(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 341 154 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.07.2011 Bulletin 2011/27

(51) Int Cl.:
C21C 1/10 *(2006.01)*

(21) Application number: **10382002.3**

(22) Date of filing: **05.01.2010**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

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(54) **Process for making nodular cast iron**

(57) The invention starts from the use of a metal chilled casting installation, with a further annealing heat treatment, which produces ferritic flake graphite gray cast iron.

The object of the present invention is a process which allows obtaining ferritic-perlitic nodular gray cast iron in metal chill-mold in the as-cast condition (without heat treatment) in the one and the same casting installation which produces ferritic flake graphite gray cast iron.

An embodiment variant provides for obtaining in parallel nodular gray cast iron and flake graphite gray cast iron in metal chill-mold, starting from a common load in the melting furnace.

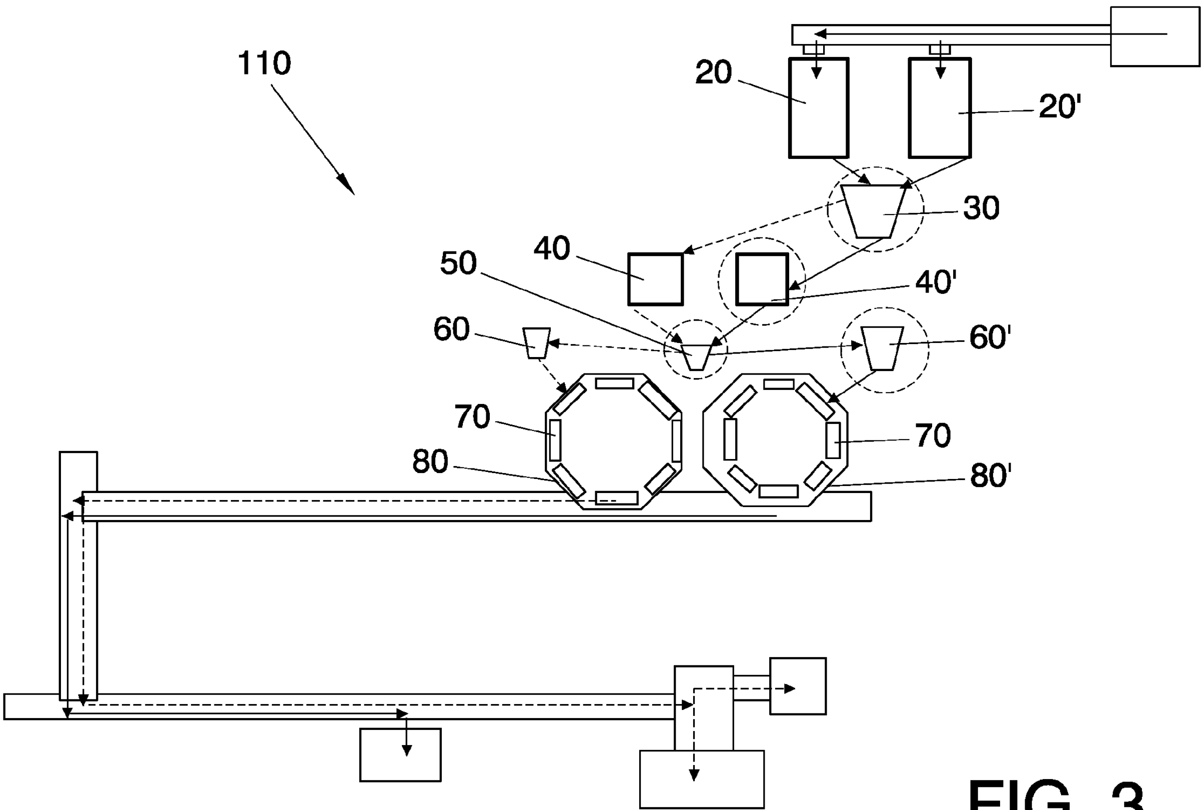

FIG. 3

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Description

Technical Field of the Invention

[0001] The invention starts from the use of a metal chilled casting installation, with a further annealing heat treatment, which produces ferritic flake graphite gray cast iron.

[0002] The object of the present invention is a process which allows obtaining ferritic-perlitic nodular gray cast iron in the as-cast condition in a metal chill-mold (without heat treatment) in one and the same casting installation which produces ferritic flake graphite gray cast iron.

[0003] An embodiment variant provides obtaining in parallel nodular gray cast iron in metal chill-mold and flake graphite gray cast iron, starting from a common load in the melting furnace.

Background of the Invention

[0004] Normally, the foundries are specialized in flake graphite type or nodular type casting. Thus, when they are required to produce the two casting qualities due to certain circumstances, it is necessary to separate the materials and the material transfer and casting elements, among other modifications of the foundry.

[0005] From another point of view, due the risks of contamination of some materials with others, it is necessary to perform the casting of one type of material before the other and that the returns (sprues, risers, defective parts, etc.) do not mix with the other type of material, i.e., it is not possible to melt the two types of materials at the same time or simultaneously. As a result, the raw material collections are extensive and require very strict controls.

[0006] The most currently used and common nodular casting process is the so-called *disamatic*®, in which green sand molds are used without metal cases, and the molding is carried out under high pressure. There are others such as molding with chemical setting, but the *disamatic*® system is preferably used for the automotive industry and more specifically for manufacturing several components of vehicle brake systems.

[0007] This nodular casting process produces very high quality parts for many sectors of the industry in general and particularly for the automotive sector, for example, the nodular casting allows obtaining parts for disc brakes (actuators) the components of which are clamps and forks. Likewise, brake parts such as the controls (master cylinders, wheel cylinders, compensators and clutch controls) have always been mainly cast in a metal chill-mold.

[0008] The casting parts for brake systems and, therefore, for safety systems need to have a series of characteristics which must be met to give the guarantees which are required by automobile manufacturers, ranging from the service, quality and price to the quickness in the development of new products at the lowest costs. Evidently, brake manufacturers require the same from the foundries that manufacture these parts.

[0009] The main characteristics in the parts that brake manufacturers require from foundries, in addition to the mechanical characteristics such as tensile strength, elastic limit, elongation, hardness, resilience and type of structure, are: the parts must be easy to machine, have a good machining surface finish, less wear of the tools when machining, the material must be very compact and have good leak-tightness, dimensional stability before and after machining, the parts must have a high capacity of thermal evacuation, and the material to be machined must be the minimal amount due to reduced tolerances.

[0010] With respect to the casting process, brake manufacturers require: that it has a good internal quality by a controlled variable process, that it has a high productivity, without intermediate stocks, that the lead time is the lowest possible, that the costs are very competitive and that the release of new products is very fast.

[0011] The foundries specialized in producing flake graphite gray cast iron in metal chill-mold have an increasingly more limited field in industrial sectors, such as the automotive and wind sectors, where parts of both qualities are required i.e., flake graphite gray cast iron and nodular gray cast iron quality. This is why the applicant of the present application, who is aware of the drawbacks and has ample experience in the field of casting, applies knowledge, research and innovation to developing a process which allows using, without needing structural changes, expansions and/or adaptations, a conventional flake graphite gray cast iron in metal chill-mold installation to also obtain nodular gray cast iron and even both qualities in parallel.

[0012] A flake graphite gray cast iron in metal chill-mold installation has at least one melting furnace, and its corresponding loader; at least one maintenance furnace; a transfer ladle for transferring the molten load from the melting furnace to the maintenance furnace; a distribution ladle for feeding the casting ladle; a carousel with a plurality of metal molds (chill-molds) in which the hot melt is cast; feeding and classification belts and an annealing heat treatment furnace.

[0013] The process for producing flake graphite gray cast iron in metal chill-mold, when only this type of quality is produced, is as follows:

> A loader feeds the metal and non-metal load to the melting furnace and when the metal is molten, with an equivalent carbon content of 4.40 to 4.60%, it is transferred to the maintenance furnace by means of the transfer ladle.

[0014] In the maintenance furnace, the composition and the temperature are refined. The molten load is passed from the maintenance furnace to the distribution ladle and from the latter to the casting ladle.

[0015] The casting ladle casts the cast iron in the molds and when the parts have solidified they are demolded.

[0016] The demolded parts are transported to the heat treatment furnace and from the latter to the different phases of the process of classification, unitary control and finishing.

Object of the Invention

[0017] The invention which is the object of this application is based on a conventional installation, such as the one described above and based therein, without any economic investment, without structural changes or expansions, it provides a process which allows obtaining ferritic-perlitic nodular gray cast iron in metal chill-mold. In a variant of the process, the two qualities of gray cast iron, i.e., nodular and flake graphite gray cast iron, can be obtained in parallel.

Description of the Invention

[0018] The process object of the present application, i.e., the process for obtaining nodular gray cast iron in metal chill-mold in the as-cast condition, comprises the following steps:

Feeding the melting furnace with a metal and non-metal load, to obtain an equivalent carbon content of 4.70 to 4.90 and transferring the load to the maintenance furnace by means of the transfer ladle.

[0019] In the maintenance furnace, the metal base is completely refined in terms of composition and temperature. When the base metal is correct, it is treated with Fe-Si-Mg and inoculant in the distribution ladle itself and then an additional amount of inoculant is added into the casting stream in the casting ladle.

[0020] Fe-Si-Mg is the nodulizing agent and 7 to 10% by weight of the load to be treated is added. The inoculant which is added together with Fe-Si-Mg is to reduce the formation of metal carbides (cementite) of the latter and to increase the power of nucleation (nodularization) at the time of the treatment. The amount of inoculant which is added in the distribution ladle is 0.15 to 0.22% the weight of the load.

[0021] The inoculant which is added into the casting stream in the casting ladle is to reinforce the non-precipitation of cementite due to the quick solidification of the metal in the chill-mold. This addition of inoculant into the casting stream in the casting ladle is 0.07 to 0.15%.

[0022] It is cast from the casting ladle into the metal molds and when the parts have solidified they are demolded and passed to containers in order to clean them, classify them and perform the unitary controls and carry out the finishing operations when they are cold.

[0023] In some cases, the parts with very special characteristics are passed through the heat treatment (ferritization) furnace to improve their strength and elongation values. Furthermore, the subsequent heat treatment gives a very special characteristic to the parts produced in metal chill-mold in terms of the absorption of noises caused by friction or contact with other parts (vibrations due to friction).

[0024] A variant of the invention provides a process which allows obtaining in parallel nodular gray cast iron and flake graphite cast iron in metal chill-mold, for which a metal and non-metal load is initially fed to a melting furnace.

[0025] The material of the melting furnace is transferred from the melting furnace both to a first maintenance furnace (for the flake graphite cast iron) and to a second maintenance furnace (for the nodular cast iron) by means of a transfer ladle.

[0026] However, in the event of producing flake graphite cast iron, FeP and FeMn are added in the transfer ladle and the material is poured into the first maintenance furnace.

[0027] And in the event of producing nodular cast iron, graphite, FeSi and FeMn are added in the transfer ladle and the material is poured into the second maintenance furnace.

[0028] Subsequently, the material is poured from the first maintenance furnace and from the second maintenance furnace to at least one distribution ladle; in which, in the event of producing nodular cast iron a nodulizing agent and an inoculant are added in the distribution ladle. And for the case of flake graphite cast iron no component is added.

[0029] The material is fed from the distribution ladle to at least one casting ladle, in which in the event of producing nodular cast iron an additional amount of inoculant is added in the casting ladle. For the case of flake graphite cast iron no component is added.

[0030] Finally, the material from the casting ladle is poured into at least one metal mold.

[0031] For the process of simultaneously obtaining nodular and flake graphite cast iron, the equivalent carbon content in the melting furnace is 4.4 to 4.60, for the purpose of allowing producing both types of cast irons.

[0032] In an additional embodiment, after adding the graphite, FeSi and FeMn in the transfer ladle for the nodular cast iron, a molten material with the following composition is obtained:

3.90-4.00% C;
2.60-2.80% Si;
0.65-0.70% Mn;
0.010-0.015% S and
0.10- 0.15% P.

[0033] Likewise, for the flake graphite cast iron, after adding FeP and FeMn, a molten material with the following composition is obtained:

3.57-3.62% C;
2.40- 2.50% Si;
0.60-0.70% Mn;
0.010-0.015% S and
0.30-0.35% P.

[0034] In the variant of the process for obtaining the two types of cast irons, for the purpose of preventing down times and optimizing the flow of materials, it is preferable to work with two maintenance furnaces and two carousels of metal molds. The melting furnace can be the same but it is more operative to use one of the melting furnaces for the flow of materials of the flake graphite gray cast iron and a second maintenance furnace for the flow of materials of the nodular gray cast iron.

Brief Description of the Drawings

[0035] To complement the description which is being made and for the purpose of aiding to better understand the features of the invention according to certain preferred practical embodiments thereof, a set of drawings is attached as an integral part of this description, in which the following has been depicted with an illustrative and non-limiting character:

Figure 1 schematically depicts a conventional type of installation for flake graphite cast iron production, in which the flow of materials has been indicated by means of arrows.

Figure 2 depicts the same diagram of the previous figure, in which the flow of materials has been indicated with arrows and the points at which the additives (nodulizing agent and inoculant) are added have been indicated with a circle.

Figure 3 depicts the same previous diagram in which the flow of materials for nodular cast iron has been indicated with solid arrows and the flow of materials for flake graphite cast iron has been indicated with dotted arrows, and the points at which the additives are added have been indicated with a circle.

Detailed Description of the Preferred Embodiments of the Invention

[0036] As has been mentioned, the present invention provides a process for making nodular cast iron using a prior art installation which is traditionally intended for flake graphite cast iron, which is described below.

Flake graphite cast iron

[0037] To contextualize the above, reference is made to Figure 1, which shows a traditional casting installation 10 formed by a melting furnace 20 in which a casting load introduced by a feeding belt 11 is melted. In this installation 10 there is also a transfer ladle 30 which receives the material from the melting furnace 20. Another part of this installation is a maintenance furnace 40 which is fed by the transfer ladle 30. In the installation 10, a distribution ladle 50 receives the material from the maintenance furnace 40 and feeds it to at least one casting ladle 60; from which the molten material is drained towards at least one metal mold 70 assembled in a carousel 80.

[0038] Once the parts have solidified, they are demolded and transported by means of a conveyor belt 12 and a classification belt 13 towards a heat treatment furnace 90 and from the latter to the different phases of the process of classification, unitary control and finishing. The returns are recovered at the outlet 95.

[0039] More particularly, to make the flake graphite cast iron the (metal and non-metal) casting load is fed to the melting furnace 20, when the metal is molten and an equivalent carbon content "Ce" of 4.40 to 4.60 has been achieved, the molten material is transferred to the maintenance furnace 40 by means of the transfer ladle 30, and there the composition and the temperature of the molten material are refined in the event that there is any deviation.

[0040] In a typical example of this type of flake graphite cast iron, the casting load comprises as metal materials: pig iron, first quality scraps, internal returns, graphite, FeSi, FeP and FeMn, achieving a composition of:

3.57-3.62% C;
2.40-2.50% Si;
0.60-0.70% Mn:
0.010-0.015% S and
0.30-0.35% P.

[0041] In turn, when the molten material reaches the maintenance furnace 40 its composition is the same as that present in the melting furnace 20, with some small adjustments if there is a deviation. Likewise, the same composition as the one of the maintenance furnace 40 is in the distribution ladle 50 and casting ladle 60.

[0042] Having described this installation, the way in which it is used to produce nodular cast iron according to the invention is described below.

Nodular cast iron

[0043] As has been described, an object of the present invention is to make nodular cast iron using an installation for obtaining flake graphite cast iron, to that end the process of the present invention which is described below with the aid of Figure 2 has been devised.

[0044] In the process, a casting load is fed by means of a conveyor belt 11 to a melting furnace 20; this casting load is then transferred to a maintenance furnace 40 by means of a transfer ladle 30.

[0045] The molten material is poured from the maintenance furnace 40 into a distribution ladle 50, adding thereto a nodulizing agent and an inoculant. The distribution ladle 50 is marked in Figure 2 by means of a circle with a dotted line to indicate that that is where the nodulizing agent and the inoculant are added, establishing a great difference with the prior art.

[0046] The distribution ladle 50 feeds the molten material to at least one casting ladle 60, in which an additional amount of inoculant is added; and, finally, the molten material is cast from the casting ladle 60 into metal molds 70 assembled in a carousel. Again, a circle with a dotted line is used to indicate that an additional amount of inoculant is added in the casting ladle 60.

[0047] In a preferred embodiment of this process, it is preferred that the equivalent carbon content in the melting furnace 20 is 4.7 to 4.90 to be able to obtain the nodular cast iron in the installation 10.

[0048] The casting load used for this process comprises: pig iron, first quality scraps, internal returns, graphite, FeSi and FeMn. In the maintenance furnace 40 this molten material is completely refined in terms of composition and temperature.

[0049] When the molten material has a correct composition and temperature, it is treated with the nodulizing agent and the inoculant in the distribution ladle 50. The nodulizing agent used is preferably Fe-Si-Mg and is added in a percentage of 7 to 10% with respect to the molten material to be treated. The inoculant which is added together with the nodulizing agent is to reduce the power of formation and precipitation of metal carbides (cementite) due to the quick solidification of the metal in the chill-mold and to increase the power of nucleation (nodularization) at the time of the treatment. The inoculant used is preferably of the Germalloy type with a composition of 71.50% Si; 0.88% Ca and 3.78% Al and is added in a percentage of 0.15 to 0.22 with respect to the molten material to be treated.

[0050] An oxidizing reaction and at the same time an increase of the Si due to the FeSi content in the alloy occur in the distribution ladle 50, after the treatment with the nodulizing agent and the inoculant.

[0051] After the treatment with the nodulizing agent and the inoculant, the molten material has the following composition in the distribution ladle 50:

3.60-3.80% C;
2.80-3.00% Si;
0.65-0.75% Mn,
0.008-0.013% S; and,
0.10-0.15% P.

[0052] The composition of the molten material in the distribution ladle 50 also contains residual Mg, Ti and Cu.

[0053] As has been mentioned, an inoculant is added in the casting ladle 60, which inoculant is preferably of the SMW type with the following composition 62.80% Si; 2.35% Ca; 0.97% Al; 0.81% Bi and 0.99% TR.

[0054] The inoculant which is added into the casting stream of the casting ladle is to reinforce the non-precipitation of cementite due to the quick solidification of the metal in the chill-mold. This addition of inoculant into the casting stream is carried out in a proportion of 0.07 to 0.15% by weight of the treated load.

[0055] As is observed in Figure 3, the molds 70 are assembled in a carousel 80, so that in the moment in which the parts have solidified they are demolded and passed to containers and when the parts have cooled, they are cleaned, classified, unitarily controlled and the finishing operations are carried out.

[0056] As is observed, the process of the present invention is characterized by the way in which ferritic-perlitic nodular gray cast iron in the as-cast condition (without heat treatment) is obtained, using the same installation with which the ferritic flake graphite gray cast iron with subsequent annealing heat treatment is produced.

[0057] In an embodiment of the process, when parts with very special characteristics are required, the parts are passed through the treatment (ferritization) furnace 90 to improve the strength and elongation values.

[0058] It is very important to mention that nodular casting in metal mold allows the produced parts to have advantages with respect to those made according to the prior art (disamatic type green sand, furan resin or chemical setting of the mold, ceramic, precoated sand etc.), the following can be mentioned among said advantages:

- Better machining as a result of the much finer and better distributed graphite nodules which reduce the shearing stresses and this is much more clearly shown when it is treated.
- The fineness and distribution of the graphite nodules also have another advantage over the quality of the surface finish state in machining: such as: milling, reaming, grinding, burnishing, rolling, boring and threading.
- Its surface finish quality often allows eliminating an obligatory rolling operation in another type of casting.
- It allows working at higher shearing speeds and the wear of tools is much lower, therefore the machining times and the stops for changing tools are reduced, which allows considerable productivity increases (in some cases productivity increases of 50% can be reached).
- Greater tightness since its hypereutectic composition causes a grain expansion during the solidification which, due to the rigidity of the mold, only allows doing it towards the interior, which causes a more compact cast iron. The fineness of the graphite nodules reduces the effect of notches, thus improving the resistance to pressure and also the fatigue strength.
- The metal mold furthermore allows a much greater reproducibility.

[0059] Other also very important properties which are obtained by means of casting in metal chill-mold are: the thermal evacuation capacity as a result of the well distributed and fine-grain structure, the reduction of the size tolerances due to the resistance of the metal mold during solidification, the possibility of reducing allowance or overthicknesses for machining due to its high stability and the reproducibility of the molds, as well as the capacity to produce small parts.

[0060] In addition to all that mentioned above, this type of part obtained by means of casting in metal chill-mold allows, with a subsequent treatment, acoustic absorption or non-amplification of noises just like compact graphite but with much better mechanical characteristics.

[0061] Another aspect of the present invention is described below.

Parallel flake graphite and nodular cast

[0062] In an embodiment variant, the process allows obtaining in parallel flake graphite and nodular cast iron, to that end reference is made to Figure 3, which shows a casting installation 110 similar to the one described for obtaining flake graphite in a conventional manner but in which, to make it more operative and profitable, using the times better, two melting furnaces, two maintenance furnace and two carousels of metal molds are used. For a better understanding of the installation 110, its common elements with respect to the installation of Figures 1 and 2 have the same reference numbers. In Figure 3 the flow of materials for nodular cast iron are marked with a solid line and for flake graphite cast iron they are marked with a dotted line.

[0063] In this casting installation 110 there is a melting furnace 20 for melting a casting load, a parallel melting furnace 20' for providing versatility to the process is also observed. In the casting installation there is also a transfer ladle 30 which receives the material of any of the melting furnaces 20 or 20'. It is also seen that there is a first maintenance furnace 40 and a parallel second maintenance furnace 40', both fed by the transfer ladle 30, the objective of each of these melting furnaces will be explained below. Likewise, a distribution ladle 50 which receives the material from the first maintenance furnace 40 or from the parallel second maintenance furnace 40' is seen in the installation.

[0064] In the installation there are also casting ladles 60 and 60' which are fed by the distribution ladle 50; and, finally, at least metal molds 70 assembled in carousels 80 and 80' in which the material is discharged from the casting ladle 60 or 60' are seen. The installation 110 also has a heat treatment furnace 90.

[0065] For the process of the present invention, a casting load is fed to the melting furnace 20 or 20'; the material from the melting furnace 20 is then transferred to a first maintenance furnace 40 (for the flake graphite cast iron) and to a second maintenance furnace 40' (for the nodular cast iron) by means of a transfer ladle 30, in which, in the event of producing flake graphite cast iron, FeP and FeMn are added in the transfer ladle 30, and poured into the maintenance furnace 40; and, in the event of producing nodular cast iron, graphite, FeSi and FeMn are added in the transfer ladle, and the material is poured into the parallel maintenance furnace 40'. The transfer ladle 30 is marked with a circle to indicate that said addition is carried out therein depending on the type of cast iron to be obtained.

[0066] The material is subsequently poured from the first maintenance furnace 40 or from the second maintenance furnace 40' to at least one distribution ladle 50; in which in the event of producing nodular cast iron a nodulizing agent and an inoculant are added to the distribution ladle 50. For the case of flake graphite cast iron no component is added.

[0067] Then, in the event of producing nodular cast iron an additional amount of inoculant is added in the casting ladle 60' whereas no component is added in the casting ladle 60 for flake graphite cast iron.

[0068] However, in this simultaneous process for obtaining both types of cast irons, the casting load comprises: pig iron, first quality scraps, internal returns, graphite and FeSi, achieving an equivalent carbon content in the melting furnace 20 or 20' of 4.4 to 4.60. In other words, one and the same load is used whether one type or another of cast iron is to be produced.

[0069] As has been described, the changes necessary for achieving one type of cast iron or another are done below. For the case of nodular cast iron, after adding graphite, Fe-Si and Fe-Mn in the transfer ladle 30, a molten material with the following composition is obtained:

3.90-4.00% C;
2.60-2.80% Si;
0.65-0.70% Mn;
0.010-0.015% S and
0.10- 0.15% P.

[0070] in the distribution ladle, Fe-Si-Mg is added as nodulizing agent and the inoculant is of the germalloy type with a composition of 71.50% Si; 0.88% Ca and 3.78% Al and is added in a percentage of 0.15 to 0.22 with respect to the molten material to be treated.

[0071] The composition of the molten material in the distribution ladle 50 for nodular cast iron is:

3.60-3.80% C;
2.80-3.00% Si;
0.65-0.75% Mn,
0.008-0.013% S and
0.10-0.15% P,

[0072] The molten material also contains residual Mg, Ti and Cu in the distribution ladle 50.

[0073] With respect to flake graphite cast iron, after adding FeP and FeMn in the transfer ladle 30, a molten material with the following composition is obtained:

3.57-3.62% C;
2.40- 2.50% Si;
0.60-0.70% Mn;
0.010-0.015% S and
0.30-0.35% P.

[0074] The composition achieved in the transfer ladle 30 with a phosphorus content of 0.30-0.35% allows increasing the castability and the manganese content neutralizes the action of the sulfur. After that the process is the same as that shown in Figure 1, i.e., the molten material from the maintenance furnace 40 passes to the distribution ladle 50 and from there to the casting ladle 60 to pour the molten material into the mold 70.

[0075] A very important aspect in the present invention relates to the metal molds used compared to the casting in any of the known types (disamatic type green sand, furan resin or chemical setting of the mold, ceramic, precoated sand etc.), since their specific properties are directly linked to their metallurgic structure and to the mode of preparation.

[0076] The process for obtaining nodular cast iron in the as-cast condition and in metal mold (chill-mold) has a series of advantages compared to the traditional disamatic sand process, including the following:

- The lead time passes from one day to two and a half hours.
- Evidently upon reducing the lead time, the control of the process is much easier and quicker and will therefore produce parts of a better quality.
- The process for manufacturing prototypes for new products passes from one month to one week.
- There are no intermediate stocks.
- Lower percentage of rejected parts due to the reduced lead time and furthermore without intermediate stocks.
- Capacity to produce smaller batches.
- Capacity to simultaneously cast 36 different parts.
- Better service due to: shorter lead time, without intermediate stocks, better control of the process, lower internal rejection, capacity for small batches, simultaneous manufacture of different references and greater quickness in the launch of new products.

[0077] Likewise, in an overall manner this installation which allows the simultaneous casting of both cast iron qualities has the following advantages:

- the same metal load quality.
- the same ferroalloys.
- the same melting furnaces.
- the same maintenance furnaces.
- the same distribution ladles.
- the same casting ladles.
- the same casting carousels
- the same casting chill-molds, with different references
- the same belts for discharging parts which have been completely cast.

[0078] In view of this description and set of figures, the person skilled in the art will understand that the embodiments of the invention which have been described can be combined in many ways within the object of the invention.

Claims

1. Process for obtaining nodular gray cast iron in metal chill-mold in a casting installation consisting of:

- at least one melting furnace (20)
- at least one maintenance furnace (40)
- at least one transfer ladle (30) for transferring the molten load from the melting furnace (20) to the maintenance furnace (40)
- at least one distribution ladle (50) for passing the loads of the melting furnaces to the casting ladle
- at least one casting ladle (60) fed by the distribution ladle (50)
- at least one carousel (80) with at least one metal mold or chill-mold (70) in which the material is discharged from the casting ladle (60) **characterized in that** it comprises the steps of:

a) feeding a casting load to a melting furnace (20);
b) transferring the molten material from the melting furnace (20) to a maintenance furnace (40) by means of a transfer ladle (30);
c) pouring the material from the maintenance furnace in a distribution ladle (50) adding thereto a nodulizing agent and an inoculant;
d) feeding at least one casting ladle (60) with the material from the distribution ladle (50), wherein an additional amount of inoculant is added in the casting ladle (60);
e) casting the material from the casting ladle (60) in a metal mold or chill-mold (70); and
f) cooling and demolding the part once solidified.

2. Process for obtaining nodular gray cast iron in metal chill-mold according to claim 1, **characterized in that** the equivalent carbon content in the melting furnace is 4.7 to 4.90.

3. Process for obtaining nodular gray cast iron in metal chill-mold according to claim 1 or 2, **characterized in that** the casting load comprises:

pig iron, first quality scraps, internal returns, graphite, FeSi and FeMn.

4. Process for obtaining nodular gray cast iron in metal chill-mold according to any of claims 1 to 3, **characterized in that** the nodulizing agent is Fe-Si-Mg and is added in a percentage of 7 to 10% with respect to the weight of the molten material to be treated.

5. Process for obtaining nodular gray cast iron in metal chill-mold according to any of claims 1 to 4, **charac-**

terized in that the inoculant added in the distribution ladle (50) is of the Germalloy type with a composition of 71.50% Si; 0.88% Ca and 3.78% Al and is added in a percentage of 0.15 to 0.22 with respect to the molten material to be treated.

6. Process for obtaining nodular gray cast iron in metal chill-mold according to any of claims 1 to 5, **characterized in that** after the treatment with inoculant and nodulizing agent, the molten material in the distribution ladle (50) has the following composition:

3.60-3.80% C;
2.80-3.00% Si;
0.65-0.75% Mn,
0.008-0.013% S and
0.10-0.15% P.

7. Process for obtaining nodular gray cast iron in metal chill-mold according to any of claims 1 to 6, **characterized in that** the inoculant which is added into the casting stream in the casting ladle (60) is of the SMW type with the following composition 62.80% Si; 2.35% Ca; 0.97% Al; 0.81% Bi and 0.99% TR and is added in the amount of 0.07 to 0.15% by weight of the load.

8. Process for obtaining nodular gray cast iron in metal chill-mold in an embodiment variant which allows obtaining in parallel flake graphite gray cast iron according to claim 1, **characterized in that** it comprises the steps of:

a) feeding a casting load to the melting furnaces (20) and (20');
b) transferring the molten load from the melting furnaces (20-20') to a first maintenance furnace (40) and to a second maintenance furnace (40') by means of a transfer ladle (30), wherein in the event of producing flake graphite cast iron, FeP and FeMn are added in the transfer ladle (30) and poured in the first maintenance furnace (40) and, in the event of producing nodular cast iron, graphite, FeSi and FeMn are added in the transfer ladle (30) and the load is poured into the second maintenance furnace (40');
c) pouring the material from the first maintenance furnace (40) or from the second maintenance furnace (40') in the distribution ladle (50); wherein in the event of producing nodular cast iron a nodulizing agent and an inoculant are added in the distribution ladle (50);
d) feeding at least one casting ladle (60) with the material from the distribution ladle (50), wherein in the event of producing nodular cast iron an additional amount of inoculant are added into the casting stream in the casting ladle (60); and,
e) casting the material from the casting ladle (60) into at least one metal mold (70); and
f) cooling and demolding.

9. Process for obtaining nodular gray cast iron in metal chill-mold according to claim 8, **characterized in that** the casting load comprises: pig iron, first quality scraps, internal returns, graphite and FeSi.

10. Process for obtaining nodular gray cast iron in metal chill-mold according to claims 8 and 9, **characterized in that** the equivalent carbon content in the melting furnace is 4.4 to 4.60.

11. Process for obtaining nodular gray cast iron in metal chill-mold according to any of claims 8 to 10, **characterized in that** for the nodular cast iron, after adding graphite, FeSi and FeMn in the transfer ladle (30), a molten material with the following composition is obtained:

3.90-4.00% C;
2.60-2.80% Si;
0.65-0.70% Mn;
0.010-0.015% S and
0.10- 0.15% P.

12. Process for obtaining flake graphite and/or nodular cast iron according to claims 8 to 11, **characterized in that** FeSiMg is added as a nodulizing agent in the distribution ladle (50).

13. Process for obtaining nodular gray cast iron in metal chill-mold according to claims 8 to 12, **characterized in that** the inoculant is of the Germalloy type with a composition of 71.50% Si; 0.88% Ca and 3.78% Al and is added in a percentage of 0.15 to 0.22 with respect to the weight of the molten material to be treated.

14. Process for obtaining nodular gray cast iron in metal chill-mold according to claims 8 to 13, **characterized in that** the composition of the molten material in the distribution ladle (50) is:

3.60-3.80% C;
2.80-3.00% Si;
0.65-0.75% Mn,
0.008-0.013% S and
0.10-0.15% P.

15. Process for obtaining nodular gray cast iron in metal chill-mold according to claims 8 to 14, **characterized in that** for the flake graphite cast iron, after adding FeP and FeMn, a molten material with the following composition is obtained:

3.57-3.62% C;

2.40- 2.50% Si;
0.60-0.70% Mn;
0.010-0.015% S and
0.30-0.35% P.

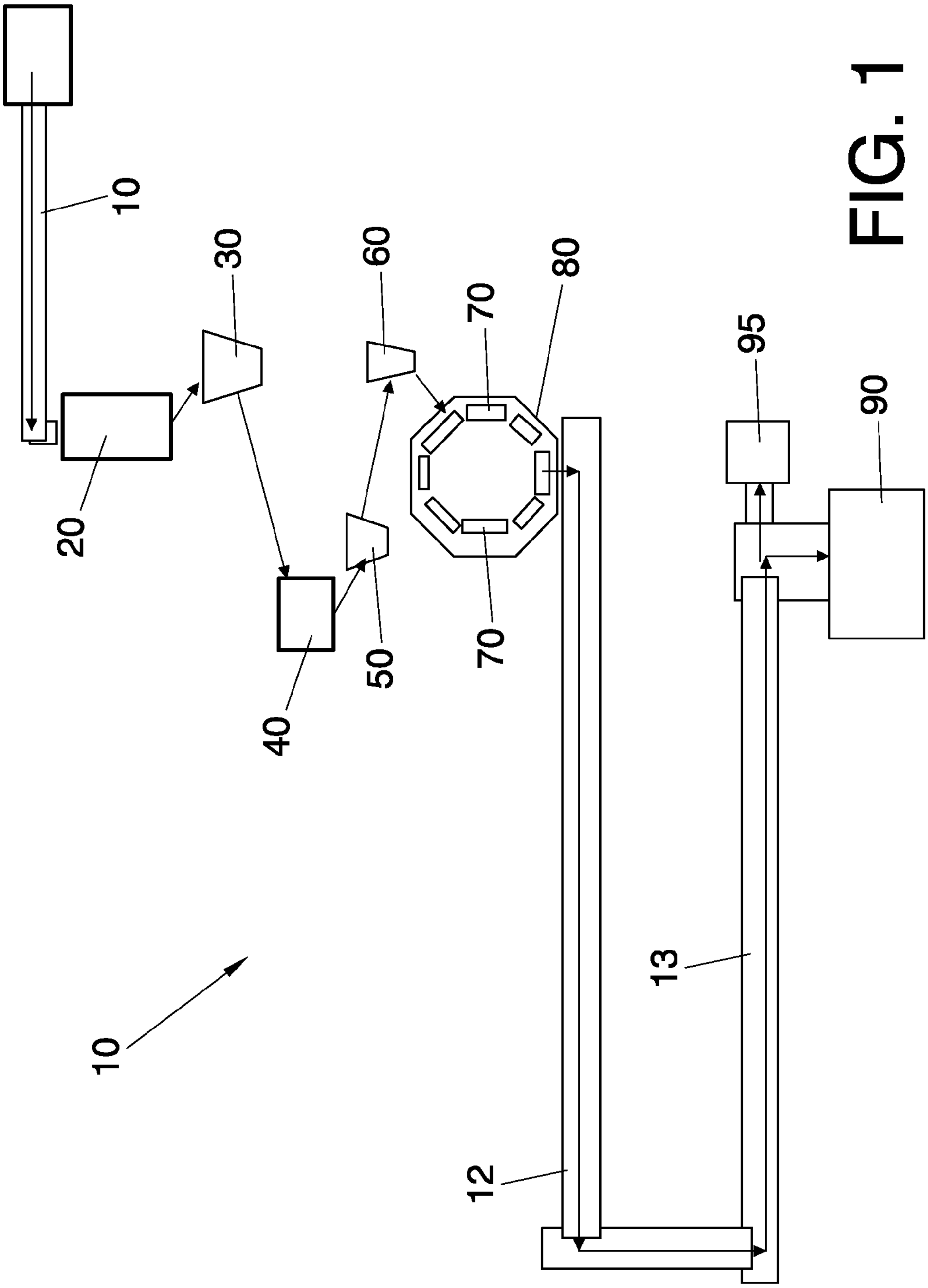

FIG. 1

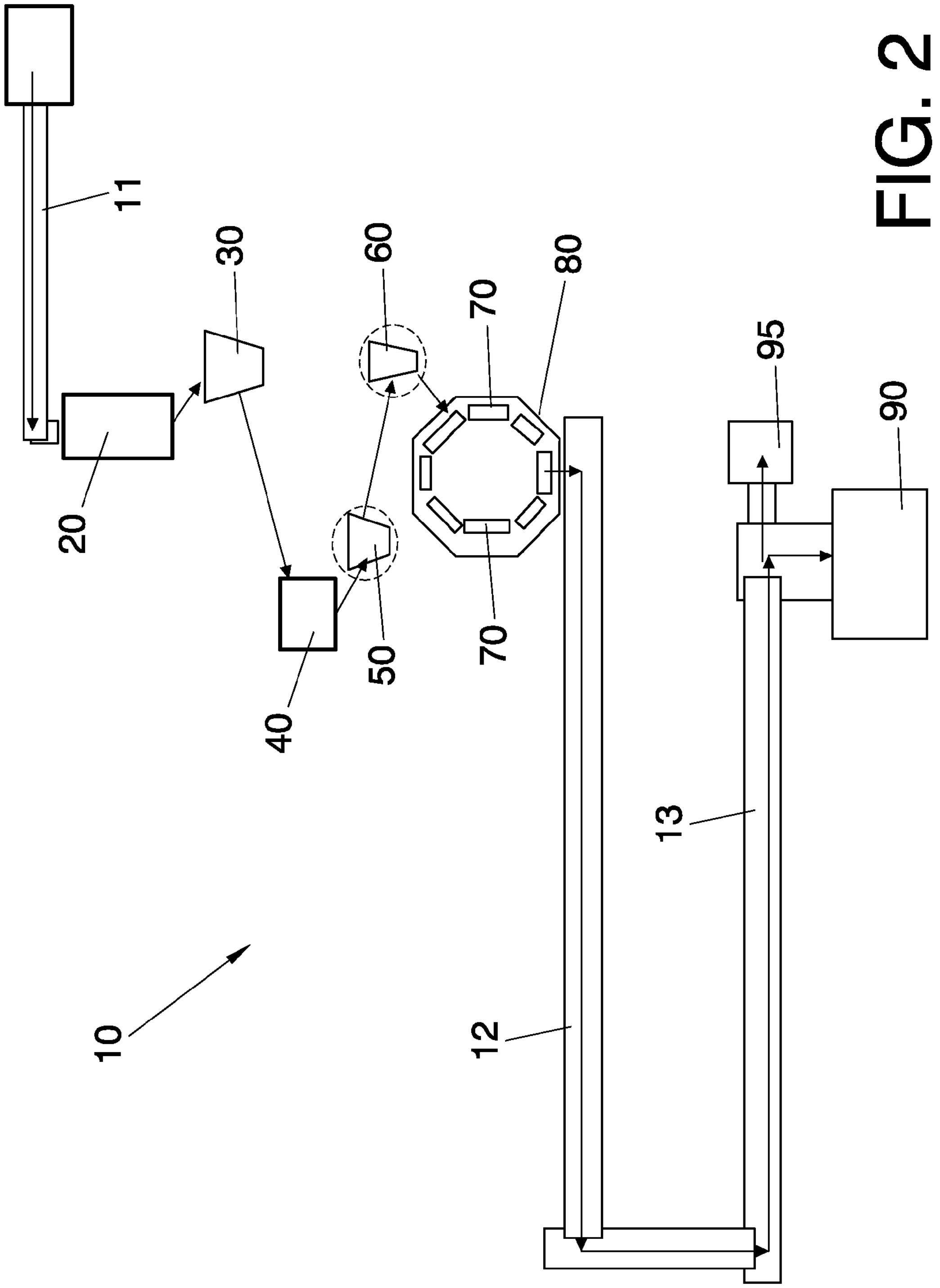

FIG. 2

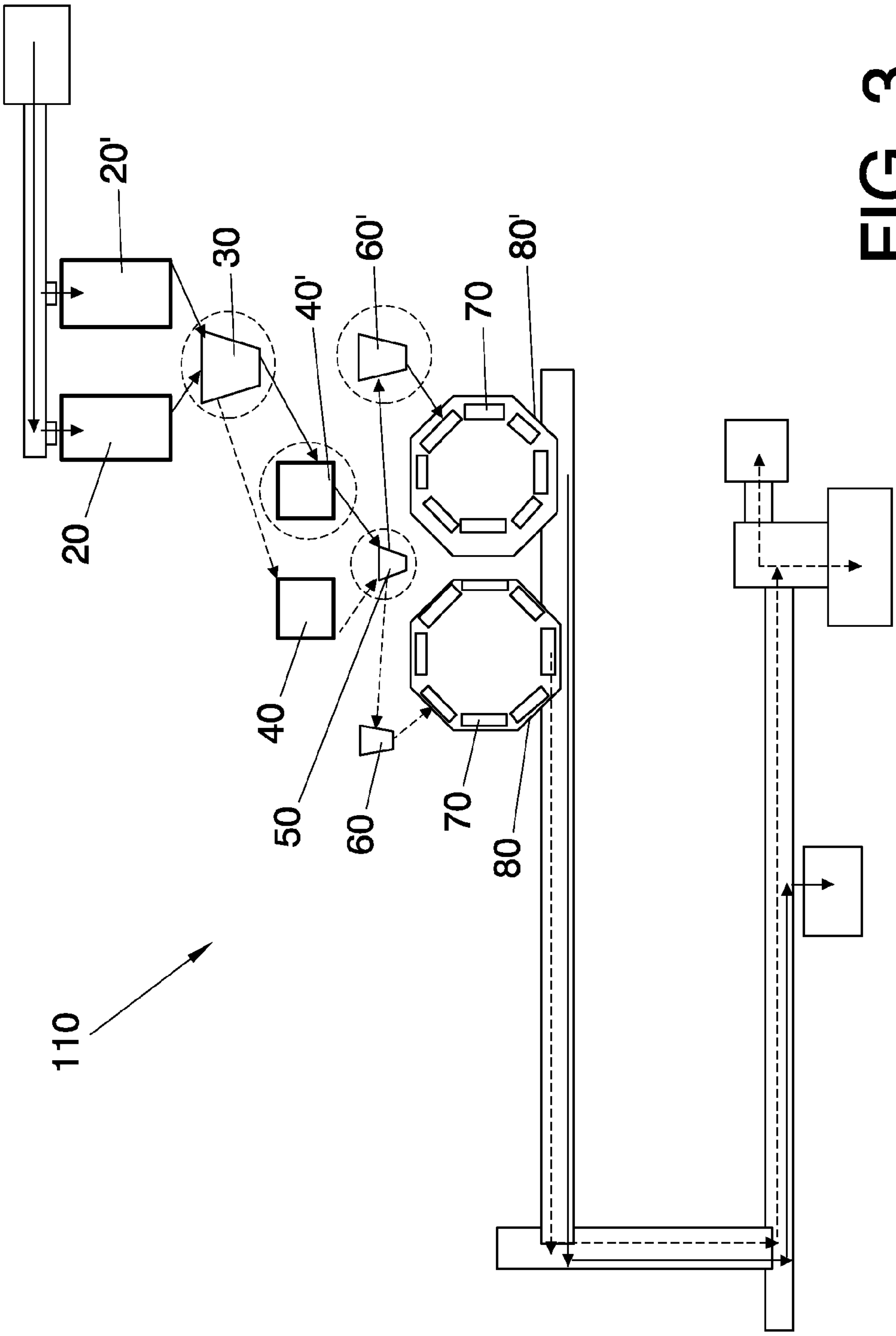

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 10 38 2002

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2 855 336 A (CURRY THOMAS W) 7 October 1958 (1958-10-07) * column 4, line 39 - column 9, line 25; figures 1-4 *	1-15	INV. C21C1/10
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C21C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	8 June 2010	Juhart, Matjaz

CATEGORY OF CITED DOCUMENTS

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