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MICROSTRUCTURAL DEVELOPMENTS DURING HIGH TEMPERATURE TENSILE TESTS OF ASS 304 SHEETS USED IN DAIRY INDUSTRY

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Abstract : Hot deformation of ASS sheets are in great demand and its application has prominent importance in dairy sector. In the present investigation the austenitic stainless steel (ASS)-304 blanks are subjected to tensile tests at elevated temperatures to check whether formability is improved. Numbers of tests are conducted under hot conditions to study the microstructure at elevated temperatures from room temperature to 600°C at an interval of 100°C. In this investigation, changes in the microstructure are observed for all specimens at ambient and elevated temperatures.

***IndexTerms* - Formability, ASS304, hot tensile test, microstructure.**

I. INTRODUCTION

In manufacturing industry sheet metal forming is widely used technology since many decades, with huge increase in production of thin sheet metal parts at low cost. The Sheet metals of thin hot-rolled strip or cold rolled sheet have many applications in automobiles, domestic appliances, building products, aircraft, food and dairy industries. Sheet metal components have high elastic modulus and high yield strength to bear good strength to weight ratio characteristics. Recent investigations showed that under warm conditions the formability of extra deep drawing (EDD) steel rapidly increases at elevated temperature [1]. Tensile deformation behavior of IN 718 super alloywas studied at 650°C at different strain rates and found that effect of strain hardening exponent and strain rate should be incorporated during deformation modelling [2]. The correlation of microstructure and tensile behavior for the multiple rolling from low to high temperature for ASS-304 was investigated by [3]. Flow stresses of ASS304 at elevated temperatures were predicted modifying the extended Rusinek-Klepaczko (RK) model in order to use an exponential strain dependent term for dynamic strain aging (DSA) region [4]. Investigations on high temperature flow stress in ASS316 steel sheet metal for both non-dynamic strain aging and dynamic strain regimes were done by [5] and further, the predicated flow stresses were validated with experimental data. In the work of [6], experiments were conducted on high-temperature tensile tests of SUS304 at different strain rates. The test interval was 100°C in a range from 800°C to 1200°C. In spite of all this still some gap is there for better usage of ASS-304 at elevated temperature. So, ASS-304 material is investigated at elevated temperature for improvement in formability and metallographic studies.

II. MATERIALS AND METHODS

The material selected for this research work is cold rolled austenitic stainless steel 304 sheet of 1.00mm thickness. Chemical composition of the material is listed below in Table I. Tensile tests at room temperature as per ASTM E8M standard and hot tensile tests as per ASTM E21 standards were performed. The standard geometry of room temperature specimen is shown in Fig. 1. The strength coefficient (K) and strain hardening exponent (n) data were calculated using power law as given in eq.(1).

$$\sigma = K \in^{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Table I: Chemical composition of ASS304.

Elements	C	Mn	Si	P	S	Cr	Ni	N
% wt	18.4	1.43	0.36	0.01	0.002	0.01	0.05	8.28

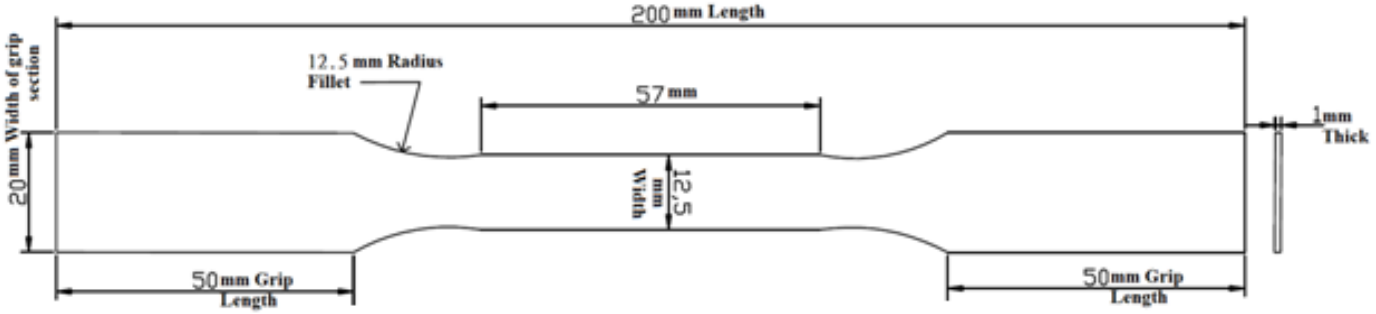

Fig.1 Standard tensile test specimen as perASTM-E8M [7]

Mechanical properties determined from room temperature tensile tests are shown in below Table II.

Table II: Mechanical properties of ASS-304 specimen.

Sl. No.	Parameter	Values		Average
1	Strain Hardening Exponent 'n'	0°	0.44	0.413
		45°	0.42	
		90°	0.38	
2	Strength Coefficient 'K'	0°	770.75	765.13
		45°	760.78	
		90°	763.88	
3	YS(MPa)			320
4	UTS(MPa)			620
5	%EL			55
6	Normal Anisotropy '$\bar{r}$'			0.67
7	Planar Anisotropy 'Δr'			-0.16

III. RESULTS AND DISCUSSION

A. Tensile test at room and elevated temperature

Fig. 2 shows the tensile tested samples performed at room temperature and at elevated temperatures (100°C, 200°C, 300°C, 400°C, 500°C and 600°C). From stress-strain curves determined high numerical values of yield strength, strain hardening exponent (n), and % elongation were observed for tensile tested sample at 300°C.

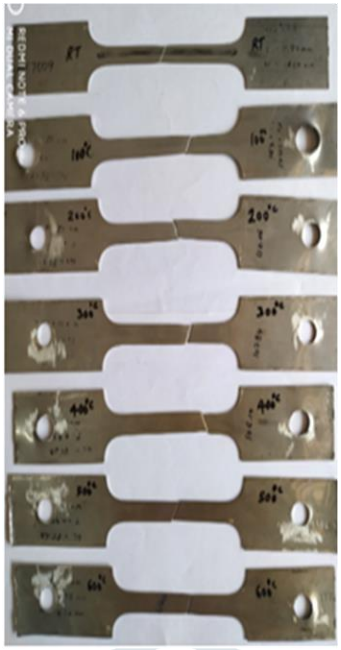

Fig. 2 Tensile tested test specimens.

B. Microstructure developments during high temperature tensile tests

After the tensile test, microstructures were observed using SEM in the secondary electron imaging mode and then the fracture necking zone was characterized using electron back-scattered diffraction (EBSD). The 304 ASS specimens were characterized for micro-texture using FEG scanning electron microscope system. Metallographically polished samples were further prepared for EBSD investigations by final electro-polishing.

Fig. 3 shows the IPF maps and misorientation distributions of the elevated temperature from 100°C to 600°C tested tensile specimen. It is observed that there is slight grain coarsening with the increase in the testing temperature. However, IPF map seems to remain unchanged indicating that there is little change in the texture. Also, the misorientation distribution is also very marginally changed.

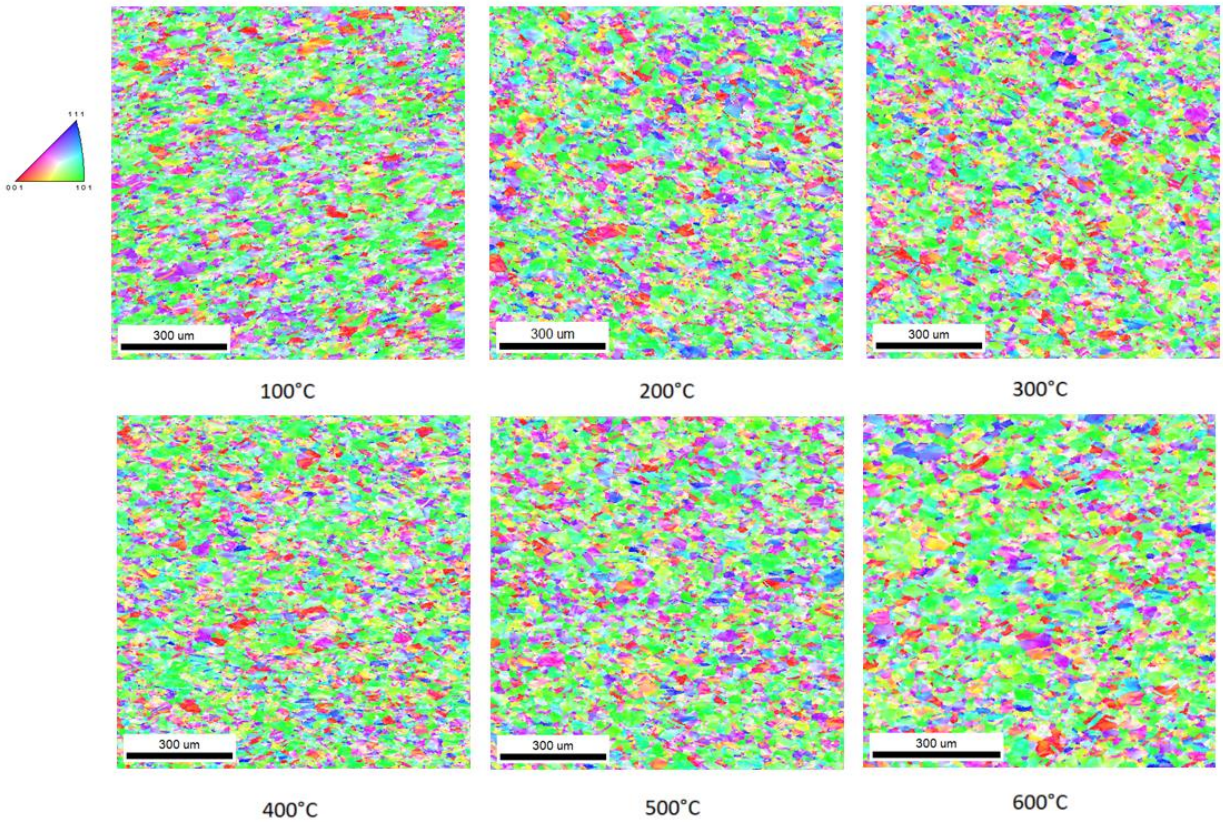

Fig. 3 Tested Tensile test specimen as per ASTM E8 standard.

IV. CONCLUSIONS

In this work the tensile behavior of ASS-304 is studied by subjecting the specimens to tensile tests at room temperature and elevated temperatures. Following conclusions were drawn

- Yield strength (430Mpa) found to be higher for 300° C specimen.
- The average strain hardening exponent (n = 0.4297) is found to be higher for 300°C specimen.
- Increased value of percentage elongation (37%) is observed for 300°C specimen compared to other specimens
- From EBSD measurements, it was found that grain coarsening takes place as testing temperature increases.

V. ACKNOWLEDGMENT

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