above this level is known to be undesirable.

An article by A. M. Petrichenko et al, published as Paper 24 at the 45th International Foundry Congress Budapest 1978, discloses a special gating system and reaction chamber for a casting in the mould process and there is disclosure of Mg/S ratios necessary to achieve production of cast iron with vermicular graphite. No reference is made to an alloy which does not contain titanium.

According to the present invention, an alloy which does not contain titanium is used. This is made possible because the system described in UK—PS—1,278,265, with which a great detail of control can be achieved, makes possible the production of cast iron with vermicular graphite without having to use an alloy containing a nodularization inhibitor.

In carrying out the process of the invention a suitable base iron for the grey iron charge, excluding carbon, is:—

Si: 2.17% by weight

Al: 0.01% by weight

Ti: 0.013% by weight.

According to the present invention the size of the intermediate chamber, the pouring rate of the molten grey iron and the amount of magnesium retained in the cast metal may be determined according to the relationship defined in our U.K. Patent Specification Serial No. 1,511,246.

That is, the total area of the base or bases of the chamber or chambers [in cm²] are equal to a

$$\frac{\text{cm}^2\text{s}}{k \text{ kg}}$$

× (metal pouring rate) [kg/s] × (total concentration of the vermicularizing agent in the cast metal, expressed as a proportion of the weight of the cast metal) wherein *k* is a constant depending on the physical form and chemical composition of the vermicularizing agent.

According to this embodiment of the invention, the required amount of magnesium can be calculated with great accuracy.

For example, for a magnesium alloy agent with a grading in the range of 0.5 to 4 mm., the following constants (*k*) have been determined

k (6% Mg alloy) = .0225 kg/cm² (0.032 lb/in²) sec.

k (9% Mg alloy) = .0337 kg/cm² (0.048 lb/in²) sec.

We have found experimentally, using a magnesium alloy as the agent, that a product which is cast iron containing vermicular graphite can be obtained when the total concentration of the magnesium in the cast metal expressed as a proportion of the weight of the cast metal is between 0.01% and 0.02%.

Thus, using a 6% Mg alloy with a grading in the range of 0.5 to 4 mm and applying the relationship:—

Base area of intermediate chamber(s) (*A*) = (factor) × (pouring rate) × (desired concentration of agent) the following results are obtained

Magnesium required (desired concentration of agent) =	$\frac{A}{\text{factor} \times \text{pouring rate}}$	=	$\frac{kA}{\text{pouring rate}}$
0.02	$= \frac{0.0225 \times (A)}{\text{pouring rate}}$	=	$\frac{1.125 \times (A)}{\text{pouring rate}}$
0.015	$= \frac{0.0225 \times (A)}{\text{pouring rate}}$	=	$\frac{1.50 \times (A)}{\text{pouring rate}}$
0.01	$= \frac{0.0225 \times (A)}{\text{pouring rate}}$	=	$\frac{2.250 \times (A)}{\text{pouring rate}}$

The factor can then be determined.

The structure obtained is generally not totally vermicular graphite but is about 80% to 90% vermicular.

We have found that the amount of magnesium required to produce vermicular graphite is dependent on the sulphur level of the metal. The tests just described were carried out with a grey iron containing 0.01 to 0.015% by weight of sulphur. Where the sulphur content is higher, the amount of magnesium required will increase and vice-versa.

The invention is further illustrated by the accompanying drawing which illustrates one embodiment of a mould system used in the process according to the invention.

In this embodiment, molten metal containing a nodular graphite inhibitor enters the mould system by way of a pouring bush (not shown) down a downsprue 1 and into a reaction chamber 2 which contains the vermicularizing agent. A gate 3 regulates the outflow of metal from the chamber thereby ensuring a sufficient residence time for the metal in the chamber for reaction with the vermicularizing agent therein. From the gate 3 the treated molten metal flows via a runner 4 and ingate e.g. 5 to the remainder of the system comprising a riser and the mould cavity proper (not shown). Thus, as molten iron containing a nodular graphite inhibitor passes into the casting mould it contacts the vermicularizing additive in the intermediate reaction chamber 2 and the graphite in the iron is converted into vermicular form.

The present invention is further illustrated by the following Example which was carried out using a mould system as described above.

Example

A base metal containing a total carbon content of 3.4%, silicon 2.4%, sulphur 0.01% and titanium 0.015%, the balance being iron, was poured to obtain a total pound weight of casting, together with riser and runner bar, of 22 kg (50 lbs). The disc casting size was 50.8 cm (20 inches) × 2.54 cm (1.0 inch) and the pouring time was ten seconds.

The intermediate chamber contained a vermicularizing agent consisting of an alloy comprising 5% magnesium, 0.3 to 0.5% calcium, 0.2% cerium, 45—50% silicon with the balance being iron.

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The process parameters were selected to give a controlled magnesium content of 0.015%.

Thus, applying the relationship base area of intermediate chamber (A)=(factor)×(pouring rate)×(desired concentration of, Mg), the required base area of the intermediate chamber (A) was calculated as follows:

$$\begin{aligned} & \text{(factor)} = \frac{1}{k} \\ & k = 0.0225 \text{ kg/cm}^2 \text{ sec (0.032 lb/in}^2 \text{ sec)} \\ & A = \frac{\text{pouring rate} \times \text{Mg concentration}}{k} \\ & = \frac{0.015 \times 22}{0.0225 \times 10} \\ & = 14.66 \text{ cm}^2. \text{ (2.35 sq. inches)} \end{aligned}$$

Therefore the required base area of the intermediate chamber is approximately 3.88 cm×3.88 cm (1.53 inches×1.53 inches).

Using an intermediate chamber of these dimensions, a structure was obtained which was found to contain 90% vermicular graphite and 10% malformed nodules of graphite.

Claims

1. A process for the production of cast iron with vermicular graphite by casting molten grey cast iron containing sulphur into a mould cavity wherein the pouring system contains at least one intermediate chamber containing a magnesium containing vermicularising agent in an amount sufficient to convert the graphite to vermicular graphite characterised in that the level of the magnesium in the cast metal is from 0.01 to 0.02% and the level of sulphur in the cast iron is from 0.01 to 0.015%; in that the vermicularising agent is an alloy comprising 5% magnesium, 0.3 to 0.5% calcium, 0.2% cerium and 45—50% silicon, the balance being iron; and in that the grey cast iron contains an inherent amount of titanium of only 0.015%.

2. A process as claimed in claim 1 characterised in that the amount of vermicularizing agent in the resulting cast iron is controlled by selection of process parameters according to the relationship:—

area of the base or bases of the intermediate chamber or chambers [in cm²]=

$$\frac{1}{k} \left[\frac{\text{cm}^2 \text{s}}{\text{kg}} \right]$$

×(metal pouring rate) [kg/s]×(total concentration of the vermicularizing agent in the cast metal, expressed as a proportion of the weight of the cast metal), wherein *k* is a constant depending on the physical form and chemical composition of the vermicularising agent.

Patentansprüche

1. Verfahren zur Herstellung von Gusseisen mit vermikularem Graphit durch Vergiessen von geschmolzenem grauen, schwefelhaltigen Gusseisen in einen Formenhohlraum, bei dem das Giesssystem wenigstens eine Zwischenkammer enthält, welche ein Magnesium enthaltendes Vermikularisierungsmittel in einer Menge enthält, die ausreicht, den Graphit in einen vermikularen Graphit zu überführen, dadurch gekennzeichnet, dass die Menge des Magnesiums in dem Gussmetall 0,01 bis 0,02% und die Menge an Schwefel in dem Gusseisen 0,01 bis 0,015% beträgt, dass das Vermikularisierungsmittel in der Legierung 5% Magnesium, 0,3 bis 0,5% Calcium, 0,2% Cer und 45 bis 50% Silicium, Rest Eisen, umfasst, und dass das graue Gusseisen eine inhärente Menge an Titan von nur 0,015% enthält.

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2. Verfahren gemäss Anspruch 1, dadurch gekennzeichnet, dass die Menge an Vermikularisierungsmittel in dem gebildeten Gusseisen eingestellt wird, indem man die Verfahrensparameter gemäss der folgenden Beziehung kontrolliert:

5 Grundfläche oder Grundflächen der Zwischenkammer oder- kammern (in cm^2)=

$$\frac{1}{k} \frac{\text{cm}^2\text{s}}{\text{kg}}$$

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$\times (\text{Metallgiessrate}) [\text{kg/s}] \times (\text{Gesamtkonzentration des Vermikularisierungsmittels in dem Gussmetall, ausgedrückt als Gewichtsanteil des Gussmetalls}),$ worin k eine Konstante ist, die von der physikalischen Form und der chemischen Zusammensetzung des Vermikularisierungsmittels abhängt.

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Revendications

1. Procédé de fabrication de fonte à graphite vermiculaire par coulée d'une fonte grise fondue, contenant du soufre, dans une empreinte de moule, le système de coulée comportant au moins une
20 chambre intermédiaire contenant un agent vermicularisant contenant du magnésium en une quantité suffisante pour convertir le graphite en graphite vermiculaire, procédé caractérisé en ce que la concentration du magnésium dans le métal de coulée est de 0,01 à 0,02% et la concentration du soufre dans la fonte est de 0,01 à 0,015%; en ce que l'agent vermicularisant est un alliage comprenant 5% de magnésium, 0,3 à 0,5% de calcium, 0,2% de cérium et 45—50% de silicium, le reste étant du fer; et en ce
25 que la fonte grise contient une quantité inhérente de titane de seulement 0,015%.

2. Procédé selon la revendication 1, caractérisé en ce que la quantité d'agent vermicularisant dans la fonte résultante est réglée en choisissant les paramètres du processus suivant la relation:

surface de la base, ou des bases, de la chambre, ou des chambres, intermédiaires (en cm^2)=

30

$$\frac{1}{k} \frac{\text{cm}^2\text{s}}{\text{kg}}$$

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$\times (\text{vitesse totale de coulée}) [\text{kg/s}] \times (\text{concentration totale de l'agent vermicularisant dans le métal de coulée, exprimée en proportion du poids du métal de coulée}),$ où k est une constante qui dépend de la forme physique et de la composition chimique de l'agent vermicularisant.

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