PROCESS FOR CONTINUOUS CASTING OF STEEL FOR MAKING GRAIN-ORIENTED ELECTRICAL SHEET IN STRIP OR SHEETS

Inventors: Paolo Arbitrio; Sandro Basevi; Alfredo Fornari; Antonio Sensi, all of Terni, Italy

Assignees: Centro Sperimentale Metallurgico S.p.A.; Terni Societa' Per L'Industria E L'Elettricità S.p.A., both of Rome, Italy

Filed: Dec. 28, 1970

Foreign Application Priority Data
May 19, 1970 Italy..............................50,811 A/70

U.S. Cl..................................164/89, 164/128
Int. Cl..................................B22d 11/12
Field of Search..........................164/82, 89, 283,
164/128, 122, 281

References Cited
UNITED STATES PATENTS
2,747,245 5/1956 Junghans.............................164/89
3,512,574 5/1970 Taylor..............................164/89
3,575,230 4/1971 Calderon............................164/82
3,630,267 12/1971 Hlinka et al........................164/82

FOREIGN PATENTS OR APPLICATIONS
911,066 5/1954 Germany..............................164/89
758,121 9/1956 Great Britain........................164/82
783,365 9/1957 Great Britain........................164/89

Primary Examiner—R. Spencer Annear
Attorney—Young & Thompson

ABSTRACT
A process for the continuous casting of steel for the manufacture of grain-oriented electrical sheet, in strip or in sheets, wherein a primary cooling water and a secondary cooling water is used, characterized in that the primary cooling water is maintained at the minimum value compatible with not damaging the mould and with the attainment of a sufficient mechanical strength in the outer shell of the output slab.

6 Claims, No Drawings
PROCESS FOR CONTINUOUS CASTING OF STEEL FOR MAKING GRAIN-ORIENTED ELECTRICAL SHEET IN STRIP OR SHEETS

The present invention relates to a continuous casting process for silicon steel suitable to make grain-oriented electrical sheet in strip or sheet form.

It is known that for making the silicon steel for magnetic use, the entire transformation cycle of the semifinished product is tied to a set of critical conditions which must be complied with, as far as both the teeming of steel ingots (weight, size and shape of the ingot) and the subsequent operations of hot and cold plastic working, and the thermal treatments, are concerned. It is also known that these critical conditions are strictly connected to one another, whereby if one or more of the aforesaid conditions are changed, particularly the conditions concerning the ingot making, it will no more be possible to control the reproducibility of the critical features of the final product. By the trend recently revealed of adopting the continuous casting also for the silicon steels, the problems connected to the metallurgical conditions characterizing the solidification of a conventionally cast ingot in pig iron ingot mold undergone a radical change whereby the manufactured products of silicon steel obtained by continuous casting will show a largely heterogeneous behavior, affecting the magnetic features of the finished product.

In fact, the influence shown by the composition, the dimensions and the distribution of the impurities in the grain orientation process is known; when the additive selected for this purpose is the sulphur, it is observed that due to the particular solidifying conditions occurring in the continuous casting, the distribution, composition and shape of the sulphides is such that a Bauman etching made on a continuous cast slab gives an almost invisible image of the distribution of said sulphides, contrarily to the result obtained from the Bauman etchings of the slabs, obtained from an ingot.

It is necessary, therefore in the silicon steel continuous casting, to achieve certain conditions which are rather critical.

The purpose of the present invention is that of specifying the critical variable values intervening during the continuous casting of said silicon steels, so as to attain a final product having an optimum and reproducible quality.

Following long tests on a continuous casting plant, said critical conditions, forming the subject matter of the present invention have been defined: said critical conditions, if respected, allow to obtain slabs which, when submitted to conventional subsequent working cycles, will originate a final product having magnetic features at least comparable to those obtainable by using conventional ingot cast steel. For instance, for a sheet 0.35 mm thick, the loss measured at 50 Hz and 15,000 Gauss is less than or equal to 1.11 Watt/kg and the permeability measured at 10 Oersted is greater than, or equal to, 1790 Gauss/Oersted.

According to the present invention, the molten steel to which all substances capable of imparting to it the desired magnetic features have been added, is stirred within the ladle, by blowing argon through it so that it will have at the start of the casting a temperature comprised between 1,560°C and 1,600°C, preferably a temperature comprised between 1,560°C and 1,570°C. The casting is made by means of submerged nozzles from the ladle to the tundish and therefrom to the molds, and the molten metal is protected by a slag consisting essentially of CaO, SiO₂, Al₂O₃, CaF₂. The molten metal is cast so as to have a feeding speed of the slab included between 700 and 1,000 kg/min, and for slabs of 900 × 140 mm the feed speed is about 800 kg/min.

The primary cooling water of the continuous casting plant has the minimum possible flowing rate so as to ensure the sealing of the mold and a sufficient mechanical strength of the solidified outer shell of the slab in order to allow for its extraction with no break. The primary cooling water has a flow rate comprised between 2.8 and 4 cu.m/ton of steel; for a slab of 900 × 140 mm the water flow rate must not be greater than 3.6 cu.m/ton of steel.

The secondary cooling water of the continuous casting plant, sprayed along a variable number of zones will have such a flow rate as to allow for the minimum possible removal of heat in order to have at the extraction rolls of the machine, the cross sectional area of the slab entirely solidified. Said water flow rates are comprised between 0.16 and 0.24 cu.m/ton of steel in the first of said zones, while in the other zones the rate will be included between 0.04 and 0.10 cu.m/ton.

**EXAMPLE**

A heat of 50 tons of steel having the following analysis: C 0.04, Si 3.10, S 0.022, P 0.015, Mn 0.065, Cr 0.08, Ni 0.10, Mo 0.02, Cu 0.10 Al less than 0.005, the balance being iron, is brought to the continuous casting plant after stirring by Ar, at a 1,580°C temperature, then the steel is cast in the copper mold (1,500 mm high, 900 mm wide, 140 mm thick) and after the mold has been filled, it is covered by protecting slag. The casting is started at a rate of 840 kg of steel per minute. The flow rate of the primary cooling water is adjusted at 3.6 cu.m/ton. The secondary cooling is adjusted as follows: 1st zone 0.2 cu.m/ton, 2nd zone and following four zones: 0.08 cu.m/ton.

The so obtained slabs are stacked and left to slowly cool in still air. After working the final sheet has the features as follows: 0.35 mm thick, loss at 50 Hz and 15,000 Gauss equal to 0.95 watt/kg and permeability at 10 Oersted equal to 1810 Gauss/Oersted.

The sulphur contents of the continuously cast steel according to the present invention equals 90 percent by weight of the sulphur contained in the corresponding type of the ingot-cast steel. The carbon contents of the continuously cast steel according to the process of the present invention is higher by 0.01 percent by weight than that of the corresponding type of steel conventionally teamed into ingot molds.

Having thus described the present invention, what is claimed is:

1. A process for the continuous casting of silicon steel for the manufacture of grain-oriented electrical sheet and strip, comprising casting silicon steel into a continuous casting mold at a temperature between 1,560°C and 1,600°C, cooling the mold by passing through the mold primary water at a flow rate less than 3.6 cubic meters per ton of steel, spraying on the slab that emerges from the mold secondary cooling water in a first zone at a rate between 0.16 and 0.24 cubic meter per ton of steel, and spraying on said slab which
emerges from said first zone further secondary cooling water in a second zone at a rate between 0.04 and 0.1 cubic meter per ton of steel.

2. A process as claimed in claim 1, in which said silicon is about 3.1 percent by weight.

3. A process as claimed in claim 2, in which the steel contains about 0.04 percent by weight carbon.

4. A process as claimed in claim 1, in which said temperature is between 1,560°C. and 1,570°C.

5. A process as claimed in claim 1, in which the steel contains sulphur in an amount about 90 percent of the sulphur contained in the corresponding type of steel conventionally teemed into ingot molds.

6. A process as claimed in claim 1, in which the steel contains carbon in an amount higher by about 0.01 percent by weight than that of the corresponding type of steel conventionally teemed into ingot molds.

* * * * *