IMPACT OF NOTCH DEPTH ON THE FATIGUE LIFE OF AISI 316L AUSTENITIC STAINLESS STEEL

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Abstract - *AISI 316L Austenitic Stainless steel is a popular grade of steel used in Marine and Architectural Applications. The current project aims at finding the impact of notch depth on the fatigue life of AISI 316L Austenitic Stainless steel. The scope of the project includes experimental investigation of the fatigue life of all coupons (without notch and with notches of 1mm and 2 mm depth respectively) by conducting experimental runs on 400 kg-cm Rotary Bending Fatigue Testing Machine.*

***Key Words*: Fatigue Life, Corrosion Resistance, Notch, cyclic stress, FTM (Fatigue Testing Machine)**

1. INTRODUCTION

Fatigue failures typically occur at stresses well below the yield strength, or in some cases above the yield strength but below the tensile strength of the material. These failures are hazardous because they befall without any warning [1][2]. Components of machines are usually subjected to the cyclic loads and the resulting cyclic stresses can lead to microscopic physical damage to the materials involved. Fatigue fractures usually occur at the notches such as holes, grooves, etc. The geometry of notch and other notch properties affect on the predictions of fatigue life [3]. Materials for marine applications are selected to maintain the integrity of the structure and to be corrosion resistant. Stainless steels are used in marine applications because they are resistant to corrosion easily fabricated and offer good mechanical properties [4]. The term "notch" in a broad sense is used to refer to any discontinuity in shape or non-uniformity in material such as the V-shape threads on nut-bolt connections, the square-shape key washer's grooves on shafts, scratches, non-metallic inclusions and corners, fillets and geometry discontinuities, The failure usually originates in the formation of a crack at a localized point on the notches[5]. The presence of a notch in a structure is more dangerous than a simple reduction of the net cross section. This effect is generally called the "Fracture notch effect'' [6][7]. An experimental investigation was achieved by, this study used cantilever rotating-bending fatigue testing machine to explain the effect of surface roughness on the fatigue life of low carbon steel. There are numerous evidences in the literature that the presence of notch can reduce the fatigue life of components dramatically in some circumstances. The fatigue life of V-shape notch specimens under rotating bending by analytical method was examined, Reference also shows failure cycles of notched round specimens under strain controlled cyclic loading by using strain life relations obtained from experiment for plain fatigue round specimens.

For low-cycle fatigue conditions where the stress is high enough to create plastic deformation, fatigue failure results from cyclic strain rather than from cyclic stress.

AISI 316L Austenitic stainless steel has high pitting corrosion resistance and possesses excellent resistance to sulphates, phosphates and other salts. 316L has better resistance than standard 18/8 types to sea water, reducing acids and solution of chlorides, bromides. Common uses for type 316L stainless steel include in the construction of exhaust manifolds, furnace parts, heat exchangers, jet engine parts, pharmaceutical and photographic equipment, valve and pump parts, chemical processing equipment, tanks, and evaporators. It also is used in pulp, paper, and textile processing equipment and any parts exposed to marine environments316L is a great stainless steel for high-temperature, high-corrosion uses, which is why it's so popular for use in construction and marine projects.

The current research aims at investigating the impact of notch depth on the fatigue life of the above said steel using the experimental fatigue test runs on 400 kg-cm Rotary Bending Fatigue Testing Machine.

2. MATERIALS & METHODS

2.1 MATERIALS

In the current research, fatigue life of AISI 316L austenitic stainless steel is investigated. The material composition and mechanical properties are given in tables 1 and 2 respectively.

Table- 1: Chemical composition of 316L in percentages

Composition Of 316 L stainless steel in %	
C	**0.0180**
Cr	**16.9280**
Ni	**9.5800**
Mn	**0.6020**
Si	**0.3644**
Mo	**0.2898**
P	**0.0015**

Table- 2: Mechanical Properties of Type 316L Stainless Steel

Mechanical Properties of Type 316L Stainless Steel	
Yield Point, MPa	**332**
Tensile strength, MPa	**673**
Modulus of Elasticity, GPa	**165**
Elongation at break, mm	**35.5**
Strength at break, MPa	**586**

2.2 METHOD EMPLOYED

The specimens are fabricated using CNC lathe as per the specifications of standard fatigue specimen. Experimental runs are conducted on 400 kg-cm Rotary Bending Fatigue Testing Machine to evaluate the fatigue life. The procedure employed is shown in the flow chart (Fig 1).

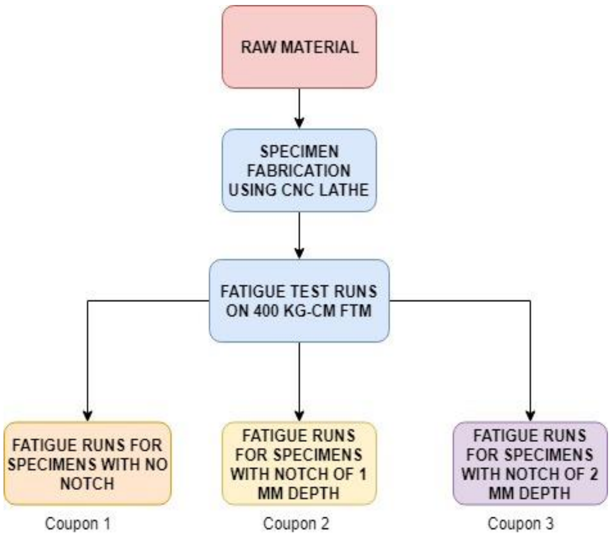

Fig- 1: Flow chart for the experimental procedure

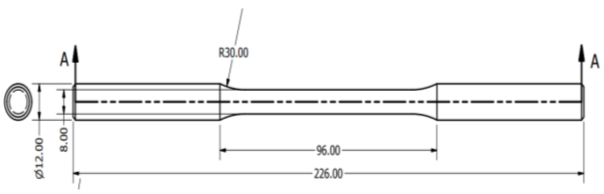

Fig -2(a): Specimen drawing

Fig -2(b): Notched Specimen

2.3 FATIGUE TESTING MACHINE

In this current investigation a 400 kg-cm capacity rotary bending fatigue testing machine (Fig 3) is employed. It has provision to record the number of cycles the specimen has undergone before failure using a data-logger and the same is displayed on the digital display.

Fig- 3(a): 400 kg-cm Rotary Bending Fatigue Testing Machine

Fig -3 (b): Mounting of specimen on the FTM

3. RESULTS AND DISCUSSION

The fatigue test results of the different specimens are tabulated below.

Table- 3: Fatigue life of 316L Austenitic stainless steel

Coupon Code	Coupon Details	Fatigue Life in cycles	
		Run 1	Run 2
Coupon 1	New coupon without Notch	No failure observed even after 12 Lakhs cycles	
Coupon 1 with Notch (after 12 Lakhs cycles of Fatigue Run without notch)	Old Coupon with 2 mm Notch on it	2,852	

Coupon 2	New coupon with Notch of 1 mm depth	8,09,202	8,12,385
Coupon 3	New coupon with Notch of 2 mm depth	81,142	83,257

In the investigation, for the specimen without notch, no failure was observed even at 12 lakhs cycles. Then the same specimen is provided with a 2 mm notch at the centre and again continued for its fatigue life estimation. The life after the notch creation was found to be 2,852 cycles only as the specimen already underwent 12 lakh cycles before the notch was created.

In another set of samples, a notch of 1mm and 2 mm depth was created at the centre and fatigue runs were performed on them. As expected, the fatigue life of the material declined when the notch was created with 1 mm depth, however the life in cycles was around 8,00,000 cycles. But when the notch depth was increased to 2 mm, the fatigue life declined drastically and the life in cycles was around 80,000 cycles. This seems to be an interesting finding as the life deteriorated by 10 times when the notch depth was increased by 1 mm.

For consistency the experiment is repeated twice to reduce the error component.

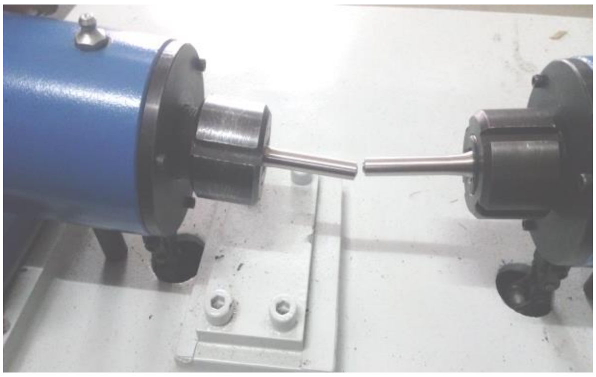

Fig- 2: 1 mm notched specimen broken after 8, 12,000 cycles

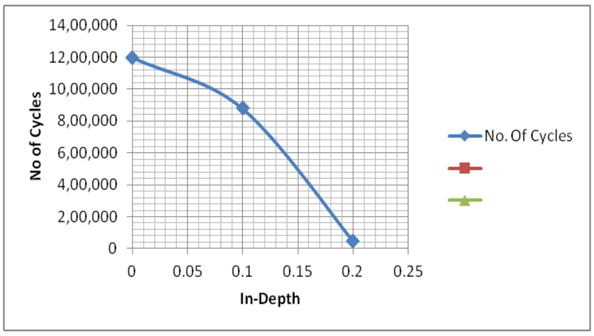

Fig- 3: Variation of fatigue life with notch depth.

4. CONCLUSION

From the results of the experimental runs on the FTM, it can be concluded that the notch depth plays a vital role on the fatigue life of a material. Till a threshold depth, the decrement in the fatigue life is marginal, but once the notch depth is around 25% of the total dimension, there a drastic fall in the fatigue life. Larger the depth of the notch, lower the fatigue life due to the quick propagation of the crack.

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