

UNITED STATES PATENT OFFICE

2,360,868

MANUFACTURE OF NONAGING STEEL

Maxwell Gensamer, Pittsburgh, Pa., assignor to
Carnegie-Illinois Steel Corporation, a corporation
of New Jersey

No Drawing. Application January 2, 1943,
Serial No. 471,178

8 Claims. (Cl. 148—16)

This invention is concerned with steel having a yield point in its annealed condition, as exemplified by plain-carbon steel, in general, and by many alloy steels.

It is frequently necessary to provide a steel free from a yield point, as in the case of deep-drawing steel, for example, and, heretofore, this has required cold-straining of steel of the above type, with the advantages of increasing its yield strength and hardness, which is sometimes desirable, but, more often, undesirable. Heretofore, the art has not had available steel, of the type normally having a yield point in its annealed condition, and processed so as to be practically free from a yield point in its annealed condition, with but one exception.

The above exception results from the discovery that steel, of the mentioned type, can be freed from a yield point, in its annealed condition, providing it is produced as a sufficiently coarse grained steel, it being known that by decarburizing such steel, as by heat treatment in a decarburizing atmosphere, and then critically straining and annealing it, whereby to produce extremely large grains, it is possible to eliminate its yield point when in its annealed condition. This exception has been of no commercial value because the steel must be made so coarse grained as to be unfit for practically every purpose requiring steel of its type.

The present invention is predicated upon the discovery that steel, having a yield point in its annealed condition, can be freed from this yield point by holding it in an atmosphere, including hydrogen, at temperatures lower than produce large grains but high enough to reduce the yield point, for a time sufficiently long to eliminate the yield point. The temperatures of this treatment are lower than produce large grains, but the time must be sufficiently long if the yield point is to be eliminated. Frequently, complete elimination of the yield point is not necessary, providing the yield point is practically eliminated, but it must be admitted that the time required for practical elimination of the yield point, by the use of hydrogen alone, at temperatures low enough to prevent excessive grain growth, is longer than would, normally, be considered commercially practicable.

With the above in mind, the present invention is additionally predicated on the further discovery that the treatment time of the steel, in the hydrogen-containing atmosphere, at the temperature sufficiently low to prevent excessive grain growth, may be critically reduced by the inclu-

sion of an adequate amount of water vapor in the atmosphere in which the steel is treated, the useable amounts of water vapor ranging from a minimum found to be required to reduce the treatment time, to a commercially practicable length, to a maximum which, if exceeded, causes scaling of the steel, at the temperatures of the treatment.

To exemplify the above, plain-carbon steel sheet, about .036 inch thick, with a composition typical of deep-drawing steel sheet, held at 710° C., which is not high enough to produce coarse grains, requires about 140 hours for elimination of the yield point it normally exhibits in its annealed condition, when the steel is bathed in an atmosphere of commercial hydrogen during the treatment. Under the same conditions, an atmosphere consisting volumetrically of 5% water vapor and 95% commercial hydrogen, requires only three hours for elimination of its yield point, and only two hours in the case of an atmosphere consisting of 30% water vapor and 70% commercial hydrogen.

It has been found that the treatment time may also be reduced by flowing the atmosphere over the steel during its treatment. To illustrate, using a small tubular furnace, having a volume of approximately .1 cubic foot, with an atmosphere flow rate of about .2 cubic foot per hour, and a furnace temperature within the range of from 700° to 750° C., 4½ hours are required to render a sample of plain low-carbon steel, treated in this furnace, free from the yield point it normally exhibits in its annealed condition. Keeping these conditions fixed, excepting for increasing the flow rate to about 1 cubic foot per hour, the yield point is eliminated in 2½ hours. It is to be understood that the atmosphere used in this demonstration is commercial hydrogen containing sufficient water vapor to provide the treatment times noted, and that the same proportions of hydrogen and water vapor prevail in both instances mentioned.

Although it has been found desirable to use an atmosphere consisting largely of hydrogen and water vapor, properly proportioned, it is unnecessary to exclude all other elements. For instance, nitrogen in the atmosphere appears to work only as a diluent, which, however, does not otherwise affect the treatment. Of course, elements obviously harmful should be excluded insofar as possible, there being no known reason, in any event, for deliberately adding other elements to the atmosphere, much less going to material expense to either include or exclude them.

Steel treated as described, and thus freed of the yield point it would otherwise exhibit in its annealed condition, and having, in fact, acquired an annealed structure, is not subject to any aging phenomena or a return of the yield point, this being true even though the atmosphere might include considerable amounts of nitrogen, providing it also includes the hydrogen and water vapor in substantial amounts. In this connection, no aging or return of the yield point will be experienced should the treated steel be cold-strained, regardless of the passage of time, and regardless of whether the atmosphere used during its treatment to free it from an otherwise inherent yield point, included nitrogen. Even before the yield point disappears, the strain-aging characteristic, if possessed by the steel, is eliminated, this effect proceeding gradually with time during the treatment, being at first reduced and finally eliminated. That is to say, after cold straining, the steel, if treated with adequate time, does not suffer a ductility loss, with the passage of time. Preferably, during the treatment, the atmosphere is caused to flow at a rate experimentally found to be both practical and to produce the maximum possible decrease in the treatment time.

As a specific example of the invention, let it be assumed that a furnace is available, of the type capable of heating steel above 700° C. while confined in a gaseous atmosphere, and, furthermore, that the steel is in the form of sheet to be used for deep-drawing applications, and has a composition typical of such a product, although the invention is not limited in this respect.

The furnace is provided with an atmosphere consisting predominately of commercial hydrogen and water vapor, and the furnace temperature is adjusted to heat the steel while it is bathed in this atmosphere. The steel temperature should range upwardly from a minimum experimentally found to reduce the yield point, with time, and, if present, the aging characteristic of the steel if the latter has this characteristic, in the atmosphere used, and the latter should contain water vapor, in amounts ranging upwardly from that experimentally found to materially increase the rate at which the yield point is removed, or the aging characteristic is eliminated, as compared to the rate it would have, at a similar temperature, in an atmosphere consisting predominately of commercial hydrogen alone; the maximum temperature of the steel being fixed by that known to cause grain growth to large grains, rendering the steel unfit for its purpose, while the maximum amount of water vapor must be limited by that causing scaling at the temperatures of the steel during its treatment. Under these conditions, the steel is maintained for a time found necessary to reduce its yield point, or its aging characteristic, to the extent required, it being understood that as the treatment progresses the yield point, and aging characteristic, continuously decrease, until they ultimately disappear.

The result of the above will be an annealed steel of a type normally having a yield point in its annealed condition, at least practically free from large grains, and processed so as to be at least practically free from a yield point in its annealed condition, thus representing an entirely new product to the art. The steel may be produced as a particularly fine grained steel, by the use of lower temperatures within the operative temperature range, and so as to be, even then, com-

pletely free from a yield point, as determined by any known method. Since the yield point has not been eliminated by resorting to the usual practice of cold-straining, the steel will have, at the same time, by comparison, a materially lower yield strength and indentation hardness. Furthermore, it has been found that even when the steel, produced by this treatment, is compared with prior art steel, of the same type, in its annealed condition, when the prior art steel will have a decided yield point, steel subjected to the present treatment has a comparatively lower elastic limit and indentation hardness, whereby it may be better fitted for many operations. These properties are, of course, adjustable, since cold-straining of the steel causes them to increase in value, as might be required in some applications.

For practical purposes, the temperature range involved by this invention may be said to be from about 700° to 750° C., and the water vapor content, of the otherwise largely hydrogen atmosphere, may be said to range from about 5% upwards to that higher value found to cause scaling at the temperature used, it being understood that more water vapor can be used without scaling when the steel contains certain alloys than when these alloys are absent. When the values here advanced are observed, the yield point, and aging characteristic, if present, are reduced, in most instances at the maximum rate, without the production of a very coarse grained steel. Actually, a much larger grain size than is thus produced, is required to substantially reduce the yield point, when reliance is placed solely on the phenomena involved by reducing the yield point by inordinate grain growth alone, which, it will be remembered, was the only way, formerly known to the art, of processing steel, normally having a yield point in its annealed state, so as to produce the steel freed from its yield point, to any degree, in its annealed state.

I claim:

1. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time sufficiently long to practically eliminate the yield point.

2. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time sufficiently long to practically eliminate the yield point, said atmosphere containing water vapor in an amount less than causes material scaling but sufficient to materially reduce said time as compared to its length when said atmosphere does not contain said water vapor.

3. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere volumetrically containing from 5% water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time long enough to materially reduce the yield point.

4. A method of treating steel having a yield point in its annealed condition, comprising holding said steel in an atmosphere volumetrically containing from 5% water vapor to greater amounts insufficient to cause material scaling

and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce the yield point and for a time long enough to practically eliminate the yield point.

5. A method of treating strain-aging steel, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce said aging and for a time rendering said steel practically free from said aging. 10

6. A method of treating strain-aging steel, comprising holding said steel in an atmosphere including hydrogen at temperatures lower than produce large grains but high enough to reduce said aging and for a time rendering said steel practically free from said aging, said atmosphere containing water vapor in an amount less than causes material scaling but sufficient to materially reduce said time as compared to its length 20

when said atmosphere does not contain said water vapor.

7. A method of treating strain-aging steel, comprising holding said steel in an atmosphere volumetrically containing from 5% water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce said aging, and for a time long enough to materially reduce said aging. 15

8. A method of treating strain-aging steel, comprising holding said steel in an atmosphere volumetrically containing from 5% water vapor to greater amounts insufficient to cause material scaling and the balance largely hydrogen at temperatures lower than produce large grains but high enough to reduce said aging, and for a time long enough to practically eliminate said aging.

MAXWELL GENSAMER.