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Aronson et al.

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[54] **PRODUCTION OF FERRITIC STAINLESS STEELS CONTAINING ZIRCONIUM**

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[22] Filed: **Mar. 17, 1972**

[21] Appl. No.: **235,849**

[52] **U.S. Cl.** ..... **75/130.5;** 75/126 C; 75/126 F; 148/135

[51] **Int. Cl.**[2] **C22C 33/00**

[58] **Field of Search** ..... 75/130.5, 126 F, 126 C; 148/37, 135, 12

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[57] **ABSTRACT**

Ferritic stainless steel slabs which can be rolled into strip and sheets free from surface defects are made by incorporating zirconium in the steel in amounts between about seven times and about fourteen times the combined carbon and nitrogen percentages by weight and grinding the slab surface.

3 Claims, No Drawings

PRODUCTION OF FERRITIC STAINLESS STEELS CONTAINING ZIRCONIUM

This invention relates to the manufacture of stainless steels which are ferritic at all temperatures up to their melting points. These are called hereinafter "fully ferritic" steels. It is more particularly concerned with a process for making slabs of fully ferritic stainless steel suitable for rolling into strip free from surface defects.

The stainless steels with which our invention is concerned are those free from deliberately added austenite formers and which contain ferrite formers in amounts sufficient to render them ferritic at all temperatures up to their melting temperatures. Chromium is, of course, a ferrite former. The unavoidable impurities carbon and nitrogen are austenite formers. If chromium is the only ferrite former present, steels containing more than about 20% chromium are fully ferritic as long as the combined percentage content by weight of carbon and nitrogen is under about 0.20%, which represents commercial tolerances. Steels with lower chromium contents may be fully ferritic if their combined carbon and nitrogen contents are low enough, or if they contain elements such as columbium which combines with carbon to neutralize its austenite forming properties. Likewise steels with lower chromium contents may be fully ferritic if they contain additional ferrite formers. For example, ordinary AISI Type 430 steel which contains 16 to 18% chromium is not fully ferritic but AISI Type 436 steel which is AISI Type 430 steel with added columbium and molybdenum, is essentially fully ferritic. Molybdenum is a ferrite former. All these steels also contain up to about 1% manganese and silicon, 0.040% maximum phosphorus and 0.030% maximum sulfur. Fully ferritic steels containing less than about 16% chromium are not commercially practicable and are not encompassed in our invention. Those steels containing from about 23% to about 27% chromium are of particular interest, and are exemplified in AISI Type 446. The presence of chromium in excess of about 27% does not appear to result in properties of any commercial interest.

In the production of both stainless and carbon steels for strip and sheets, it is conventional to teem the melt into molds and to convert the cast bodies so made into strip or sheets by hot rolling, followed normally by cold rolling. The steel is introduced into the hot rolling mill as slabs, that is, bodies 6 inches to 8 inches or so thick and approximately the width of the strip or sheet desired. These slabs may be produced directly by teeming the melt into molds of appropriate dimensions or they may be produced indirectly by teeming the melt into molds of larger dimensions and reducing those ingots to slab size by forging or rolling in a blooming mill or the like. In either case, the quality of the surface of the strip or sheet finally produced is directly dependent on the surface condition of the slab. In order to minimize surface defects in the strip or sheets, it is well-nigh universal practice in steel mills to inspect the slab surface and remove defects such as cracks, scabs, laps and the like before the slab is rolled. In the production of carbon steels, the defects are usually removed by chipping with air operated chisels or scarfing with oxy-acetylene torches. The defects are cut or melted out so as to leave relatively broad shallow depressions in the slab surface which leave no mark on the rolled strip. In the production of stainless steels, the surface defects are generally removed by grinding with a grinding wheel. Frequently, the entire surface of the slab is ground.

A major problem in the production of slabs of fully ferritic stainless steel is that of surface conditioning. The steel in slab form is highly sensitive to grinding and tends to crack in the course thereof. The tendency of the steel to crack during grinding seems to be more pronounced at lower temperatures, which has lead some shops to schedule production of fully ferritic stainless steels only during periods of mild weather, or to warm the slabs.

It is the principal object of our invention, therefore, to provide a process of making surface ground slabs of fully ferritic steel free from cracks. Other objects of our invention will appear in the description thereof which follows.

We have found that slabs of fully ferritic stainless steel entirely suitable for the production of defect-free strip and sheet can be made by incorporating in the steel melt zirconium in amounts between about seven times and fourteen times the combined weight percentage of the carbon and nitrogen of the melt, processing the steel into slabs, and grinding the slab surface. The addition of zirconium effectively suppresses the formation of cracks during surface grinding.

The effectiveness of our process is demonstrated by the results in the accompanying table. That table includes results of four zirconium-free heats, and fifteen heats containing zirconium in different amounts, the heats being otherwise of comparable compositions. All heats were processed into slabs of the same size which were surface ground in the same way. The grinding comprised one traverse of a 4 inch wide slab sample in quarter-inch steps using a 2 inch wide coarse grinding wheel of commercial manufacture (Dayton wheel 8A24J 15V25) with a grinding depth of 0.010 inch.

Each slab sample after grinding was macroetched, coated with a penetrating dye, and photographed. The extent of cracking was quantitatively determined by placing over the photograph a parallel line grid and counting the crack intersections per inch of grid.

The table shows that the crack incidence in the untreated samples was far greater than that in the samples containing zirconium in amounts between about seven times and about 14 times the combined percentage of carbon and nitrogen. In fact, four of the eight heats in this bracket displayed no cracks at all. The tabulated data also show that somewhere between about 12 and about 16 times the combined percentage of carbon and nitrogen, which we take to be about 14 times, the zirconium addition loses its effectiveness as a cracking suppresser.

Heat No.	%Cr	%Mo	%C	%N	%Zr	%Zr/(%C + %N)	Crack Intersections/In. of Grid
No Addition							
S181A	22.4	1.7	.028	.052			50.8
S182A	23.4	1.8	.020	.031			49.6
S197A	26.3	—	.004	.030			74.1

-continued

Heat No.	%Cr	%Mo	%C	%N	%Zr	%Zr/(%C + %N)	Crack Intersections/In. of Grid
S200A	24.3	1.8	.004	.036			128.6
Zr Addition							
S199A	26.0	—	.006	.029	.24	6.9	0.0
S199B	26.0	—	.003	.027	.24	8.0	0.4
S273A	26.3	—	.021	.024	.42	9.3	9.6
S273B	26.3	—	.019	.018	.76	20.5	42.8
S273C	26.3	—	.021	.015	1.1	30.6	82.6
S274A	26.3	1.1	.028	.014	.48	11.4	0.4
S274B	26.2	1.1	.024	.013	.72	19.5	28.3
S274C	26.2	1.1	.021	.010	.85	27.4	47.1
S350A	25.5	1.0	.015	.024	.3	7.7	0.0
S350B	25.7	1.0	.016	.025	.5	12.2	3.3
S351A	26.3	1.1	.047	.022	.6	8.7	1.9
S352A	26.3	1.1	.041	.019	.5	8.3	0.0
S352B	26.2	1.1	.048	.016	.7	10.9	4.2
S353A	26.4	1.1	0.26	0.21	.5	10.6	0.0
S353B	26.4	1.1	.023	.020	.7	16.3	77.3

We claim:

1. The process of making a fully ferritic stainless steel slab characterized by its ability to resist surface cracking during grinding and thus be suitable for rolling into strip consisting essentially of preparing a melt of steel consisting essentially of carbon, nitrogen, approximately 1% maximum manganese and silicon, approximately 0.04% maximum phosphorus, approximately 0.03% maximum sulfur, ferrite forming elements including a minimum of approximately 16% chromium to render the resulting steel ferritic at all temperatures below its melting point, zirconium in percentage by weight between about seven times and about fourteen times the combined carbon and nitrogen percentages by weight to effectively suppress the formation of cracks during surface grinding of a slab formed from the melt, balance iron, processing the melt into a slab, and grinding at least one surface thereof.

2. The process of claim **1** in which the chromium content of the melt is between about 23% and 27% by weight.

3. The process of claim **1** in which the melt contains molybdenum.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,926,624 Dated December 16, 1975

Inventor(s) Arthur H. Aronson and Charles R. Rarey

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 17: "0.26" should be - .026 - and "0.21" should be -.021 -.

Signed and Sealed this

sixteenth Day of *March 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks