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SVEN-EINAR STENKVIST ETAL

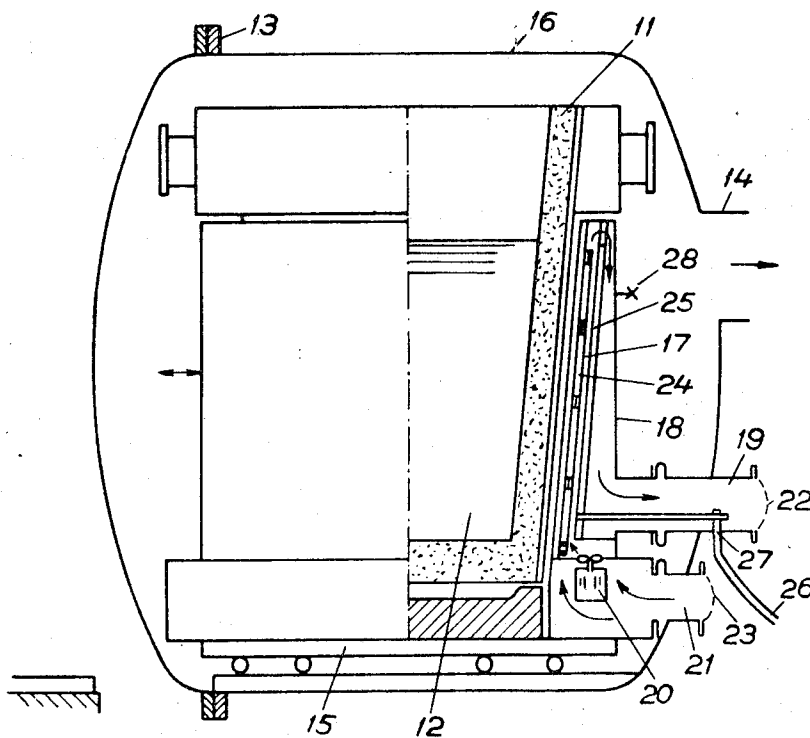
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DEGASSING OF MELTS

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2 Sheets-Sheet 1

Fig. 1



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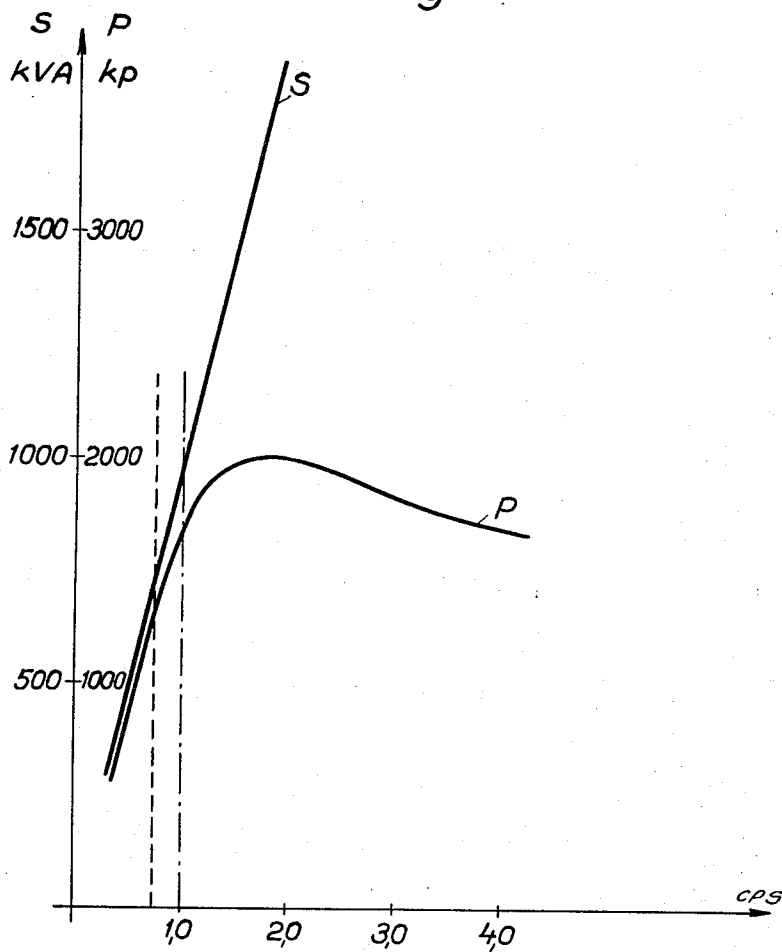
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Fig. 2



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DEGASSING OF MELTS

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3 Claims. (Cl. 75—49)

The present invention relates to a method of degassing melts of metal or metal alloys, such as steel, in which a container such as a ladle or a furnace containing a melt is enclosed in a vacuum tight tank or is provided with a vacuum tight cover which vacuum tight space is evacuated to a pressure below 50 torr, preferably below 20 torr.

The tank (space) is normally evacuated to a pressure of about 0.1 torr and during the first part of the vacuum treatment gas bubbles rise quickly to the surface of the melt and are then evacuated from the tank. It has been proved, however, that by this method, because of the hydrostatic pressure in the melt, the parts of the melt lying near the bottom of the ladle are not reached, and therefore are not subjected to the treatment. In order to remedy this, different ways have been tried to effect surface exchange in the melt, amongst others by applying an electro-magnetic stirrer, generally placed vertically at the side of the ladle. In the same way, the placing of several stirrers besides each other around the ladle, or also, as previously known, the use of stirrers in the form of circular coils around the container have been tried. The amount of degassing, i.e. the removal of such substances as for example N_2 , H_2 , O_2 has by these means been considerably increased since it has been possible to bring all parts of the melt at some time or other during the treatment in or near the surface, so that the amount of degassing becomes great.

It has, however, been proved that the intensity of the degassing during the latter parts of the vacuum treatment has been low or almost nonexistent, so that that part of the process takes such a long time that it is difficult to keep the melt from cooling more than is desirable. This involves considerable technical complications and expense in order to supply heat to the melt and therefore it is important that the degassing time is made as short as possible, so that either no additional energy is required for the melt or in any case as little additional energy as possible is required. The above mentioned stirring also has the advantage that furnishing of the additional energy needed to prevent excessive cooling—if it is thus required—is simplified. The surface of the melt can be heated, for example by arcs or by a cover enclosed over a ladle with a heating means and because of the stirring thus quickly produces an even temperature in the whole melt in spite of the great depth. If it is desired to have the amount of degassing as complete as possible in order to have a high quality in the end product, it is necessary to take steps which further increase the degassing effect even during the final part of the treatment.

The present invention relates to a process which increases the degassing effect and which considerably shortens the degassing time. A container (ladle, furnace or the like) is enclosed in a vacuum tight tank which is evacuated to a pressure suitably of about 0.1 torr, and the melt is stirred by means of an electro-magnetic, low frequency multiphase stirrer. The invention is characterised in that during the first part of the vacuum treatment the energy supplied to the stirrer remains low, after which during the intermediate part the stirring energy is increased, and during the last part the stirring energy is further increased. The gas inclusions which previously could not be

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reached during the stirring can now be brought to or in the vicinity of the melt surface, so that these can also be removed from the melt, for example the steel melt. It is clear both theoretically and practically that with stirring by means of electromagnetic stirrers the magnetic field is weakened when the distance from the stirrer is increased and when the field penetrates the casing of the container. The currents induced in the melt further effect their own magnetic field, which influences the stirrer field. The stirring power therefore is strongest nearest the container wall and then reduces towards the center of the melt. It is known that the stirring field penetration of the melt increases with reduced frequency, and it is amongst other things for this reason that the frequency in the stirrer is kept low (0.2–10 cycles per second). The low frequency is also a reason why the field penetrates the metallic wall of the ladle without inducing excessive currents in it. It has, however, been shown that this low frequency above is not sufficient in the later periods of a degassing treatment for sufficient degassing to be produced, but a temporary power increase (overloading) in the stirrer and in the electrical equipment in the final phase results in an addition to the stirring power during an otherwise critical phase, which means an essential shortening of the total degassing period and/or an increased amount of degassing. By making the overloading temporary, it is not necessary to dimension the stirrer and/or the other electrical equipment for a rated power equal to the maximum load in the final period. Neither is it necessary to increase the degassing power in the final period with a further increased vacuum which would of course complicate the equipment. It is possible to temporarily overload a rotating machine such as the generator of the stirrer, and the same is possible for the stirrer itself.

In a previous embodiment of the method according to the invention, the power is kept low during a third of the treatment, for example less than half the rated power, after which the power is increased to full rated output for a third of the whole process, and the power is further increased during the final third of the treatment. During the first part of the treatment gas bubbles spontaneously escape from the melt, including the lower parts of the melt, whereby the rising gas bubbles themselves effect fast stirring, and the power fed to the stirrer can be kept low. When these accessible gas inclusions have been released and the formation of bubbles in the melt has returned to normal, the power is increased to about normal power whereby a considerable movement of the melt is effected by the stirring, so that good degassing is produced. After a time, i.e. when the formation of bubbles has become insignificant, the stirring power is further increased, and the otherwise decreasing amount of degassing is counteracted by this, so that, without overdimensioning the stirrer and other electrical equipment, a satisfactory final condition of the treated melt can be obtained.

The method according to the invention is exemplified in FIG. 1, which shows stirring under vacuum according to the invention. FIG. 2 shows the relationship between the ratios of the necessary generator power to frequency and the corresponding stirring power to frequency respectively.

In FIG. 1 a ladle 11 with a stainless steel wall is shown (a ferro-magnetic wall would lower the stirring power), containing a steel melt 12. A vacuum tank 16 is connected vacuum tightly at 13 and provided with at least one evacuating conduit 14 going to an evacuating pump, not shown. The ladle on base 15 is placed inside the tank and the vacuum is raised. Near the ladle 11, beside and/or below it, are arranged one or several stirrers 17, suitably of air-cooled or water-cooled type. In the case shown the stirrer is enclosed in a casing of non-magnetic stainless steel connected with the atmosphere

(at 19) and with the chamber inside the tank 16 by a valve 28 opening and closing at a certain pressure. During the stirring a cooling fan 20 is used, intended to blow cool air along and/or through the stirrer 17. The air ducts 19 to the stirrer 17 and cooling fan 20 (21) can be provided with covers 22, 23, in order to maintain a certain vacuum and/or to keep a closed cool air circulation during the degassing process itself. The stirrer 17 consists usually of a rod 24 and a core 25 and is provided with longitudinal cool air ducts. The electrical energy is produced from a generator (not shown) over cables 26, drawn through the vacuum tight inlets 27.

When the ladle containing the melt is placed in the tank 16, this is evacuated to a pressure of about 0.1 torr. The pressure round the stirrer 17 is kept at atmospheric pressure. The reason why it is desirable to have no under-pressure around the stirring windings, or at least a higher pressure than that in the tank, is that particularly at higher voltages glowing would appear with accompanying insulation problems and energy losses. These phenomena are especially great during the high power output of the stirrer in the final period, i.e. the period when the highest voltage occurs in the stirring windings.

A strong current of rising gas bubbles is produced in the vacuum for the reason given above, which simplifies the stirring so that for a certain time, for example for 5 minutes, a lower power can be fed to the stirrer by using a lower voltage. The frequency is kept at about 1 cycle per second during the whole treatment process. The evacuation of gas inclusions in the melt proceeds easily during this first phase of the vacuum treatment. When the formation of bubbles becomes insignificant, the voltage over the stirrer (power output) is increased to rated power or voltage and the stirring power from the stirrer is increased, whereby a lively evacuation of gas can be maintained. It is also possible to increase the cooling of the stirrer (from the fan 20). This intermediate phase can be continued for about 5 minutes, during which the release of gas is gradually reduced.

When this release of gas has been reduced (the formation of bubbles has become small) the power output in the stirrer is increased to more than 25% above the rated power, suitably about 70% above the rated power during a further 5 minutes, so that the degassing can be maintained, and the quality of the degassed melt can be further improved. In this final phase higher cooling can be required, which can easily be effected by increasing the number of turns of the fan 20 or by coupling in a further fan or the like.

When 15 minutes of degassing has been applied, the evacuation is stopped, the vacuum is eliminated, the tank 16 is opened and the melt is brought to a tapping place (not shown). The frequency as mentioned will be kept between 0.2 and 10 cycles per second, suitably 0.3-1.5 cycles per second. The rated power for the generator of the stirrer is 250-2000 kva., suitably 750-900 kva. and the melt content should lie between 15 and 200 tons/ladle,

As mentioned the power increases on the stirrer (stirrers) are made intermittently in three steps, but it is also possible, of course, to make this more or less continually. It is even feasible to apply the method according to the invention to another container containing a melt, for example to arc furnaces, so that vacuum can suitably be effected between the furnace and a cover closing vacuum tightly against it. It is, of course, possible to produce an increase of the stirring by also altering the stirring frequency, which necessitates more complicated current producing devices. The diagram according to FIG. 2 shows by curve S the relation between the necessary generator power S and frequency, and by curve P the corresponding relation between the stirring power measured in kiloponds (kilograms force) and the frequency. It is evident that the greater the frequency produced, the greater the required power, while at the same time a maximum in the stirring power P is produced at a frequency around 2 cycles per second. The stirring is also great at 1 cycle per second and in production it is usual to use the area between the dotted lines in the figure.

The above given and other variations within the scope of the following claims are possible.

We claim:

1. Method for degassing melts of metal or metal alloys, which comprises placing the melt in a container, placing the container in a vacuum tight tank, evacuating said tank to a pressure of less than 20 torr, stirring said melt by means of an electromagnetic stirrer fed with a multiphase current of a frequency less than 10 cycles per second, and during a first interval of the stirring feeding a relatively low power to the stirrer, during an intermediate interval of the stirring feeding a larger power to the stirrer than during said first interval, during a last interval of the stirring feeding a further increased power to the stirrer.

2. A method as claimed in claim 1, in which the changes of power take place intermittently, each interval of the stirring comprising about a third of the total time of stirring.

3. A method as claimed in claim 1, feeding to the stirrer during said first interval a power not larger than half the rated power of the stirrer, feeding to the stirrer during said intermediate interval a power of about the rated power of the stirrer, feeding to the stirrer during the last interval a power at least 25% more than the rated power of the stirrer.

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