Structure of 22Cr25NiWCoCu austenitic stainless steel after ageing

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Introduction

The 22Cr25NiWCoCu (Sanicro 25) austenitic stainless steel was developed by AB Sandvik Material Technology in Sweden. Due to its high creep strength and good corrosion resistance, this material is well suited for use in superheaters in advanced coal-fired power boilers as well as in other types of steam boilers using various types of fuel. The examined material was subject to long-term ageing for the time of annealing up to 20 000 h at 700 and 750 °C—precipitation processes and microstructure stability as-received and after ageing were investigated. Examination of the microstructure was conducted using scanning electron microscopy. The identification of secondary phases was carried out by X-ray phase composition.

Materials

The investigations were carried out on the test specimen of ϕ38x8.8mm taken from a superheater coil made of Sanicro 25 creep-resistant austenitic steel, acquired during the project for selection of materials for modern power engineering.

Results

In the as-received condition, Sanicro 25 steel was characterised by approx. 14% higher tensile strength R_m and approx. 25% higher yield strength $R_{p0.2}$ compared to the required mechanical properties. Elongation was at the required minimum level.

Figure 1 shows the effect of ageing time at 700 °C on tensile strength R_m, yield strength $R_{p0.2}$ (Fig. 2) and elongation A (Fig. 3) determined at room temperature of Sanicro 25 steel.

A slight increase in tensile strength is observed until the ageing time of 20,000 h when it amounted to 10% relative to the as-received condition of the material. For yield strength, also a slight increase (approx. 17%) in relation to the as received condition is visible, whereas extension, after ageing for up to 20,000 hours, halved compared to elongation of the material in the as-received condition.

In the microstructure of the test steel in the solution-treated condition, primary NbX and NbCrN precipitates (Z phase) occur (Fig. 4). These particles are precipitated at the final stage of crystallisation, therefore most of them are observed near or at the grain boundaries. Due to their micrometric dimensions, the primary precipitates do not play a significant role in hardening of the test steel.

Ageing of Sanicro 25 steel contributes to the precipitation of secondary phases (Fig. 5) both at and inside the austenite grain boundaries, and the sequence of occurring precipitates and changes in their size depends on ageing temperature and time.

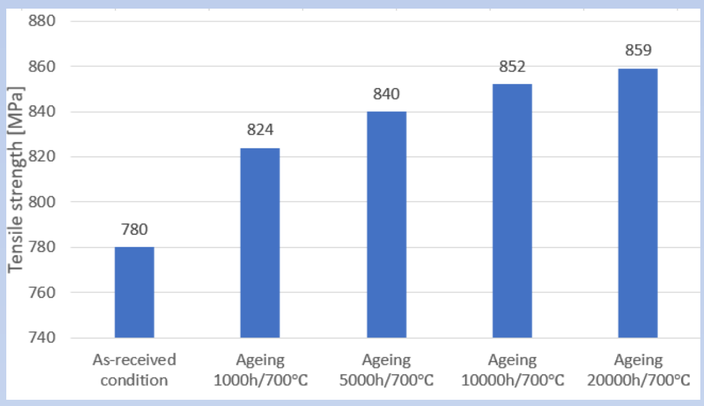


Fig.1. Change in tensile strength of Sanicro 25 steel after long-term ageing at 700°C

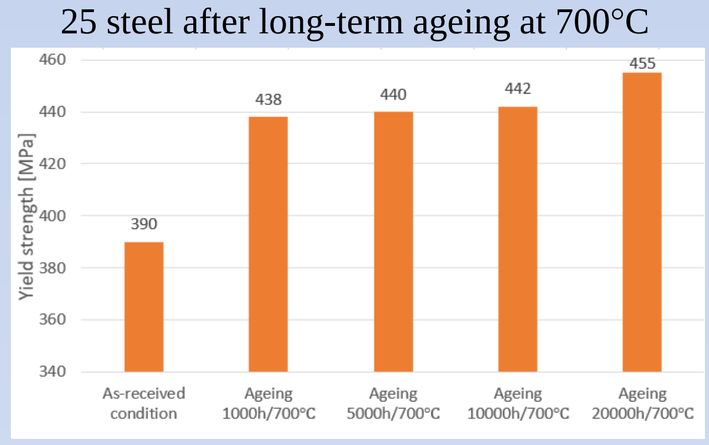


Fig.2. Change in yield strength of Sanicro 25 steel after long-term ageing at 700°C

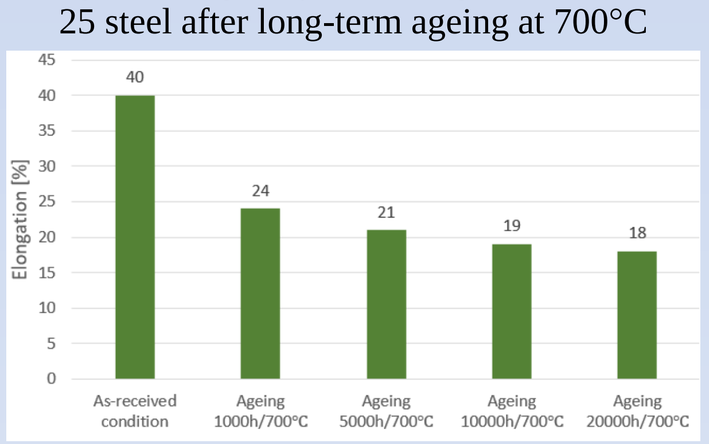
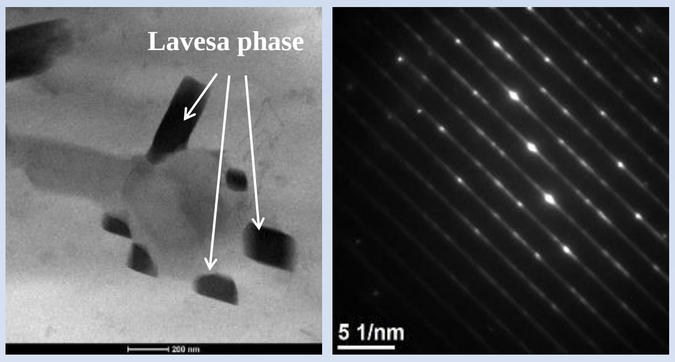


Fig.3. Change in elongation of Sanicro 25 steel after long-term ageing at 700°C



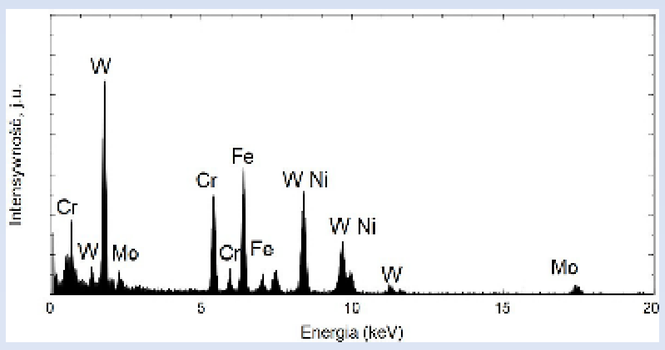


Fig.5. Laves phase in Sanicro 25 steel after 1,000 h ageing at 750°C

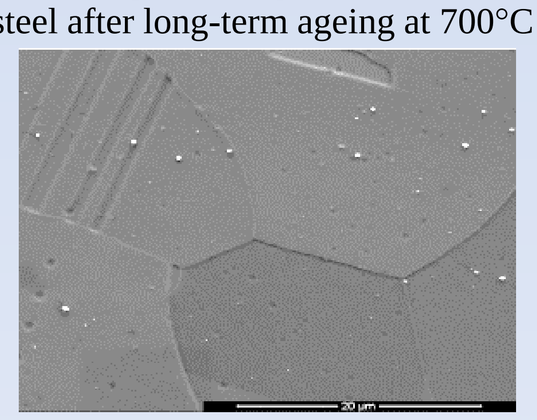


Fig.4. Microstructure of Sanicro 25 in the as-received condition, SEM

Conclusions

1. The investigations of the microstructure of Sanicro 25 steel after long-term ageing of up to 20,000 hours at 700 °C made it possible to evaluate the dynamics of changes in the microstructure and the intensive precipitation process.
2. The increase in tensile strength and yield strength at the expense of plastic properties was observed.
3. On the basis of the investigations performed, mechanical and plastic properties, phase composition and analysis of changes in the microstructure of the test steel, the Sanicro 25 steel can be concluded to be suitable for use in the power industry for the construction of ultra-supercritical boilers.