FROM THE FOREIGN LITERATURE

LAMELLAR STRUCTURES IN AUSTENITIC STAINLESS AND HEAT-RESISTING STEELS.

[A Review of Two Papers from Trans. ASM]

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A pearlite-like structure was discovered [1] in austenitic chrome-nickel steel with 18 to 20% Cr, 8-12% Ni, 1% Si and 2% Mn round cracks in specimens tested for long-time stress rupture. This structure appears only when the steel contains chromium nitrides. A similar structure also was observed in austenitic stainless steels based on chromium and manganese with carbon and nitrogen. However, the constitution of its structural components and the kinetics of their formation remained unknown.

In this connection investigations [2] conducted on forged chromium-manganese stainless steels with nitrogen are of interest. The steels were melted in a laboratory electric furnace and had a composition 0.4% C, 13.5-18% Mn, 17-24% Cr and 0.18-0.46% N. A large part of the work was conducted on a heat containing 0.43% C, 0.25% Si, 13.54% Mn, 23.23% Cr, 0.17% Ni and 0.46% N. Specimens were austenitized at 1200°C (2190°F) so that all carbides and nitrides were in the γ solid solution and were then aged for various periods between 540 and 1100°C (1000-2000°F) in 55°C (100°F) intervals. Some of the specimens were isothermally treated by quenching them after austenitizing in a lead bath heated to the proper aging temperature and held there for various periods.

The kinetics of formation of lamellar precipitates was studied by quantitative metallography. The component phases were identified by X-ray studies and by micro-chemical analysis of the residues. The absence of an α-phase was established by a magnetic method. Dilatometry was used to follow aging and also to determine the density of the metal. The effects of aging were also determined by micro and macro-hardness measurements on the metal and its structural components.

Secondary phases along grain boundaries of austenite and slip planes in this steel after austenitizing were first observed after aging at 690°C (1270°F) for five hours. As the aging temperature increased, the size of these formations also grew. The lamellar structure became discernible in specimens aged hardened at 815°C (1500°F) for 4 hours. As the aging temperature was raised further the interlamellar spacings increased distinctly. Finally, when this procedure was continued the lamellar structures had a tendency to spheroidize. Also, although during precipitation a thickening of the slip planes was noted, no lamellar structures were observed inside the grains; the lamellar regions were formed only at grain boundaries. The precipitates inside the grains could be seen only at a magn. of 1000× and they appeared only after the transformation at the grain boundaries was essentially completed. However, larger precipitates in the form of minute crystals were observed in specimens subjected to much longer aging (16 hours) at higher temperatures (1040°C = 1900°F).

The results of quantitative determinations are reproduced in Fig. 1. The C-shaped transformation curves (T-T-T curves) are characteristic for nucleation
and growth. The formation of lamellar phases in the investigated austenitized steel essentially ends in one hour at 1040°C or after 4 hours at 990°C; however, at 870°C the process ends in 16 hours. In aging austenitized steel at 790°C for 100 hours, about 35% of the (max.) quantity of lamellar structure was formed, whereas during an isothermal treatment under the same conditions, this figure increased to 51%.

Consequently, to produce the maximum quantity of lamellar products relatively low temperatures and extended aging periods are required. Photographs of a lamellar structure obtained upon aging of steel austenitized at 815°C and 870°C are in Fig. 2. Specimens aged at lower temperatures (650-790°C) for 125-180 hours contain Widmanstätten type precipitates of the secondary phases inside the grains, on the (111) austenite planes (Fig. 2).

During aging of austenitized steel of the same type but with less nitrogen (0.32%), lamellar structures developed less clearly and globular precipitates of the secondary phase dispersed through the entire mass of the grains were predominant. In steel with even less nitrogen (0.18%) the lamellar structures were practically absent.

Experiments on re-solution of the precipitates formed during the aging of austenitized steels have shown that when they are heated either below or above the first austenitizing temperature, a certain proportion of lamellar structures is left undissolved. During subsequent aging the undissolved lamellar elements represent nucleating centers for precipitation and for a development of a lamellar structure.

Irrespective of the heat treatment, all the steels were nonmagnetic. This showed that a large quantity of austenite-forming elements, primarily carbon and nitrogen, remained in solid γ-solution and therefore ferrite was not formed.

An X-ray analysis of the residue extracted from the 0.46%N steel which