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PROCESS FOR ANNEALING AUSTENITIC STEELS

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The present invention relates to an annealing process and more particularly to a process for annealing austenitic chromium-nickel steels in a nitrogen-hydrogen mixture. Austenitic chromium-nickel alloys absorb nitrogen by diffusion during the annealing in ammonia or hydrogen-nitrogen mixtures, which may be obtained by the decomposition and burning of ammonia. At the high annealing temperature, the nitrogen is bound by the austenite in a solid solution, and contributes to its stabilization.

Nitrogen-hydrogen mixtures have been employed in bright annealing, especially the bright annealing of colored metals, such as copper and its alloys, for instance brass. For ordinary steel, this annealing atmosphere is generally too expensive.

The fact that nitrogen-hydrogen mixtures can be applied, especially for the bright annealing of austenitic chromium-nickel steel, etc. was not known heretofore. Up to the present, austenitic chromium-nickel steels were first annealed in a normal oxidizing atmosphere, and the scale which entirely destroys the rust-resisting qualities, was carefully eliminated by pickling. Attempts have been made to anneal the alloys in thoroughly purified hydrogen, but this practice has not found favor since the hydrogen consumption renders the process very expensive, and moreover it is necessary to quench the alloys after annealing (in the case of a carbon content of more than 0.06 per cent). In the case of alloys without carbon, or having an additional amount of carbide-forming substances, the quenching is assumed to be advantageous. The reason that neither nitrogen-hydrogen mixtures nor ammonia, were not used heretofore for the bright annealing of austenitic chromium-nickel steels must be attributed to the belief that the absorption of nitrogen would eliminate the resistance to rust.

Thorough tests have proved, however, that it is possible to anneal in mixtures of nitrogen and hydrogen which do not cause scale, austenitic chromium-nickel steels (and that without impairing the resistivity to corrosion), and to attain a considerable mechanical improvement of the material.

The following Tables I and II illustrate tests which have been carried out:

TABLE I

Annealing tests in various atmospheres at 1100° C.

Annealing atmosphere	Cooling	Untreated		Corroded in $CuSO_4=H_2SO_4$	
		Tensile strength	Elongation	Tensile strength	Elongation
		Kg./mm.²	*Per cent*	*Kg./mm.²*	*Per cent*
Air	Rapid	63	48	63	48
	Slow	57	40	7	0
Hydrogen	Rapid	70	48	70	48
	Slow	73	40	7	0
Split ammonia	Rapid	90	48	90	48
	Slow	93	40	9	0

TABLE II

Annealing tests in dissociated ammonia at 1100° C.

Time of annealing in minutes	Tensile strength	Elongation
		Per cent
5	76	45
180	89	38

A chromium nickel steel with the usual content of 18 per cent chromium and 8 per cent nickel of normal manufacture, that is to say, with carbon content exceeding 0.06 per cent, was used in the form of thin bands of 0.2 mm. thickness. This band was heated in a furnace into which dissociated ammonia was introduced. It was first heated up to 1100° C. for one-half hour, after which it was cooled, first slowly (within 5 to 6 hours) and then rather rapidly, by shifting it into the cold zone of the furnace, so that the rate of cooling would correspond to that obtainable in air. The same annealing was carried out in a hydrogen atmosphere and also in air. The specimens which were annealed in the nitrogen-hydrogen mixture by far exceed the other specimens, as regards strength. Apparently, the annealing has caused the absorption of nitrogen, and this nitrogen absorption has raised the strength by 25 to 30 per cent, without any noticeable reduction of the elongation. Likewise the resistance to corrosion has in nowise been impaired. This is also proved by the strength data listed in Table I which were obtained by means of the well known

V2A reagent, after the material had been subjected to stresses. As can be seen, a serious deterioration of the material, and considerable reduction of the strength, occurred only in the specimens that had been slowly cooled. In these specimens, inter-crystalline corrosion reduced the elongation to zero. However, in the specimens that were more rapidly cooled, the original strength was entirely retained, and the gain in strength caused by the nitrogen absorption was also maintained. The same results were obtained with rusting tests that were conducted in an air atmosphere and in a salt-spray fog. Also in this case, the resistivity to rust is reduced only in the slowly cooled specimens. The reduced resistivity to corrosion of the slowly cooled specimens can be attributed only to the carbon, and is therefore equal in all specimens. Inasmuch as the increase in strength must be attributed to the nitrogen increase of the austenite crystals, it is self-evident (and it is corroborated by further tests) that this increase will occur not only in carbon steels of normal manufacture, but also in special steels, having a low carbon content and additions of carbide-forming agents. Under this condition, there will be no difference between a slowly cooled and a rapidly cooled specimen, as regards the resistivity to corrosion. In such cases, the annealing can be simplified, owing to the fact that the cooling rate is no longer of influence.

An advantage of the nitrogen-hydrogen mixtures made of dissociated ammonia lies also in the fact that owing to the absence of oxygen and to the ease with which water vapor can be eliminated, scaling or coloring of the annealed material is prevented. The specimens mentioned in the preceding paragraphs, which had been subjected to the rust and corrosion test, had not been pickled prior to the tests. On the contrary, they were subjected to the corrosion test just as they came out of the furnace.

It will be seen from the preceding that the annealing in nitrogen-hydrogen mixtures, which mixtures can be obtained by the decomposition of ammonia or by decomposition and burning, brings about a considerable increase in strength and thus a desirable improvement of the mechanical properties. At the same time, the surface is protected, since no scaling occurs, and since the pickling which scaling requires can be dispensed with.

The increase in strength must be attributed to the nitrogen absorption, and requires, owing to the diffusion process, a certain amount of time, so that the period of heating must each time be adapted to the thickness of the material which is to be annealed. This is in contrast to the normal practice observed in soft annealing. For instance, as indicated in Table II a wire of 1 mm. thickness shows, after a short annealing period of 5 minutes, such as would suffice for the soft annealing in a continuous heating furnace, does not disclose any increase in strength. Only after three hours is the strength increased. In general, this nitrogen will be applied for absolute permeation, and in this manner the strength can be increased throughout the entire cross section, but in certain cases, for instance when it is desired to increase the fatigue strength of thicker construction parts, it will suffice to limit the nitriding to the external zones. In this manner, the same improvement is obtained which would be possible by the strengthening of edge layers according to other methods.

This method is not limited to chromium-nickel steels of the composition stated in these specifications, of 18 per cent chromium and 8 per cent nickel, but it can be applied to all austenitic chromium-nickel alloys.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. The process for annealing austenitic chromium-nickel alloy steel which comprises heating said steel in a furnace and in a nitrogen-hydrogen atmosphere at a temperature of about 1100° C. for about one-half hour, slowly cooling the steel in the furnace for about five to six hours and thereafter quickly cooling it.

2. The process for annealing austenitic chromium-nickel alloy steel which comprises heating said steel in a nitrogen-hydrogen atmosphere at a temperature of about 1100° C. for about one-half hour, cooling the steel at a rate corresponding to that obtainable in air for about five to six hours and thereafter quickly cooling the steel.

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