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METHOD OF PRODUCING STEEL FOR SHEETS TO BE ENAMELLED BY THE SINGLE-COAT METHOD

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In recent years single-coat enamelling methods have been increasingly used in industry because of their simplicity and the quality of the enamel coating, but principally because of the substantially reduced sensitivity to deformation and impact stresses. However, they impose special requirements on the material to be enamelled, particularly in respect of its carbon content, which must be very low. Since hitherto it has not been possible by conventional metallurgical methods to produce steels having sufficiently low carbon contents, the expedient has been adopted of reducing the carbon content of steel sheet by existing but expensive annealing processes. In addition to high cost, however, such methods of annealing have the disadvantage that undesirable variations occur in the technological properties of the material, which are caused mainly by the formation of coarse grains and partial scaling of the grain boundaries.

The present invention comprises a method by which the particular composition, particularly the carbon content of the steel, can be adjusted by metallurgical measures and sheets produced without any special annealing treatment.

The method of this invention makes use of conventional refining processes, preferably the oxygen blowing process, by which a steel is produced having a carbon content of about 0.03 to 0.06% and a comparatively high oxygen content of about 0.10 to 0.12%. By vacuum treatment the carbon content of the steel is thereupon reduced to below about 0.01%, whereupon the melt is brought to an oxygen content of about 0.08% by the known reaction C+O=CO. Deoxidation elements, preferably aluminium, are then added to the steel in vacuo. The addition of aluminium should be so calculated that the free aluminium content of the melt amounts to less than 0.015%. The desired low aluminium content may be reliably obtained by introducing a quantity of aluminium of about 1 kg. into the vacuum plant per ton of steel. After addition of the aluminium, the melt is advantageously vigorously mixed for a short period, so that, with a slight excess of aluminium, the soluble aluminium fraction is substantially reduced by reaction with the iron oxide absorbed from the refractory lining.

Steel produced in this manner is cast into slabs or ingots when it can be rolled in the usual way. It can be cast particularly satisfactorily in a continuous casting machine, since the difficulties which otherwise occur in the casting of steels having a low aluminium content by the continuous casting method, resulting from peripheral blow holes, are in this case entirely eliminated.

For certain existing single-coat enamelling processes it is necessary to use sheets having an extremely low carbon content, that is to say those having a carbon content of less than 0.005%. In order to achieve such values it is advisable to assist the vacuum treatment by introducing an inert flushing gas. However, here again it is essential for removal of the carbon to be effected with a relatively high oxygen content of the steel (C+O=CO) and that the free oxygen content should

be reduced only after the removal of carbon, by adding deoxidising agents, preferably aluminium.

As a further feature of the method of this invention about 0.005% of boron is added to the steel after the removal of carbon and oxygen. It has been found that by adding boron it is possible to compensate for small unintentional fluctuations in the oxygen content, thereby reliably obtaining an optimum solidification structure without peripheral blow holes. In addition, the addition of boron improves the ability of the sheets to be pickled, so that only small quantities of iron have to be removed in order to obtain good adhesion of the enamel coating.

Example

A steel refined in an oxygen blowing converter to a carbon content of 0.04% and an oxygen content of 0.10% is subjected after tapping to vacuum treatment. The latter will be explained with the aid of a vacuum syphon process, which is the subject of British Patent No. 801,518. In this process the steel contained in a pouring ladle is drawn by suction, a part at a time into a degasification vessel situated above the pouring ladle and after degasification is returned to the latter, simultaneously being mixed with the steel contained in the ladle. In the present case a fraction of about 10 tons is drawn by suction into the degasification vessel from the total quantity of 60 tons of steel contained in the pouring ladle, and after degasification is returned to the ladle through variation in the difference in height between the latter and the degasification vessel. This partial treatment lasts about 15 seconds. After about 1.5 minutes therefore the entire content of the ladle has passed once through the degasification vessel. This treatment is continued for about 10 minutes, at the end of which the steel contained in the ladle will have passed about 8 times through the degasification vessel. During this time nitrogen is additionally introduced as a flushing gas through the suction inlet of the degasification vessel and after the adjustment of the carbon content to the required amount, aluminium is added in vacuo at the rate of 1 kg. per ton, followed after about two minutes by addition of boron in the form of 20% ferroboron at the rate of 50 g. per ton. Two further mixing operations complete the vacuum treatment.

The result of this treatment is a steel having the following composition:

C, 0.005%; O_2, 0.006%; soluble Al, 0.008%; B, 0.004%.

The steel is cast into slabs by top-pouring, a high pouring speed producing the best surface results. After rolling in the usual manner into cold-rolled sheets of a thickness of 1 mm., the steel was then enameled by the single-coat method, excellent adhesion of the enamel coating being obtained by removal of only about 15 grams per square metre of surface instead of the removal of 40 grams per square metre of surface which is otherwise customary in the pickling process.

What is claimed is:

1. A method of producing steel for sheets to be enamelled by the single-coat method, which comprises the steps of (a) producing by a refining process a steel having a composition which has a relatively high oxygen content of about 0.10 to 1.12% with a carbon content of 0.03 to 0.06% thereafter (b) treating the steel melt to reduce its carbon content to below about 0.01%, (c) subjecting the steel to a deoxidation treatment in vacuo to reduce the oxygen content to a predetermined level, (d) vigorously mixing the steel in vacuo, (e) pouring the steel to produce slabs, and (f) rolling the slabs into sheets.

2. The method claimed in claim 1, in which the refining treatment is carried out by oxygen blowing.

3. The method claimed in claim 1 in which deoxidation of the steel is effected by the addition of aluminium to the melt.

4. The method claimed in claim 1 in which the refining process is carried out to a stage in which the steel has a carbon content of about 0.04% and an oxygen content of about 0.10%.

5. A method of producing steel for sheets to be enamelled by the single-coat method, which comprises the steps of (a) producing by a refining process a steel having a composition which has a relatively high oxygen content of about 0.10% with a carbon content of 0.04% thereafter (b) treating the steel melt to reduce its carbon content to below about 0.01%, (c) subjecting the steel to a deoxidation treatment in vacuo to reduce the oxygen content to a predetermined level, (d) vigorously mixing the steel in vacuo, (e) pouring the steel to produce slabs, and (f) rolling the slabs into sheets.

6. The method claimed in claim 5 in which following the refining process the steel is subjected to vacuum treatment by the syphon method in which a portion of the steel contained in a casting ladle is withdrawn by suction into a degasification vessel disposed above the casting ladle and after degasification returned to the ladle, the operation being continued until the carbon content has been reduced as required.

7. The method claimed in claim 6 in which about 1 kg. of aluminium per ton is added in vacuo to the steel after

adjustment of the carbon content, and after repeated mixing the steel in the vacuum container by varying the distance between the latter and the pouring ladle, the charge is tapped into conventional steel works or continuous casting moulds.

8. The method claimed in claim 7 in which during degasification treatment of the steel, nitrogen is introduced into the vacuum container through the suction inlet.

9. The method claimed in claim 3 in which after deoxidation with aluminium the steel is alloyed in vacuo with boron, advantageously by adding 50 grams of boron per ton in the form of 20% ferroboron.

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