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Fatigue Behaviour of Metals Under Various Surface Finishes

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Abstract: *Fatigue of materials is one of the failures that has occurred frequently and has been studied rather extensively. Such failures in metals may be induced either by large- scale hysteric heating which causes the metal to soften, or by fatigue crack initiation and propagation of final failure. The aim of the project work is to study experimentally the fatigue behaviour on materials under various surface finishes subjected to repeated cyclic loading. Totally eighteen specimens were tested for two types of materials such as Brass and En-24 in the fatigue testing machine by varying load (100 kgf , 125 kgf & 150kgf) and surface roughness of the materials (Ra= 2 µm , 1.5 µm & 0.8 µm).The stress – life data (S-N) curves for those two materials are drawn and compared . It concludes the increase in the surface roughness increases the fatigue life by 22 %.*
Keywords*: Fatigue behaviour, Surface roughness, SN curve, Brass, EN-24*

I. Introduction

Fatigue is the process in which the damage is accumulated in a material undergoing fluctuating eventually resulting in failure even if the maximum load is well below the elastic limit of the material. Final failure generally occurs in regions of tensile stress when the reduced cross section becomes insufficient to carry the peak load without rupture (Coffin, 1973). Fatigue failure occurs due to variation in live load applied during normal condition, vibration, pressure changes, temperature fluctuation wave and wave forces. Fatigue crack starts at a point of local defect (or) stress concentration and propagate towards the ends of the member till failure occur. The members with welded end connectors is most prone to fatigue damage because, the intersections of the members represents the region of stress concentration. It is well known that the resistance of the material gets reduced due to repeated loading. The repeated load application can be conveniently divided into two categories, namely constant amplitude loading and random loading (Calliste, 1994). Steel as a key component of the reinforced concrete member, it is important to understand the development and propagation of damage resulting from fatigue loading in the reinforcing steel. Extensive study was carried in very high cycle fatigue of metals (Marines et.al.2003).

The aim of this investigation is to study experimentally the fatigue behaviour of metals under various surface finishes subjected to repeated cyclic loading. Totally eighteen experiments were conducted for two types of materials such as Brass and En- 24. The parameters that are varied includes,

1. Surface roughness of the material (Ra = 2 µm, 1.5 µm, 0.8 µm).
2. Loads of the specimen (100 kgf, 125 kgf, 150 kgf)

The effect of these parameters on the fatigue behaviour of specimen was studied. The stress- life data (S-N curves) for those two materials were drawn. Hence comparisons between Brass and En-24 were made.

II. Experimental Study

Materials and Methods

The Eighteen specimens were made using two materials Brass and En-24. The three roughness index selected for study are Ra= 0.8 µm, 1.5 µm and 2 µm under three constant amplitude loading. The loading frequency was chosen as 2 HZ (2 cycles per second). Based on the ultimate tensile load carrying capacity for the static load test on the specimen three different stress levels are selected in each Ra values for fatigue testing. The values of maximum stress are kept at same level for all the roughness values. Figure 1 shows the brass and En 24 specimen after surface finish. The surface roughness values were measured using a digital roughness indicator. Figure 2 show the roughness indicator. The commonly used roughness indicator is the mechanical stylus type. A profile of surface height along the surface was obtained. Characteristics of the surface values are obtained directly on the digital display. The specifications of the specimens are shown in Table 1.

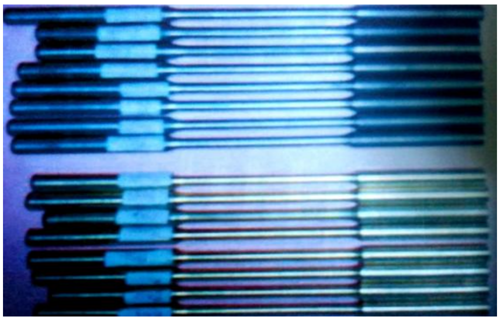

Figure 1 Brass and En-24 fatigue specimen

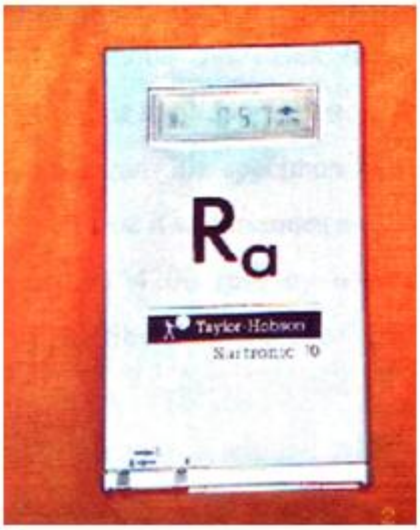

Figure 2 Digital surface indicator

Table 1 Dimensions of the specimen

Sl.No	Material Description	Ra values in (μm)	Diameter (mm)	Length (mm)
1	BRASS	2.0	8.00	96
2	BRASS	2.0	8.00	96
3	BRASS	2.0	8.00	96
4	BRASS	1.5	7.98	96
5	BRASS	1.5	7.99	96
6	BRASS	1.5	7.98	96
7	BRASS	0.8	7.85	96
8	BRASS	0.8	7.88	96
9	BRASS	0.8	7.89	96
10	En-24	2.0	8.00	96
11	En-24	2.0	8.00	96
12	En-24	2.0	8.00	96
13	En-24	1.5	7.99	96
14	En-24	1.5	7.96	96
15	En-24	1.5	7.98	96
16	En-24	0.8	7.95	96
17	En-24	0.8	7.89	96
18	En-24	0.8	7.90	96

Fatigue Test

The total eighteen specimens were tested to failure using fatigue testing machine under three different loads 100kgf, 125kgf and 150 kgf. The specimen was rotated at 4200 rpm by a motor. A complete cycle of reversed stress in all fibres of the specimen was produced during each revolution. The bending moment was applied with a lever system and can be easily changed by moving a weight over the lever. Total number of revolutions at which the specimen fails was recorded by a digital counter. An interlocking system puts off the motor when the specimen fails. The numbers of revolution taken by the specimens to fails were noted. Figure 3 shows the testing of the brass specimen in the fatigue machine. Figure 4 shows the specimens after failure.

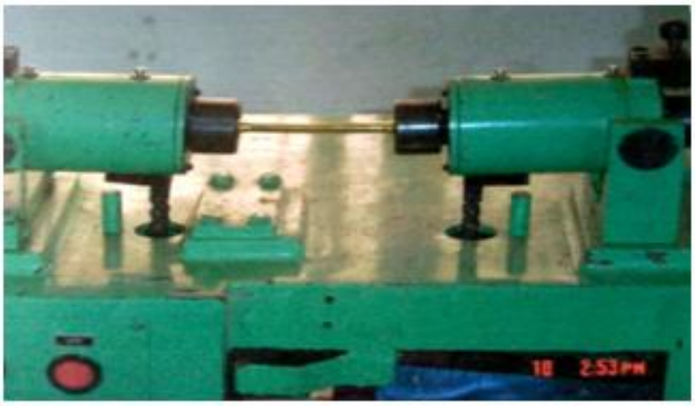

Figure 3 Test in Progress

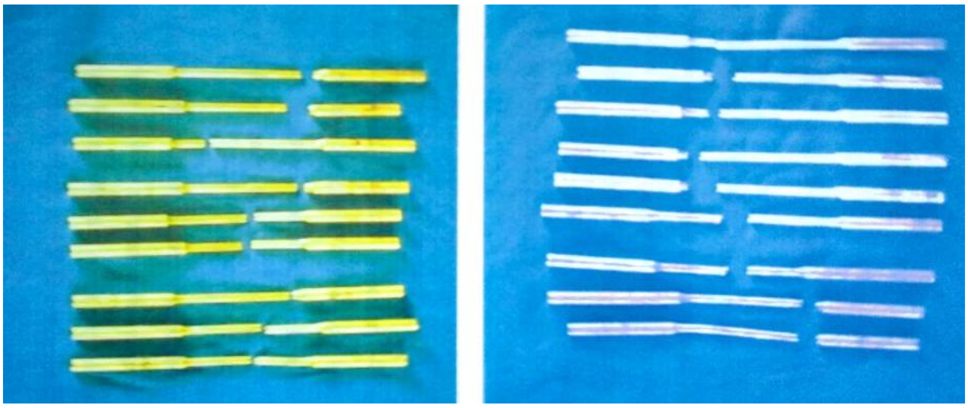

Figure 4 Specimens after test

III. Results and Discussion

Behaviour of fatigue on the Brass and En-24 under repeated cyclic loading was studied. A series of eighteen specimens of Brass and En-24 materials were tested to failure. The parameters that are varied include loading of the specimens (100Kgf, 125 Kgf, 150 Kgf) and the surface roughness of the materials (Ra=2 µm, 1.5 µm and 0.8 µm). Figure 5 shows the maximum stress verses number of cycles (S-N curves) behaviour of brass under three surface roughness values such as Ra= 2 µm,1.5 µm, and 0.8 µm. It was observed that the percentage increase in the fatigue strength is 10 % for a change in Ra from 2 µm to 1.5 µm and the percentage increase in the fatigue strength is 11 % for a change in Ra from 1.5 µm to 0.8 µm.

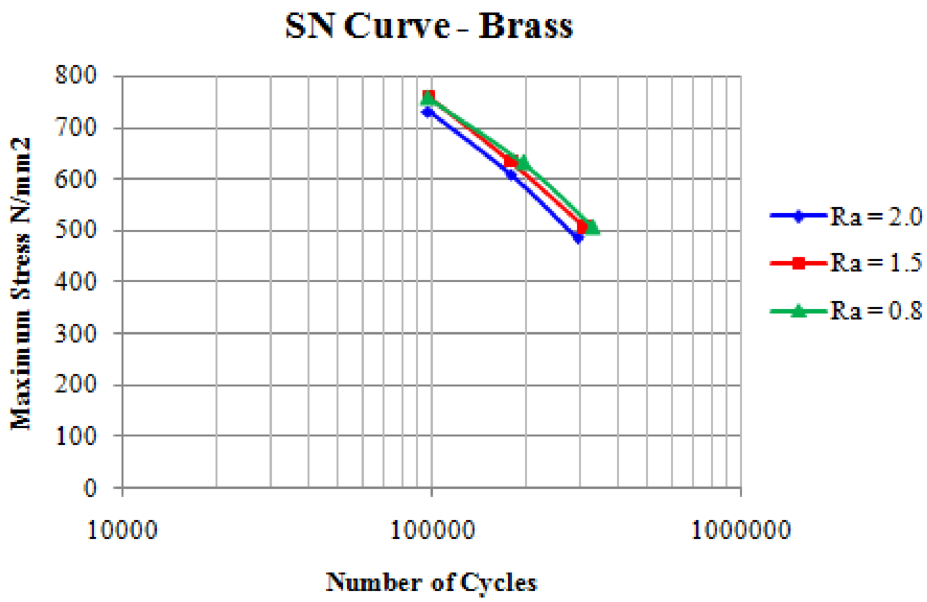

Figure 5 S-N Curve for Brass with different surface finish

Figure 6 show the maximum stress verses number of cycles (S-N curves) behaviour of En-24 under three surface roughness values such as Ra =2 µm, 1.5 µm and 0.8 µm. It was observed that the percentage increase in the fatigue strength is 15 % for a change in Ra from 2 µm to 1.5 µm and the percentage increase in the fatigue strength is 17 % for a change in Ra from 1.5 µm to 0.8 µm. Percentage increase in the fatigue strength is 17% for a change in Ra from 1.5 µm to 0.8 µm.

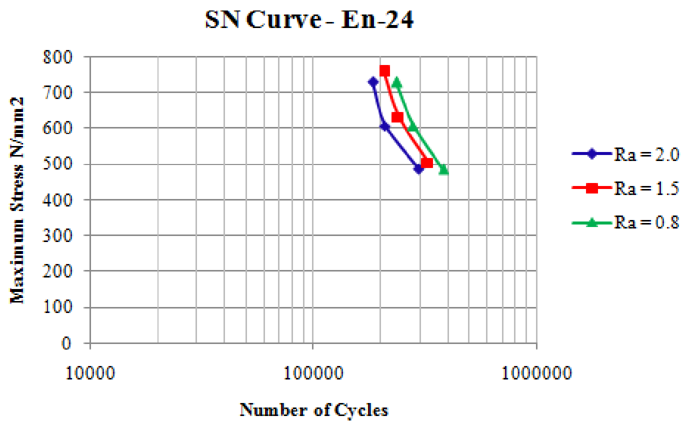

Figure 6 S-N Curve for En-24 with different surface finish

Figure 7 to Figure 9 show the comparison of number of cycles and load between Brass and En-24 under different values of Ra such as 2 µm, 1.5 µm, and 0.8 µm. It was observed that the fatigue strength of the En -24 increased when compared to the brass specimens to the percentage of 22 % irrespective of the surface roughness.

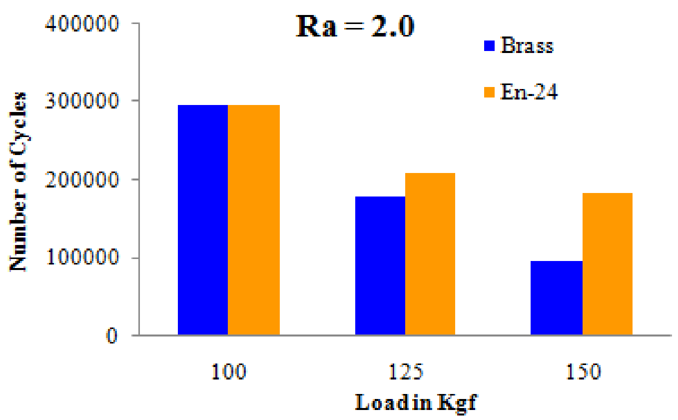

Figure 7 Comparison between Brass and En- 24 (Ra = 2.0 µm)

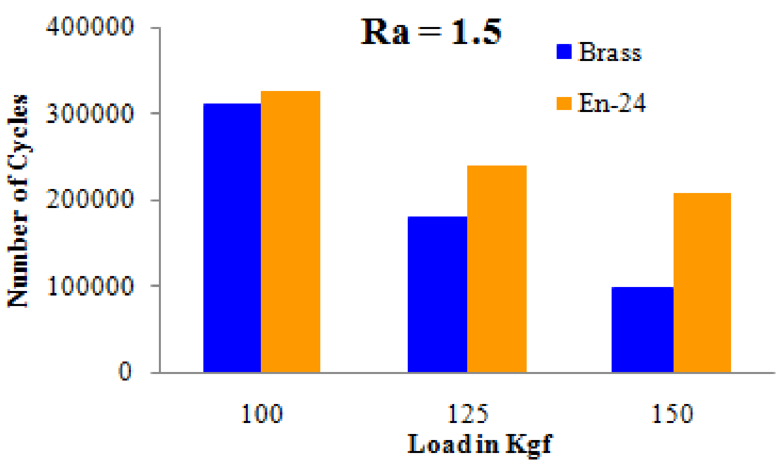

Figure 8 Comparison between Brass and En- 24 (Ra = 1.5 µm)

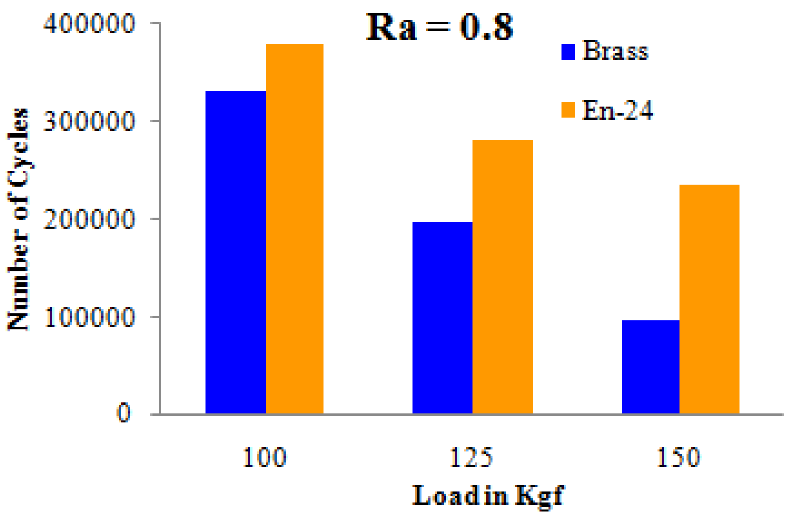

Figure 9 Comparison between Brass and En- 24 (Ra = 0.8 µm)

Figure 10 to Figure 11 shows the comparison of number of cycles and load between Brass and En-24 under different values of Ra such as 2 µm, 1.5 µm and 0.8 µm. It was observes that the fatigue life of the specimen increases with the increase in surface finish. Table 2 shows the fatigue test results with different values of Ra for Brass and En-24.

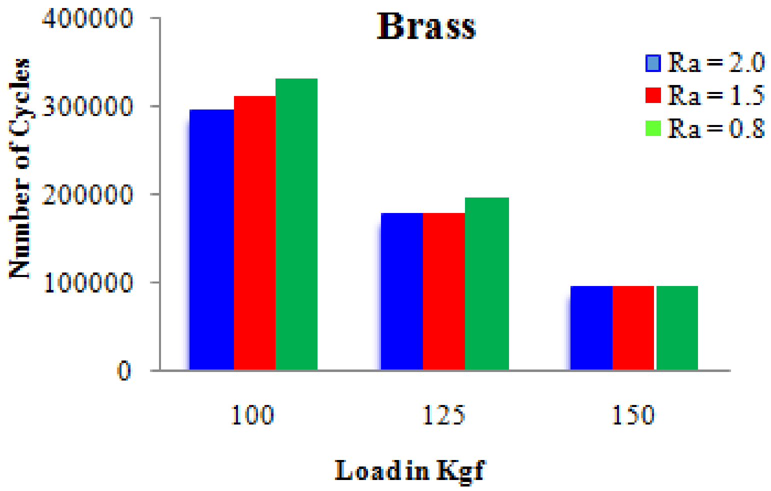

Figure 10 Comparison between the fatigue behaviour of Brass specimens

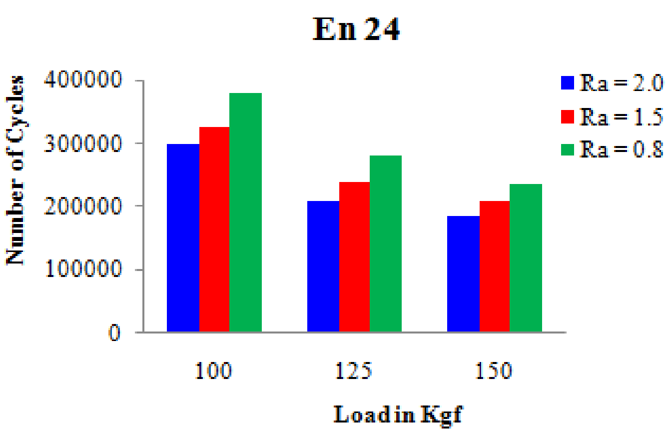

Figure 11 Comparison between the fatigue behaviour of En - 24 specimens

Table 2 Test results of the Brass and En- 24 specimens

Sl.No	Material	Ra (µm)	Load (Kgf)	Maximum Stress (N/mm^2)	Number of Cycles
1	Brass	2.0	100	486	295523
2	Brass	2.0	125	608	180074
3	Brass	2.0	150	730	97094
4	Brass	1.5	100	505	311362
5	Brass	1.5	125	632	181000
6	Brass	1.5	150	758	98064
7	Brass	0.8	100	505	330632
8	Brass	0.8	125	632	197078
9	Brass	0.8	150	758	96542
10	En-24	2.0	100	486	297027
11	En-24	2.0	125	608	239876
12	En-24	2.0	150	730	184199
13	En-24	1.5	100	505	325062
14	En-24	1.5	125	632	240000
15	En-24	1.5	150	758	187700
16	En-24	0.8	100	486	350072
17	En-24	0.8	125	608	240075
18	En-24	0.8	150	730	195196

IV. Conclusion

Behaviour of fatigue on Brass and En-24 under repeated cyclic loading was studied. A series of eighteen specimens of Brass and En-24 materials were tested to failure. The parameters that are varied include loading of the specimens (100 Kgf, 125 Kgf, and 150 Kgf) and surface roughness and loading three specimens were tested.

1. The fatigue strength increases to 11 % for change in surface roughness from 2 µm to 0.8 µm for Brass specimen.
2. The fatigue strength increases to 17 % for change in surface roughness from 2 µm to 0.8 µm for En – 24 specimens.
3. The fatigue life of the En-24 gets increased when compared to the Brass specimens to a percentage of 22% irrespective of the surface roughness.
4. The fatigue life decreases as the magnitude of maximum stress increases irrespective of varying surface roughness and varying loads.
5. The different surface finishes produced by different machining procedures, appreciably affect fatigue performance .The fatigue life of the specimen gets increased with increase in surface finish.
6. Fatigue results in a brittle appearing fracture, with no gross deformation at the fracture. On a macroscopic scale the fracture surface is usually normal to the direction of the principal tensile stress.

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