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| FRETTING<br>FRETTING FATIGUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                |
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| Effects of carburization and decarburization were studied on the fretting fatigue behavior of a medium carbon steel at room temperature. Tests were conducted in room air in a listing frame which was designed to vary the fretting (normal) load, and the relative displacement (slip amplitude) between the list specimens and fretting pads. Statistical studies conducted on the specimens indicated that after a threshold value of normal load, the fretting fatigue lives dropped by an order of magnitude. No significant effects of slip amplitude or fretting wear were observed on the fretting fatigue life. |                       |                                                                |

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**MECHANISMS OF FRETTING FATIGUE CRACK INITIATION IN  
MEDIUM STRENGTH STEELS**

**FINAL REPORT**

**SEPTEMBER 1, 1982**

**U. S. ARMY RESEARCH OFFICE**

**DAAG29-79-C-0013**

**RENSSELAER POLYTECHNIC INSTITUTE**

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## FINAL REPORT

Effects of surface thermochemical treatments, namely carburization and decarburization, on the fretting fatigue behavior of a medium carbon low alloy steel were studied at room temperature. The study involved selection of the material which could be easily surface treated to induce different surface mechanical properties, the design and fabrication of a testing frame which could reproduce fretting fatigue conditions in the laboratory, and the analysis of the results obtained. The design of the frame was based on the requirement that it must be capable of varying the two fretting parameters, namely, slip amplitude and normal load, independent of each other.

Experiments were conducted on a servohydraulic fatigue machine with a set of quench-and-tempered specimens as control specimens, along with the carburized and decarburized specimens. Plain fatigue tests were conducted on all three types of specimens to determine their respective fatigue limits. In order to ensure that fretting indeed affected the fatigue limits, a stress level of 400 MPa was chosen as the common maximum stress level for all ensuing fatigue tests. This stress level was lower than the lowest observed plain fatigue limits among the three types of specimens. The testing frequency was held constant at 20 cps and all tests were conducted at room temperature in laboratory air. The specimens dimensions were chosen so that the elastic deformation of the specimens during the fatigue cycling would provide slip amplitudes ranging from 20 micrometres to 135 micrometres. A set of two rigidly placed pads, made of hardened tool steel, was used as the fretting source. The load with which the pads pressed against the specimens, called the normal load, was varied from 200 N to 3500 N. The pad surfaces in contact with the specimen were ground into a spherical cap to make stress analysis simpler.

Both the specimens and the pads were ground to a finish of 600 grit SiC paper and cleaned with acetone prior to testing. Statistical analysis was used to determine the fretting fatigue lives of the specimens and four specimens were tested at each set of conditions. The mean of all the values of the fatigue lives was then taken as a estimate of the fatigue life of the specimens under those sets of conditions.

Test results exhibited a threshold value of the normal load in all cases, where the fretting fatigue lives of the specimens plunged by an order of magnitude. Lives remained constant at a runout value of 2 million cycles at very low normal loads and dropped to about 200,000 cycles with a very small increase in the normal load. This threshold value of the normal load, was the lowest for decarburized specimens, at about 500 N and the highest for carburized specimens, at 1000 N. The quench and tempered specimens exhibited a value in between the two, at 800 N.

The effect of slip amplitude was studied on the specimens by conducting fretting fatigue life tests at two levels of normal loads for each heat treatment. In all the cases, there was no significant effect observed at both levels of normal load on the fretting fatigue lives of the specimens.

Scanning electron microscopic studies showed less surface damage in the carburized specimens than in the decarburized specimens. Optical microscopy of the cross sections showed a higher number of cracks in the decarburized specimens at a lower stress level and more cracks as candidates for fatal cracks. Theoretical stress analysis confirmed the observations of cracks and the threshold phenomenon in the fretting fatigue life.

After making the above observations, it was concluded that:

1. Regardless of the slip amplitude, a minimum level of normal stress is necessary for the fretting process to have any effect on the fatigue life.

2. This minimum can be increased with a modification of the surface microstructure that would increase the strength of the surface material. The reverse is true if the modification decreases the surface strength.

3. The slip amplitude does not have an effect on the fretting fatigue life within the testing range.

4. Wear process, which was considered an important part of fretting fatigue, was found to play a secondary role in the experiments that were conducted. Wear was found to be severe when the slip amplitude was high, and almost nonexistent when the slip amplitude was low, but had little effect on the fretting fatigue lives of the specimens tested.

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Ph.D. Degree, 9/78-10/82.

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