Characterization and Micro Structural Study of Steel 304 to Analyze the Property Variation after CNC Milling

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Abstract- *SAE 304 is austenite stainless steel also known as A2 or 18/8 stainless steel. It is non-magnetic and it has high corrosion resistance than regular steel and can be formed in various shapes. The different applications of this steel are for various household and industrial applications such as screws, machinery parts, car headers, heat exchangers and food processing equipment, particularly in milk processing. The proposed study aims at performing various hardness tests such as brinell hardness, rockwell hardness, poldy hardness, vicker's hardness, Tensile, Compression and impact Test on the specimen of this grade in order to understand the characterization of the specimen. After that the tested specimen observed under microscope to study microstructure and analyze the variation. CNC milling operation is also performed on specimen of same grade to study the microstructure under microscope. The proposed work describes characterization and microstructural study of Steel 304 and analyze the property variation after CNC milling.*

Keywords- SAE 304, Microstructure ,CNC milling , characterization etc.

I. INTRODUCTION

These days, low carbon steels had been extensively used in numerous applications due to their greater availability and cost considerations. This can be proven by looking at the variety of applications being manufactured using low carbon steels as in the field of buildings, transportation, and machines. Unfortunately, there are some margins in the properties of low carbon steels that restricted the usage of low carbon steel at modern manufacturing process. For an instance, the carbon content for low carbon steel is approximately in between 0.15% to 0.45% which makes the surface hardness of low carbon steel is poor compared to other type of steel. Moreover, it is neither extremely brittle nor ductile and has lower tensile strength and malleable due to its low carbon content. As the carbon content increases, the metal becomes harder and stronger but less ductile and more difficult to be weld in such of application as the railways wheels, gear teeth profile, crane wheels, crane cable drum, gear wheel, pinion blanks and brake drum. In many engineering applications, it is desirable that steel being used should have a hardened surface to resist wear and tear. Nevertheless, today the problem related with surface hardness that lowered the mechanical properties of low carbon steel can still be recovered by using heat treatment process. This study shows the microstructure variations in steel 304 after performing various mechanical test such as tensile test, compression test, impact test and hardness test such as brinell, rockwell, poldi and vicker's. After performing this test analyze the microstructure of steel after CNC milling. Thus, the main attentive of this study is to explore the variations in microstructure and mechanical properties of steel 304.

II. IDENTIFY, RESEARCH AND COLLECT

Dana K. Morton et al.[1] This work aims at discussed the procedure used to perform the impact tensile testing of base material at room temperature.

Man Wang et al.[2] This work aims at the tensile property of steel 304 at room temperature. The result shows that the steel exhibited relatively high strength, and UTS reached 940 MPa which is three times higher than the common austenitic steel.

Blandford, R. K et al.[3] Stainless steels are used for the construction of numerous spent nuclear fuel or radioactive material containers that may be subjected to high strains and moderate strain rates (10 to 200 per second) during accidental drop events. Mechanical characteristics of these materials under dynamic (impact) loads in the strain rate range of concern are not well documented. The goal of the work presented in this paper was to improve understanding of moderate strain rate phenomena on these materials.

Goodwin, G. [4] Strain analysis of stampings is explained. The system is based on the strain distributions obtained from 0.2 in. inter-locking circle grid patterns etched on blanks. The strain distributions are related to a developed formability limit curve and the mechanical properties of the gridded blank. The evaluation of the graphic relation of the strains to the formability limit enables the press shop to determine what factors should be changed to produce stampings with less scrap and lower cost.

Hasan K.[5] Nanocrystalline 316L stainless steels with yttrium addition were prepared by mechanical milling at cryogenic temperature and subjected to annealing treatments at room temp. The dependence of hardness on the microstructure was utilized to study the mechanical changes in the steels occurring during annealing.

Byrne.G et al .[6]This paper reviews some of the main developments in cutting technology since the foundation of CIRP over fifty years ago. Material removal processes can take place at considerably higher performance levels in the range up to Q_w = 150 – 1500 cm^3/min for most workpiece materials at cutting speeds up to some 8.000 m/min.

III. EXPERIMENTATION

Test Specimen Geometries

The typical test specimen dimension used for material impact testing is 20mm(thickness) x 30mm(width) x175mm(long). Dimension of specimen used for tensile test is 20mm(thickness)x50mm(width)x250mm (long). For various hardness test the dimension of the steel specimen used is 20mm(thickness)x50mm(width)x50mm(long).

Impact Test

Impact testing is testing an object's ability to resist high-rate loading. An impact test is a test for determining the energy absorbed in fracturing a test piece at high velocity. Basically it is one object striking another object at a relatively high speed. This test is used to determine material's toughness in the presence of flaw or notch and fast loading condition. Steel 304 of dimension 20mm(thickness) x30mm(width) x175mm(long) specimen is used for the test. Impact test is carried out in atmospheric temperature.

Compression Test

A compression test determines behaviour of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. Compressive stress and strain are calculated and plotted as a stress-strain diagram which is used to determine elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength.

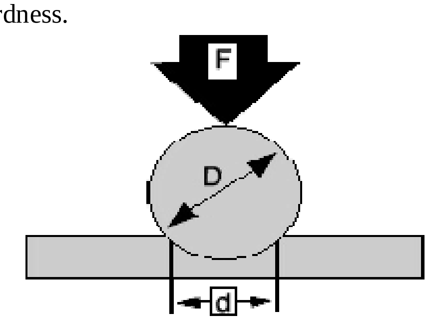
Tensile Test

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on material. Tensile tests are simple, relatively inexpensive, and fully standardized. The results from the test are commonly used to select the material for an application, for quality control, and to predict how a material will react under other types of forces. The process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The elongation measurement is used to calculate the engineering strain,

$$\in = \frac{\Delta L}{Lo}$$

Brinell Test Method

All Brinell tests use a carbide ball indenter. The indenter is pressed into the sample by an accurately controlled test force. The force is maintained for a specific dwell time, normally 10-15 seconds. After the dwell time is complete, the indenter is removed leaving a round indent in the sample. The size of the indent is determined optically by measuring two diagonals of the round indent using either a portable microscope or one that is integrated with the load application device. The Brinell hardness number is a function of the test force divided by the curved surface area of the indent. The indentation is considered to be spherical with a radius equal to half the diameter of the ball. The average of the two diagonals is used in the following formula to calculate the Brinell hardness.



$$HB = \frac{2F}{\pi D\,(D - \sqrt{D^2 - d^2})}$$

Fig. 3.4.1 Brinell Test

The Brinell number, which normally ranges from HB 50 to HB 750 for metals, will increase as the sample gets harder. Tables are available to make the calculation simple. A typical Brinell hardness is specified as follows:Where 356 is the calculated hardness and the W indicates that a carbide ball was used. Note- Previous standards allowed a steel ball and had an S designation. Steel balls are no longer allowed.

Vickers Test Method

All Vickers ranges use a 136° pyramidal diamond indenter that forms a square indent. The indenter is pressed into the sample by an accurately controlled test force. The force is maintained for a specific dwell time, normally 10 – 15 seconds. After the dwell time is complete, the indenter is removed leaving an indent in the sample that appears square shaped on the surface. The size of the indent is determined optically by measuring the two diagonals of the square indent. The Vickers hardness number is a function of the test force divided by the surface area of the indent. The average of the two diagonals is used in the following formula to calculate the Vickers hardness. HV = Constant x test force / indent diagonal squared

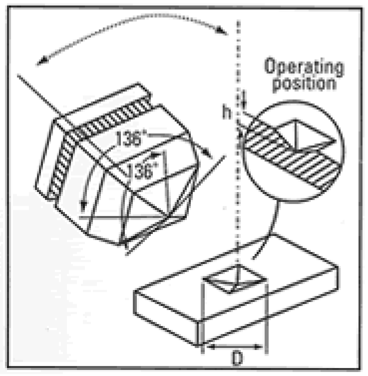


Fig. 3.5.1 Vickers Test

The constant is a function of the indenter geometry and the units of force and diagonal. The Vickers number, which normally ranges from HV 100 to HV1000 for metals, will increase as the sample gets harder. Tables are available to make the calculation simple, while all digital test instruments do it automatically. A typical Vickers hardness is specified as follows. Where 356 is the calculated hardness and 0.5 is the test force in kg.

Rockwell Test

The indenter moves down into position on the part surface. A minor load is applied and a zero reference position is established. The major load is applied for a specified time period (dwell time) beyond zero The major load is released leaving the minor load applied.

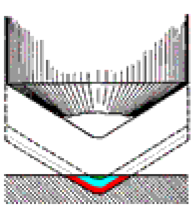


Fig. 3.6.1 Rockwell Test

The resulting Rockwell number represents the difference in depth from the zero reference position as a result of the application of the major load

Poldi Hardness Test

Load is applied by a hammer blow on the specimen and a standard test bar in linear direction through a hardened steel ball of 10 mm dia. The impact load on both is the same. The extent of indentation on the specimen and the test bar depends on their hardness. The two diameters of indentations on test bar and specimen are measured by a magnifier supplied along with the tester. The hardness of the specimen can be determined, by referring got the chart supplied with the machine.

CNC milling

Milling is the machining process of using rotary cutters to remove material from a workpiece advancing (or *feeding*) in a direction at an angle with the axis of the tool. It covers a wide variety of different operations and machines, on scales from small individual parts to large, heavy-duty gang milling operations. It is one of the most commonly used processes in industry and machine shops today for machining parts to precise sizes and shapes.

IV. METHODOLOGY

Defining Problem statement: Initially the problem statement for the project was defined. Also the objectives and expected outcomes of the project were established.

Literature survey: The work done so far by researchers in the domain area and their significant conclusions were studied through technical papers and patent applications.

Test of Specimen of Steel 304: The test to be performed are Brinell Hardness, Rockwell Hardn ess, Poldy Hardness, Vicker's Hardness, Tensile , Compression and Impact Test.

Study of micro structure of Steel 304 specimen: After test performed on the specimen, the properties and micro structure of the steel 304 specimen will be studied.

CNC milling operation of steel 304: after studying microstructure of specimen CNC Milling operation will be performed on steel grade.

Study of Variation in the Properties of Steel Grade after CNC Milling: After performing on CNC machine there will be change in microstructure of Steel specimen.

V. CONCLUSION

1. By performing various Hardness test, Tensile test, Compession test and Impact test characterization of steel grade will be studied.
2. After perfoming the CNC Milling operation on steel grade the microstructural changes and change in properties will be analyzed.

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