

Effects of Short Range Ordering on Dimensional Change in Type 304 Stainless Steel

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1. Introduction

It is confirmed that the ordering reaction occurs in Alloy 600 through a differential scanning calorimeter (DSC) [1, 2]. On the other hand, it is rarely understood that a short range ordering (SRO) occurs in almost all stainless steels. The ordering can be confirmed by differential scanning calorimeter (DSC) analysis using specimens with an ordered and a disordered state. An evidence for the ordering reaction in SS304 is shown in Fig. 1. The lattice contraction by aging at 400°C is due to SRO reaction.

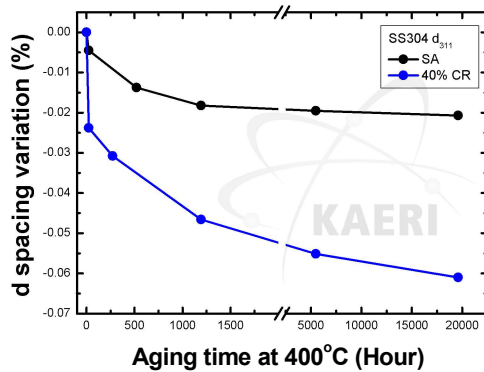


Fig. 1. The lattice contraction of (311) plane with ordering time at 400 °C in SA (solution anneal) and 40% cold rolled stainless steel 304.

It is known that the SRO causes a lattice variation [3, 4]. The SRO formation causes a lattice contraction. It is expected that the lattice contraction cause the dimensional change in the structures made of 304 stainless steel.

It is worthy to confirm whether the dimensional change occurs due to the SRO reaction in the 304 stainless steel.

2. Experiments

The 40% cold rolled 304 stainless steel (40% CR 304SS) plates were used. The chemical composition is shown in Table 1. The dimensional change is directly examined by a micrometer using 100mm long specimens. The 40% CR 304 specimens was cut into 100mm in longitudinal and transverse directions, as shown in Fig. 2. Each 4 specimens were prepared and

the lengths of 304 specimens were measured before and after ordering treatment in the resolution of 1 micrometer. The 40% CR 304 specimens were aged at 350, 400, 475°C for 600 hours.



Fig. 2. Comparisons of d_{111} and d_{200} variation during heating and cooling processes in 40% CR SS 316L.

In order to check the resolution of measurements, the length of the aged and unaged specimens measured again together. It is confirmed that the measurement error of unaged specimen appeared to be lesser than 1 micrometer. The length change is calculated by a relationship of $(\text{length}_{\text{ordered}} - \text{length}_{\text{40\% CR 304 SS}}) / (\text{length}_{\text{40\% CR 304 SS}})$.

Table 1. Chemical composition of SS304 (wt. %).

elements	Fe	Cr	Ni	C	Si	Mn	P	S
[%]	71.62	18.18	8.03	0.043	0.46	1.04	0.031	0.004

3. Results and Discussions

Fig. 3 shows the ratio of length change in longitudinal direction in 40% CR 304 SS. The dimensional change varied from 0.02-0.06% according to aging temperatures. This length change is due to SRO reaction in SS 304. This behavior can be understood by lattice contraction, as shown in Fig. 1. The length of materials is due to an accumulated stacking of atoms. Thus, when the interatomic distance reduced the length of material contracts.

Fig. 4 compares the length change in the longitudinal and transverse direction in 40% CR 304 SS. This shows that the length in longitudinal direction is contracted

whereas that in transverse is expanded by SRO treatment. This seems due to the difference in texture or grain orientations.

It is thought that the SRO formation is general phenomenon in Fe-Cr-Ni ternary alloys. Therefore, it is expected that these alloys exhibiting SRO will show a dimensional change. The ordering reaction is an unavoidable process in nuclear reactor operating condition. Therefore, the effect of lattice contraction due to ordering reaction should be considered, since the ordering reaction is a spontaneous and an unavoidable phenomenon below 500°C.

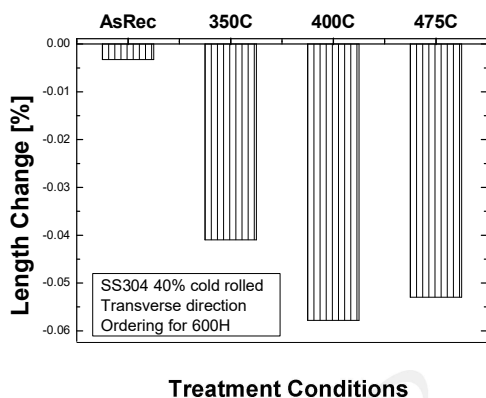


Fig. 3. Comparisons of ratio of length change in longitudinal direction by aging at 350, 400, 475°C for 600 hours in 40% CR 304 SS.

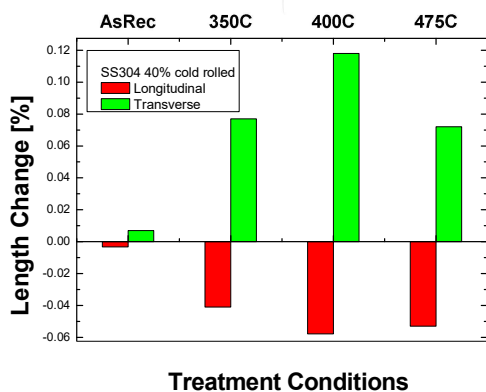


Fig. 4. Comparisons of ratio of length change in longitudinal and transverse direction by aging at 350, 400, 475°C for 600 hours in 40% CR 304 SS.

4. Conclusions

1. The 40% cold rolled 304 stainless steel shows a contraction of length in longitudinal direction in the magnitude of 0.02-0.06% by aging at 350, 400, 475°C for 600 hours.
2. The 40% cold rolled 304 stainless steel shows a contraction of length in transverse direction in the

magnitude of 0.07-0.12% by aging at 350, 400, 475°C for 600 hours.

3. The difference in dimensional change in longitudinal and transverse direction seems due to the texture and/or the anisotropy of crystal.

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