Effect of Partition Quenching on Mechanical Properties of AISI 316LN Stainless Steel

Mr. Ch. Sai Teja[1], Mr. J Pradeep kumar[2], Dr. G Sreeram Reddy[3]

[1]*Student. Department of Mechanical Engineering, VJIT, Hyderabad.*
[2]*Assistant Professor, Department of Mechanical Engineering, VJIT, Hyderabad.*
[3]*Professor, Department of Mechanical Engineering, VJIT, Hyderabad.*

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Abstract -The aim of the current investigation is to examine the mechanical properties of AISI 316LN stainless steel when it is subjected to partition quenching .In this material is subjected to mechanical property evaluation in as received condition. Tensile strength, Izod impact toughness, hardness and microstructure of the material are found by employing the ASTM standard specimens. The material is now subjected to partitioning quenching (PQ) by heating in a furnace above 900^0 c and quenched in SAE 30 oil till it reaches above M_f temperature. The material is now again heated in furnace above recrystalisation temperature and is annealed till it reaches room temperature. The PQ material is again subjected to mechanical property evaluation.

Keywords: Partition Quenching, Tensile strength, Impact Toughness, Hardness, Recrystalisation temperature.

1. INTRODUCTION

Stainless steel is one of the most widely used materials today because of its corrosion resistance and strength. Stainless steel has excellent corrosion resistance because of the presence of a passive chromium-rich oxide film that forms naturally on the surface. Low carbon grade type 316 austenitic stainless steel, alloyed with nitrogen designated as 316 LN exhibit superior strength at ambient and high temperatures, excellent corrosion resistance to replace other expensive materials[1]. Austenitic stainless steel gets sensitized during welding. The problem of sensitization can be overcome by decreasing the carbon content. Reducing the carbon content would cause drastic reduction in mechanical properties[2]. Replacing much of the carbon with nitrogen can offset this deterioration in mechanical properties. Nitrogen in solid-solution is the most beneficial alloying element in promoting high strength in austenitic stainless steel without sacrificing their good ductility and toughness. The upper limit of nitrogen is set on considerations of minimizing scatter in mechanical properties and improving weld ability. Phosphorous, sulphur and silicon are treated as impurities having adverse effects on weldability [3]. The selection of the material is based on its good combination of tensile, creep strength, ductility and its high resistance to stress corrosion cracking and sensitization[5]. Nickel content has been known as an element that stabilizes austenite and increases toughness[6].

AISI316LN austenitic stainless steel has excellent mechanical properties and good resistance to pitting corrosion at high temperatures, so it is a prospective structural material for nuclear equipment, surgical instruments and orthopedic implants. Compared with conventional 316L stainless steel, the addition of nitrogen could stabilize austenite and introduce solid solution hardening. Furthermore, 316LN steels have much higher yield strength and tensile strength than 316Lsteels. However, 316LN stainless steel has a relatively low yield strength (250–400 MPa), therefore, it is imperative to enhance the strength for improving equipment safety.

316L stainless steel contains molybdenum, which facilitates the formation of molybdenum-rich intermetallic phases such as sigma (σ) and chi (χ) phases. Homogenization heat treatment helps to eliminate interdendritic segregation and ferrite, encouraging the development of a uniform austenitic matrix with spheroidized phase distribution.

In the quenching step, fully austenitized samples are quenched to temperatures below martensite start temperature (Ms) but above martensite finish temperature to form controlled volume fractions of martensite. The quenched Steels are held at same temperature or higher than quenching temperature during subsequent partitioning step. Austenite that prevails after quenching is considered to be stabilized through carbon partitioning from martensite into austenite during the partitioning treatment. The resultant microstructure of steel mainly consists of tempered martensite and retains austenite so that higher strength can be achieved.

This makes it difficult to distinguish the contributions of Carbon enrichment into Austenite during partitioning step caused by bainite transformation from that caused by carbon partitioning from martensite. So it is aimed at providing direct atomic scale of carbon partitioning from martensite to austenite during quenching and partitioning heat treatment excluding bainite transformation. Koistimen-Marburger equation is used to estimate the austenite at quench temperature.

2.0 EXPERIMENTAL DESIGN

2.1 Material Employed

AISI 316LN austenitic stainless steel plate of 5mm thick is undertaken for the current investigation. AISI 316LN is more popularly used in chemical industries, power plants, marine components etc as it has superior resistance to corrosion and greater strength. The chemical composition (%Wt) is presented in Table 1and the microstructure in as received condition is shown in Fig 1.

2.2 Equipment Used

Universal Testing Machine of 100 KN for Tensile strength, ITM 300 model Impact testing machine for finding Izod toughness and KAS model Rockwell hardness tester for hardness are employed in the current investigation. Also a furnace of pyrometric make is used for heat treatment along with the SAE 30 oil for quenching.

Table 1 Chemical Composition (%wt)

C	Cr	Ni	Mo	S	N	Mn	Fe
0.02	16.6	10.1	2.09	0.01	0.2	1.24	balance

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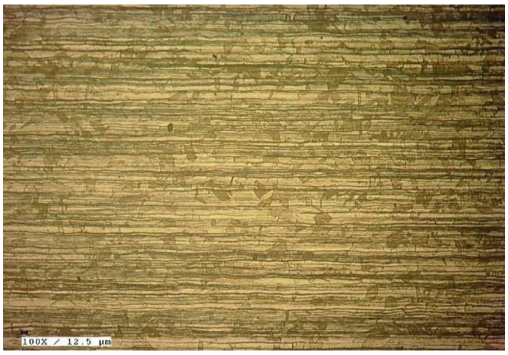

Fig 1 Microstructure of Base material

3.0 Results and Discussion

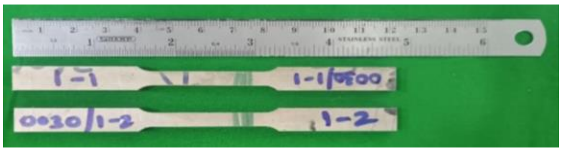

Fig 2 Tensile Test Specimen before Quenching

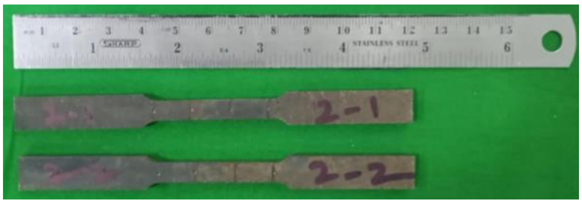

Fig 3 Tensile Test Specimen after Quenching

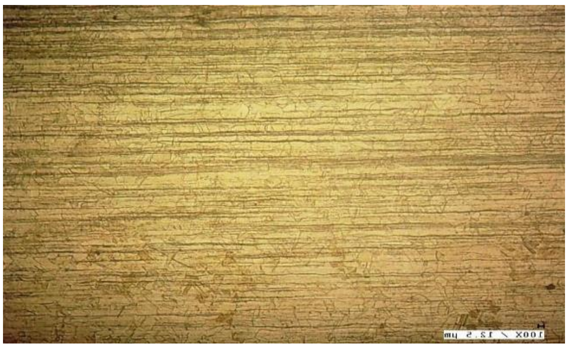

Fig 4 Microstructure after Quenching

Table 2 Results Before and PQ Operation

S No	Property	Base material	After PQ operation
1	Tensile strength	618 MPa	616.9 Mpa
2	Izod Impact toughness	1.975 J/mm^2	2.087 J/mm^2
3	Hardness	94.6	95.16
4	Ductility	51	49
5	% Vol of Austenite	60%	30%

4.0 CONCLUSION

1. The volume fraction of ferrite and austenite phases increased the grain size of the material.
2. The tensile strength and ductility of steel decreased due to the increase in grain size of the two phases.
3. The precipitation of chromium nitride in ferrite during quenching is observed.

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