March 15, 1966 J. DAUBERSY 3,240,636

METHOD OF TREATING SHEET STEEL

Filed Nov. 25, 1964 2 Sheets-Sheet 1

FIG.I.

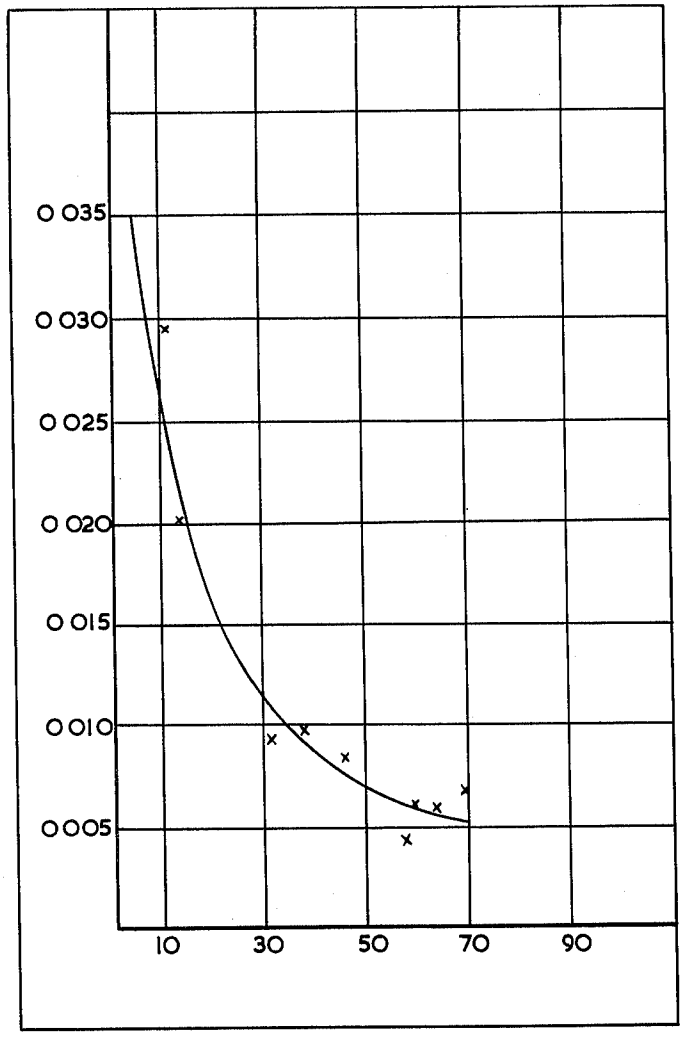

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FIG. 2.

	Weight of charge in annealing furnace Thickness	Annealing in wet hydrogen to render non-aging	Recarburization to remove brittleness	Analysis ±10 ±10 3% 4%		Natural condition (after skin-pass rolling)				After Aging for 1 hour at 100° C											
				C	N	E	R	A	V	E	R	A	V	N	00	01	02	03	04	05	06
No superficial recarburization Steel {Non-Aging, Brittle}	Total weight 25·6 tons 1mm thick	300 Cubic meters per hour of H_2 Dew Point +60° C	None	2	5	16·9	30	46·7	O	16·6	29·5	47	1	54	4	5	18	11	9	6	1
	Total weight 26·3 tons 1mm thick	400 Cubic meters per hour of H_2 D.P.+60° C	None	2	5	17·6	30·6	46·3	O	17·8	30·5	46·3	O	54	10	17	13	10	4		
Correct recarburization Steel {Non-Aging, Non-Brittle}	Total weight 24·8 tons 1·2mm thick	900 Cubic meters per hour of H_2 D.P.+60° C	1 hour in H_2+2·1% CO D.P. 0° C	2-3 2-3	8 8	17·2 16·8	29·5 29·7	50 47	O O	17·5 16·9	29·8 29·7	49·6 46·2	O O	24	22	2					
	Total weight 23·6 tons 1·2mm thick	300 Cubic meters per hour of H_2 D.P.+60° C	1 hour in H_2+2·1% CO D.P. 0° C	2-3 2-3	5 5	16·9 15·2	30·2 29·4	47 52	O O	17·1 15·5	30·2 29·4	46·2 49·6	O	18	18						
Excessive recarburization Steel {Non Brittle, Aging}	Total weight 17·5 tons 1mm thick	300 Cubic meters per hour of H_2 D.P.+60° C	5 minutes in HNX + 8% CO D.P.-7° C	3-5	5	18·9	30·8	46	O	21·8	30·7	45·6	4	12	12						
	Total weight 16·13 tons 1mm thick	300 Cubic meters per hour of H_2 D.P.+60° C	5 minutes in HNX + 8% CO D.P.-6° C	3-5	8	20·1	30·7	45·4	1	22·1	31	44·3	5	12	12						
	Total weight 22·6 tons 1mm thick	450 Cubic meters per hour of H_2 D.P.+60° C	15 minutes in HNX + 8% CO D.P.-7° C	3-5 3-5 3-5	5 5	17·6 17·9	30·3 29·9	47·8 46·6	O O	20·6 21·7	30·7 30·2	47·2 45	3 4	18	18						

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METHOD OF TREATING SHEET STEEL

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Claims priority, application Luxembourg, July 17, 1961, 40,409
3 Claims. (Cl. 148—16.5)

It is well known that sheets of extra-soft steel can be rendered non-aging and suitable for deep drawing by treating them in an atmosphere containing wet hydrogen at an elevated temperature. The hydrogen extracts the carbon and nitrogen from the steel and after treatment the contents of these elements in the steel correspond to their limits of solubility at atmospheric temperature, i.e. about 0.0005% by weight for nitrogen and 0.004% by weight for carbon, though exact determinations are difficult.

However sheet steel treated in this manner has the disadvantage of being subject to brittleness after work-hardening. Brittle fractures may appear along one or more of the surfaces of an article after after deep drawing if the article is subjected to a shock on leaving the press or even sometimes during the actual stamping operation.

A similar type of brittleness is found to occur in acid or basic Bessemer steel sheets containing nitrogen.

It is well known that such brittleness diminished with diminishing nitrogen and carbon levels.

Since treatment with wet hydrogen at elevated temperatures serves to remove nitrogen and carbon it would therefore not seem particularly probable that the reintroduction of carbon into steel would serve to prevent brittleness after work hardening. Moreover, it is well known from the experiments of Low and Gensamer that after a slight recarburization, sheet steel previously rendered non-aging by treatment in wet hydrogen, recovers its tendency to age, because againg is caused by the atoms of carbon (and nitrogen) present in the steel. However after hypotheses that the tendency to work-hardening might be due to the absorption of hydrogen or to a lack of cushion of the metal grains following the removal of the last traces of carbon from the joints of the grains, had been examined and rejected, experiments were conducted on the basis that the tendency to brittleness after work hardening were connected with properties of the superficial regions or surfaces of the metal after extensive decarburization in wet hydrogen.

Thus it has been shown that when sheet steel is treated in a wet hydrogen atmosphere in such a manner that at the end of the first stage of the treatment the atmosphere contains not more than 0.4% of preferably 0.2% by volume of carbon monoxide, the steel is rendered non-aging. If however the treatment is carried out so that the carbon monoxide level at the end of it is 0.8% by volume and the treatment is carried out for 10 hours the resulting steel is found to be subject to aging. If however only 5 hours of treatment are carried out the steel is neither subject to brittleness after work-hardening or to aging owing to the slight recarburization.

Such experiments therefore proved that if sheet steel which had been previously been treated with wet hydrogen at an elevated temperature to remove carbon and nitrogen to eliminate aging, carbon was diffused into the sheet steel, the liability to brittleness after work-hardening was considerably reduced, and the tendency to age was negligible.

Conviently carbon can be defused into the steel sheet, for instance, by treatment of the steel sheet in an atmosphere containing hydrogen, steam, and a carbon compound such as carbon dioxide, carbon monoxide methane or other hydrocarbon.

For example the precise composition of the atmosphere (by volume) can be as follows.

8% of CO
4% of CO_2
16% of H_2
Less than 1% of CH_4
71% of N_2

The dew point of the atmosphere is 10° C. The thin sheet steel to be carburized, for instance in a 20 or 40 ton lot in open coil bobbins is placed in a furnace in the atmosphere and held at a temperature between 600–720° C. for to one hour. Alternatively instead of the composition of atmosphere given above, one can use an atmosphere consisting mainly of hydrogen with 2% carbon monoxide or some hydrocarbon, the dew point being 0° C. After the recarburizing treatment the metal can be cooled in any protective atmosphere for example dry nitrogen containing 5–10% of hydrogen by volume.

The amount of carbon monoxide used in the recarburizing atmosphere should be proportional to the surface area of the batch of metal being treated. Thus for instance if it is found that 2% of carbon monoxide is suitable for treating 30 tons in a furnace, the percentage for treating 40 tons will be ⅔ of that necessary for a 30 ton batch.

The process can be carried out in such a manner that in superficial layers of 20 microns thickness on each side of the sheet the carbon content is 0.020% to 0.060% (optimum 0.040%) by weight while in the central part of the sheet representing four fifths of its total thickness the carbon content does not exceed 0.005% by weight. If recarburization exceeds these limits, the tendency to age returns but there is no tendency to brittleness.

The uptake of carbon can be about 0.001% of the weight of the sheet or at the most about 0.002% of it.

The attached graph (FIGURE 1) indicates the carbon content at various depths from the surface of a piece of sheet steel treated in accordance with the invention. The horizontal axis is calibrated in microns measured from the surface of the sheet steel while the vertical axis indicates carbon content by weight as found by spectrum analysis.

Results of trials in connection with the invention are shown in FIGURE 2 of the attached drawing. In this table E indicates the elastic limit in kg./mm.^{2}, R indicates the ultimate tensile strength in kg./mm.^{2}, A equals the elongation up to rupture as a percentage. N indicates the number of test pieces, V indicates the length of yield point elongation. The last seven columns headed 00, 01 etc. indicate the number of brittle fractures. Thus the first column indicates the number of test pieces with no brittle fractures, the second headed 01 indicates the number of test pieces with three millimetre brittle fractures, the next column headed 02 indicates the number of specimens or test pieces having brittle fractures of six millimetres. The following columns refer to number of specimens having respectively fractures of 9 millimetres 12 millimetres etc.

While I have described practical details of my invention for enabling those skilled into the art to put the invention into practice, it is to be understood that the monopoly I seek in the United States is to be by no means limited to these practical details and is to be defined by gist and spirit of the appended patent claims.

I claim:

1. In a process comprising the step of extracting carbon and nitrogen out of a sheet steel by the action of an atmosphere of wet hydrogen during a duration long

enough that the sheet steel contains less than 0.005% by weight of carbon and 0.0005% by weight of nitrogen so as to render said sheet non-aging but subject to brittleness, the invention which consists in subsequently superficially recarburizing the sheet steel by heating it in an atmosphere comprising a carbon-containing gas so as to achieve an uptake of carbon up to 0.001% maximum.

2. In a process comprising the step of extracting carbon and nitrogen out of a sheet steel by the action of an atmosphere of wet hydrogen according a duration long enough that the sheet steel contains less than 0.005% by weight of carbon and 0.0005% by weight of nitrogen so as to leave said sheet non-aging though subject to brittleness, the invention which consists in subsequently superficially and moderately recarburizing said non-aging sheet for having an uptake of carbon up to 0.001% maximum by submitting it to an atmosphere comprising 98% by volume of hydrogen and 2% by volume of a carbon-containing gas and having a dew point of 0° C., during a duration continued until the carbon content in 20 micron layers to each side of the sheet steel is between 0.020% and 0.060% by weight while in the central four-fifths of the thickness of the sheet steel the carbon content is of maximum 0.005% so as to render the sheet steel simultaneously non-brittle and non-aging.

3. In a process comprising the step of extracting carbon and nitrogen out of a sheet steel by the action of an atmosphere of wet hydrogen according a duration long

enough that the sheet steel contains less than 0.005% by weight of carbon and 0.0005% by weight of nitrogen so as to leave said sheet non-aging though subject to brittleness, the invention which consists in subsequently superficially and moderately recarburizing said non-aging sheet so as to achieve an uptake of carbon up to 0.001% maximum by submitting it, at a temperature comprised between 600 and 720° C., to an atmosphere composed of 8% by volume of CO, 4% by volume of CO_2, 16% by volume of H_2, less than 1% by volume of CH_4 and 71% by volume of H_2, and having a dew point of 10° C., during a duration continued until the carbon content in 20 micron layers to each side of the sheet is between 0.020% and 0.060%, by weight, while in the central four-fifths of the thickness of the sheet steel the carbon content is of maximum 0.005% and then cooling said sheet steel in a protective atmosphere such as dry nitrogen with 5% to 10% by volume of hydrogen, so as to render the sheet steel simultaneously non-brittle and non-aging.

References Cited by the Examiner

"Aging and the Yield Point in Deep Drawing Steel," by Low and Gensamer, Steel Processing, May 1944, pages 302–306.

DAVID L. RECK, *Primary Examiner.*