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METHOD OF MAKING SHEET STEEL

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The present invention relates generally to the sheet steel art and more particularly to a new method of making low carbon sheet steel having uniform, good drawing and forming characteristics and having grains which range in size between about 5 and about 7 in terms of the standards of the American Society for Testing Materials throughout the steel from surface to surface.

For certain purposes sheet and strip steel should have fairly large grains of substantially uniform size throughout the thickness of the steel, a minimum amount of resiliency or spring-back, commonly referred to as temper, and low yield points. Such properties are desired in sheet steel which is to be used in making various products by forming or drawing, for example, eave troughs, conductor pipes and allied products. These properties and characteristics have not been obtainable heretofore in sheets or strips produced by conventional rolling methods in continuous sheet or strip mills. These mills, as operated heretofore, produced sheets and strips which had grains ranging in size from about 7 to about 9 in terms of the standards of the American Society for Testing Materials, the smaller grains being in the interior portions and the larger grains being in the surface portions, and the sheets and strips had a relatively high degree of resiliency or spring-back, and yield points which were higher than was desired in the above mentioned products.

Many efforts have been made, ever since the continuous sheet or strip mills came into general use, to use those mills to produce sheet and strip steel having the desirable properties and characteristics above mentioned, but so far as we know, none of these efforts by standard or conventional mill processing has been entirely satisfactory.

We have discovered that these desirable properties and characteristics in the finished sheet or strip may be obtained, when simple steel is rolled in a continuous sheet or strip mill, by critically straining the steel in the hot rolling operation. This straining is produced while the steel is at a temperature between about 1600° F. and about 1000° F., preferably between 1600° F. and 1420° F., by making successive finishing pass reductions which relatively and percentagewise are medium heavy, light and medium heavy. Steel which has been so strained should be given a small reduction while still in the alpha iron form or magnetic transition range, as in a finishing pass, and may also be reduced in a later pass. It may be continuously pickled, cold rolled to the desired thickness after hot rolling and before being annealed.

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The steel should be given some degree of temper, as by being rolled in a light skin or temper pass, after being annealed.

The present invention will be better understood by those skilled in the art from the following illustrative, but not limiting, examples: Slabs of low carbon steel containing about .07% of carbon, about .30% of manganese, about .012% phosphorous, about .033% of sulphur, about .06% nickel, and about .04% copper were heated to a temperature of about 2250° F. in a triple-fired Rust furnace using natural gas as a fuel. These slabs were continuously hot rolled into strips about 31¼" wide and about .070" thick on a continuous hot mill and were coiled without quenching. The hot mill setup was such that the strips entering the finishing stands of the mill were as light as possible consistent with good rolling practice. In a typical instance the six finishing roll stands were so adjusted that the reductions made in the strip were respectively as follows:

Stand	1	2	3	4	5	6
Percentage	50	40	35	40	4	6

The light reduction in pass 3 preceded by one or more heavy or medium reductions, such as in pass 2 or 1 and 2, and followed by the medium heavy reduction in pass 4 is important to the present invention. According to prior practice the reductions have decreased in each succeeding finishing stand and have not been medium heavy, light and then medium heavy as is essential to attain the results of this invention.

These hot rolled coiled strips were continuously pickled and cold rolled to the desired final thickness of about .018". These strips were then annealed at a temperature of about 1200° F., after which they were given a light skin or temper pass to give the steel about a #4 temper and were then cut into sheets of the desired lengths and widths.

Examination of these sheets showed that the size of the grains was between 5 and 8 of the A. S. T. M. grain size standard and that there was substantially no variation in grain size from surface to surface of the strips. These sheets were readily drawn or formed into products of the type mentioned and had a low degree of resiliency or spring-back and low yield points.

The achievements of the present invention are indicated by the following tables which show the contrasts in physical properties and microstructure of steel sheets .018" thick of substantially the same composition which were made in the

conventional manner with a continuous mill and when they were made by the present invention.

Physical properties and microstructure for comparative purposes on conventional material and material produced according to this invention would conform to the following:

Conventional material cold reduced, box annealed, temper rolled

Yield Point, lb./sq. in.	Ult. Strength, lb./sq. in.	Elong. in 2", percent	Rockwell "T"	Olsen	Microstructure
39,770	48,500	30	51	368	S9C9+
38,540	50,200	32	53	389	S9C9+
38,690	50,920	30	53	374	S9C9+
32,910	46,470	34	51	391	S9M8C9
33,880	47,430	36	51	377	S9M8C9
38,490	49,330	29	54	382	S9C9+
36,210	48,090	23	53	366	S9M8C9
37,900	50,350	29	52	383	S9C9+
35,950	47,930	33	55	364	S9M8C9+
33,810	46,770	34	52	387	S M8C9+

Material produced according to our invention

Yield Point, lb./sq. in.	Ult. Strength, lb./sq. in.	Elong. in 2", percent	Rockwell "T"	Olsen	Microstructure
27,070	44,220	37	45	376	6-7M5-8
28,200	43,300	35	47	364	6-7M5-8
27,600	44,800	41	44	360	7M6-8
25,600	41,100	41	47	349	6M5-7
28,600	46,800	36	47	355	6-7M5-8
28,760	43,100	39	41	331	5-6M5-8
27,410	44,700	36	46	344	6-M5-7
25,600	42,810	36	45	366	7-8
29,860	43,200	43	46	375	5-6
29,520	44,300	36	49	368	8M7-8

It will be noted that the sheets of the first table have yield points which range from 32910 to 39770 and average 36615; and that the grains range from 8 to 9. In contrast, the sheets of the second table have yield points which range from 25600 to 29520 and average 27316; and grains ranging from 5 to 8. It will also be noted that the elongation is higher and the hardness is lower in sheets of the second table. These several factors, in combination, give uniform, good drawing and forming qualities and admirably adapt the sheets to fabrication into products of the type mentioned above.

While many simple steels may be treated by this process, steels which have been found to be particularly suitable for treatment by this process are simple low carbon, rimmed steels. Such steels may have the following composition ranges:

Carbon	.02% to .15%
Manganese	.03% to .6%
Phosphorus	.005% to .05%
Sulphur	.01% to .08%
Silicon	Residual amounts
Copper, Chrome, Nickel, Molybdenum	Up to .2%
Iron	Remainder

The present process may also be used on simple low carbon steels killed with either aluminum or silicon. In case a steel of the foregoing general composition is killed with silicon, the silicon in the killed steel would amount to from about .04% to about .08% if semi-killed, or over .08% if fully killed. Likewise, if killed with aluminum, the aluminum in the killed steel would amount to over .025%.

The range of reductions in the medium heavy finishing pass, illustrated by pass 4, and following the light pass, illustrated by pass 3, may be from about 38% to about 42%. When the reductions are in the lower end of this range the grains are not as nearly uniform in size from surface to surface of the steel as is the case when reductions in the higher part of this range are used, but the grains in the surface portions are between about 5 and about 7 on the A. S. T. M. scale. When the reduction in the medium heavy pass is approximately 40% and follows a reduction of about 35% in the light pass, the size of the grains is uniformly 5 to 7 throughout the steel.

The medium heavy pass reduction taken after the light pass may be taken at temperatures between about 1600° F. and about 1000° F. but preferably is taken between about 1600° F. and about 1420° F. The extent of hot reduction following this medium heavy reduction of the steel may range from about 2% to about 6% with the larger reduction being taken when this medium heavy reduction has been in the lower portion of the 38% to 42% range. About 4% reduction is preferred with this medium heavy reduction of about 40%.

Since continuous hot mills are not usually employed to reduce hot strip to less than about .070" in thickness, for cold reducing purposes, the steel rolled to that thickness by the present process may be subsequently cold rolled to bring it to thinner desired thickness.

The cold rolling reductions in thickness may range from about 15% to about 80%, but preferably range between 30% and 75%.

The steel, whether hot rolled only or hot rolled and cold rolled, is annealed at temperatures from about 1175° F. and about 1380° F., but preferably at about 1200° F.

The annealed steel may be given the desired degree of temper by being cold rolled, but such rolling is preferably of the light skin pass type for a low degree of temper is preferred with the large grains of the steel resulting from the foregoing steps.

Steel produced by this invention may be used

in the uncoated form or may be coated as by being galvanized, hot dipped or electroplated.

This application is a continuation-in-part of our copending application, Serial No. 627,794, filed November 9, 1945, now abandoned.

Having thus described our invention so that others skilled in the art may be able to understand and practice the same, we state that what we desire to secure by Letters Patent is defined in what is claimed.

What is claimed is:

1. The method of making steel in sheet or strip form which comprises the steps of continuously rolling simple low carbon steel while such steel is in the temperature range of from about 1600° F. to about 1000° F., and reducing its thickness about 40% in a medium heavy reduction finishing pass, then about 35% in a light reduction finishing pass, and then about 40% in a medium heavy reduction pass.

2. The method of making steel in sheet or strip form which comprises the steps of continuously rolling simple low carbon steel while such steel is in the temperature range of from about 1600° F. to about 1000° F., reducing its thickness about 40% in a medium heavy reduction finishing pass, then about 35% in a light reduction finishing pass, and then about 40% in a medium heavy reduction finishing pass, and then about 4% and about 6% respectively in the next two succeeding finishing passes.

3. The method of making steel in sheet or strip form which comprises the steps of continuously rolling simple low carbon steel while such steel is in the temperature range of from about 1600° F. to about 1000° F., reducing its thickness about 40% in a medium heavy reduction finishing pass, then about 35% in a light reduction finishing pass, and then about 40% in a medium heavy reduction finishing pass, then about 4% and about 6% respectively in the next two succeeding finishing passes, cold rolling the thus hot rolled steel, and annealing the thus cold rolled steel at a temperature between about 1175° F. and about 1380° F.

4. The method of making steel in sheet or strip form which comprises the steps of continuously rolling simple low carbon steel containing between about .02% and about .15% of carbon, between about .03% and about 0.6% of manganese, between about .005% and about .05% of phosphorous, between about .01% and about .08% of sulphur, residual amounts of silicon, copper, chromium, nickel and molybdenum totaling up to about 0.2%, and the remainder iron, while such steel is in the temperature range of from about 1600° F. to about 1000° F., reducing its thickness about 40% in a medium heavy reduction finishing pass, then about 35% in a light reduction finishing pass, and then about 40% in a medium heavy reduction finishing pass, cold rolling the thus hot rolled steel, and annealing the thus cold rolled steel at a temperature between about 1175° F. and about 1380° F.

5. The method of making steel in sheet or strip form which comprises the steps of continuously rolling simple low carbon steel while such steel is in the temperature range of from about 1600 F. to about 1000° F., reducing its thickness about 40% in a medium heavy reduction finishing pass, then about 35% in a light reduction finishing pass, and then about 40% in a medium heavy reduction finishing pass, pickling the steel, cold rolling the thus hot rolled and pickled steel and reducing its thickness between about 30% and about 75% to bring it to the desired thickness, and annealing the thus cold rolled steel at a temperature between about 1175° F. and about 1380° F.

6. The method of making steel in sheet or strip form which comprises the steps of continuously rolling simple low carbon rimmed steel containing between about .02% and about .15% of carbon, between about .03 and about 0.6% of manganese, between about .005% and about .05% of phosphorous, between about .01% and about .08% of sulphur, residual amounts of silicon, copper, chromium, nickel and molybdenum totaling up to about 0.2% and the remainder iron, while such steel is in the temperature range of from about 1600° F. to about 1000° F., reducing its thickness about 40% in a medium heavy reduction finishing pass, then about 35% in a light reduction finishing pass, and then about 40% in a medium heavy reduction finishing pass, and then about 4% and about 6% respectively in the next two succeeding passes, pickling the steel, cold rolling the thus hot rolled and pickled steel and reducing its thickness between about 30% and about 75% to bring it to the desired thickness, annealing the thus cold rolled steel at a temperature between about 1175° F. and about 1380° F. and thereafter imparting a small degree of temper to the thus annealed steel by subjecting it to a light skin rolling pass.

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