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# DEEP DRAWING OF STAINLESS STEELS, AND STEEL THEREFOR

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This invention relates to the deep drawing of stainless steels containing 14–20% chromium, and has as its object to provide a steel amenable to deep drawing without the occurrence of stretch strains, and to provide a procedure for production of deep drawn products free of stretch strains, as well as a procedure for providing a steel suitable for deep drawing without the occurrence of stretch strains.

Numerous investigations have been made in to the cause of stretch strains (Lüders' lines) and into the possibility of their avoidance in unalloyed deep drawing steels. It has been found that there is a cause-effect relationship between the formation of stretch strains and the establishment of the yield point as determined by the tensile test. Accordingly, very strong stretcher strains are to be expected whenever a sharp yield point is found in the stress-strain diagram, with a plainly apparent yield point elongation. The yield point in this case is due to the carbon and nitrogen atoms embedded in the dislocations, and its expression is the stress that is necessary in order to move the dislocations away from the embedded atoms. The sharp yield point can be eliminated by a slight cold deformation of less than 3%, and at the same time the point at which flow begins can be shifted to the lower strain figures, since the release of the dislocations from the carbon atoms or nitrogen atoms has already taken place. A slight cold working, therefore, results in a lower yield point and hence in an easier flow, and makes it possible to avoid the occurrence of the great elongation at the yield point and hence to avoid the undesired stretch strains. This knowledge has led to the widespread practice of subjecting deep drawing sheets and strips after annealing to cold rolling with a slight reduction of thickness (temper rolling), in order to eliminate the sharp yield point and reduce the tendency toward the formation of stretch strains. The amount of temper rolling required is determined by the length of the yield point elongation, which in turn depends on the amount of cold deformation before the final annealing.

Conditions are similar in the case of the stainless cold rolled sheets and strips containing about 14 to 20% chromium, max .15%, preferably max .12% carbon, max 1% manganese and silicon resp. max 1.5% molybdenum, max 0.5% nickel, and the usual low contents of phosphorus, sulfur, and nitrogen, up to .1% aluminum. All these steels are in the following meant by the expression "steel containing about 14 to 20% chromium." Here again, the length of the yield point elongation is an indication of the tendency to form stretcher strains. With these steels, too, the yield point elongation depends on the amount of cold rolling before the final annealing. Consequently, cold temper rolling ranging from 0.5 to 2% thickness reduction has become the standard procedure for avoiding stretch strains in these steels.



Surprisingly it has developed that avoidance of stretch strains can be achieved in cold rolled ferritic chromium steels (chromium contents over 13%) even without temper rolling by adapting the final annealing to the chemical composition of the material involved. It is known that ferritic chromium steels, such as x 8 Cr 17 steels after German Standard DIN 17006, corresponding to AISI 430, are not stable ferritic steels; as a result of brief annealing at temperatures in the range of 850 to 930° C., small amounts of austenite occur along with the ferrite, which during the subsequent cooling are transformed to the pearlite phase, bainite phase or martensite phase, depending on the rate of cooling. The temperature at which the first austenite is formed depends on the ratio of ferrite formers (Cr, Si, Mo, etc.) to austenite formers (C, Mn, Ni, $N_2$, etc.). In the case of longer annealing times, small amounts of austenite can occur even at temperatures under 850° C. Now, if the annealing temperature and time are adapted to the chemical composition in such a manner that, in addition to the ferrite, some austenite occurs or, after cooling, some martensite or bainite structures occur, stretcher strains no longer occur in the material thus treated, even if it is not temper rolled. This surprising effect is to be attributed to the fact that the yield point elongation, which is, of course, essential to the occurrence of stretch strains, is greatly diminished or eliminated by the formation of martensite or bainite structures in addition to ferrite. The invention, therefore, is based on a process which results in the prevention of stretch strains by matching the annealing temperature and annealing time to the chemical composition of the sheets or strips being treated, some amounts of martensite or bainite structures being produced in addition to the ferritic basic structure. It is expedient to keep the percentage of martensite or bainite structures low so as to avoid affecting the mechanical values.

Thus, the invention provides a method for production of steel amenable to deep drawing without the occurrence of stretch strains. The method comprises annealing the steel at a temperature and for a time sufficient to provide it in such condition. The annealing temperature can be above 830° C., and is preferably in the range of 850 to 930° C. The annealing time is in the range of ½ to 5, preferably of 1 to 3 minutes depending on the thickness of the sheet or strip, ranging from .5 to 3 millimetres. After annealing, the sheet or strip is air-cooled. The steel subjected to the treatment of the invention can be, and preferably is, a cold rolled steel, for example a cold rolled steel which has been cold rolled to the drawing thickness, i.e. to the thickness of steel utilized in the deep drawing step. The deep drawing employed to produce products from the steel of the invention can be any of the conventional deep drawing procedures. For the annealing preferably a continuous annealing furnace is used.

*Example*

Two chromium steel strips of the following chemical composition were cold rolled from a hot rolled strip thickness of 3 mm. to 1 mm. After the customary annealing of about 11½ minutes at 850° C., a temper rolling of 1% (strip 1) and 1.2% (strip 2) had to be performed to prevent stretcher strains. Without temper rolling, the same effect could be achieved by annealing strip 1 at 860° C., while the annealing of strip 2 was performed at 910° C. (Annealing time 1–1½ minutes).

CHEMICAL COMPOSITION

| | C | Si | Mn | P | S | Cr | Ni | Mo | N² | Al |
|---|---|---|---|---|---|---|---|---|---|---|
| Strip 1 | 0.07 | 0.07 | 0.31 | 0.025 | 0.012 | 17.40 | 0.30 | 0.06 | 0.0304 | 0.004 |
| Strip 2 | 0.07 | 0.26 | 0.35 | 0.024 | 0.015 | 17.20 | 0.17 | 0.05 | 0.0292 | 0.004 |

Whereas the invention is applicable to any deep draw product, it is especially applied in the production of hub or wheel caps and of scouring basins.

While the invention has been described with respect to particular embodiments thereof, these embodiments are merely illustrative of the invention and do not set forth the limits thereof.

What is claimed is:

1. Production of a deep drawn product of ferritic steel containing about 14–2% chromium and substantially free of stretch strains which comprises:

(a) cold rolling the steel to the drawing thickness;

(b) annealing the steel at a temperature and for a time sufficient to impart thereto, upon cooling a minor proportion of martensite or bainite structure and a major proportion of ferrite structure and to provide the steel amenable to deep drawing without the occurrence of Lüders' lines;

(c) subjecting the steel to deep drawing to form said product.

2. The method of claim 1, wherein the annealing temperature is above 830° C.

3. The method of claim 1, wherein the annealing temperature is in the range of 850–930° C.

4. Method for production of ferritic steel containing about 14–20% chromium and amenable to deep drawing without the occurrence of Lüders' lines, which comprises annealing the steel at a temperature and for a time sufficient to impart thereto, upon cooling, a structure comprising a minor proportion of martensite or bainite phase and a major proportion of ferrite phase, the steel following said annealing being amenable to deep drawing without the occurrence of Lüders' lines.

5. The method of claim 4, wherein said annealing is at a temperature of above 830° C.

6. The method of claim 7, wherein said annealing is at a temperature in the range of 850–930° C.

7. The method of claim 5, wherein the steel subjected to said annealing is a cold rolled steel.

8. The method of claim 6, wherein the steel subjected to said annealing is a cold rolled steel.

9. A deep drawn steel product produced by the method of claim 1.

**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,772,992 | 12/1956 | Kiefer et al. | 148—12 |
| 2,808,353 | 10/1957 | Leffingwell et al. | 148—12 |
| 2,851,384 | 9/1958 | Waxweiler | 148—12 |
| 2,905,577 | 9/1959 | Harris et al. | 148—12 |
| 3,067,072 | 12/1962 | Leffingwell et al. | 148—12 |
| 3,128,211 | 4/1964 | Waxweiler | 148—12 |
| 3,139,358 | 6/1964 | Graziano | 148—12 |

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