Testing and Calibration of an in-house built Fatigue Testing Machine

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ABSTRACT

College of Engineering owns an in-house built fatigue testing machine, designed and built by Advanced Mechanics and Design (MENG 4350) students. For the testing machine to be used for experimentation in class and research, it needs to be tested using different materials and be calibrated according to relevant standards. After effective calibration of this machine, faculty at the college could use the machine for research and experimental activities. The patterns of current results agreed with published plots but the observed fatigue property values don't exactly match with published values of the tested materials. Further adjustment will be conducted on the machine and more tests will be done to validate and verify results in the future.

BACKGROUND

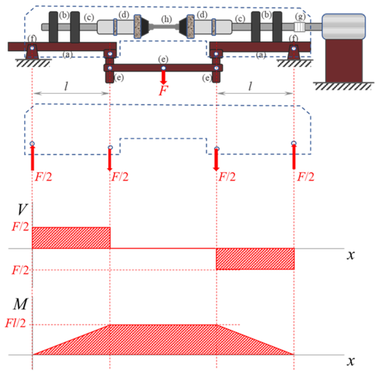
The importance of Fatigue Testing: The engineering objective of fatigue testing is to determine the fatigue properties of materials, joints, machine components and structural elements while the research objective will be to understand the fatigue phenomenon and its variables [1]. Fatigue testing requires significant effort, time and very expensive machines than most of experimental testing equipment. Typical educational fatigue testing machines cost ranges from $10,500 to $32,500 [2]. Most of these machines that are available in market are bulky, take a lot of space and are not easy to operate. In Fall 2017, our Mechanical Engineering students of MENG 4350 (Advanced Mechanics and Design) have innovatively designed and built a very compact and easy to use Rotating Beam Fatigue Testing Machine (Figure 1 [3,4]) for a total cost of $699.10. For this machine to be used for experimentation in laboratory classes and research, it needs to be tested using different materials, **v**erified and test results need to be **v**alidated (V&V) with respect to published standard test results. This project was tasked with the testing of different materials, perform V&V and calibration according to American Society for Testing and Materials (ASTM) standards [5,6].

OBJECTIVES

The objective of this project was to calibrate an in-house built Fatigue Testing Machine that will potentially be used for teaching and research. The machine was designed and built by WTAMU Mechanical Engineering students as their Advanced Mechanics and Design class final project.

METHODOLOGY

Total of 180 (36 specimens per material type) were prepared for Fatigue Testing. The needed test specimens of five different materials (steel, aluminum, copper, fiberglass and copolymer) were modeled in CAD software, prepared according to standard dimensions (refer Figure 1) and testing was conducted by applying different loading conditions. The corresponding number of cycles at which the specimen failed was also recorded and S-N log-log plots were made.



(a) Schematic of Fatigue Testing Machine, with FB, Shear and Bending Moment Diagrams and Stress Equation

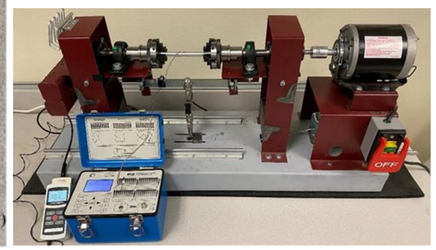
$$\sigma_{rev} = \frac{M_{max}C}{I}$$

or

$$\sigma_{rev} = \frac{16Fl}{\pi d^3}$$

(b) Material Specimens

(c) Current Testing Machine with failed Specimen



(d) Strain Measurement Setup on a Fatigue Testing Machine

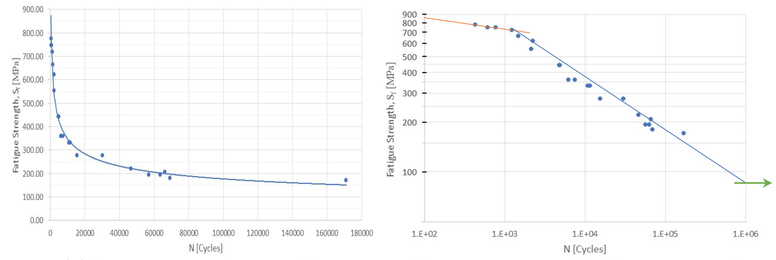
Fig 1. Material Specimen and Fatigue Testing Machine

MODIFICATION/INTERVENTION

During the testing and calibration process, it was observed that the machine needs several modifications. Hence, during the first phase of the project, the PI and his students modified the machine before the testing and calibration process. Some of the modifications are:

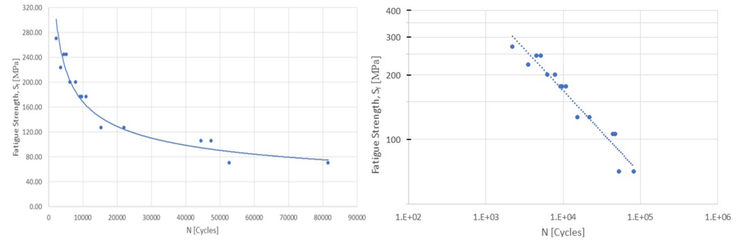
- the two tall stands of the machine were reinforced to guarantee secure installation of specimen and to increase system stiffness,
- test machine was placed on a rubber mat to alleviate system vibration and sliding during testing,
- force application steel cable loop connectors were replaced by stainless steel swageless eye and jaw connectors for smooth transfer of force,
- the inaccurate digital fishing scale that was initially installed to measure applied force is replaced by a standard load cell (Mark-10 MR01-500) and force/torque indicator (Mark-10 M5i),
- the location of the force gauge (load cell) has been moved to just under the horizontal force application link (the central link (e) of Fig. 1) for direct measurement of applied force (required a rerouting of cables and relocation of components like pulleys),
- The mechanical turn counter was replaced by a small magnet attached at the tip of the shaft, with an iPhone's built-in magnetic field sensor and a "Turns Counter" app installed on the iPhone.

RESULTS [7]



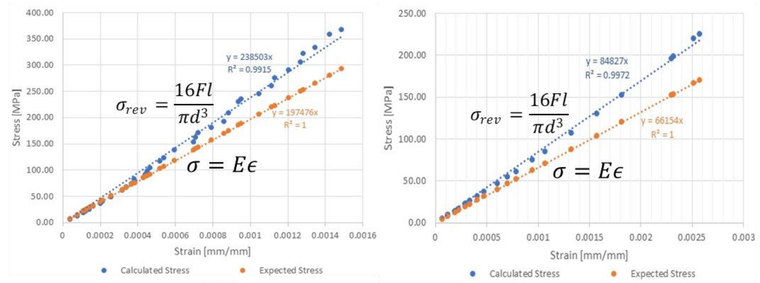
(a) Experimentally Collected Data (b) Log-Log Data with Schematic Trendline

Figure 2. S-N Curve for Annealed Steel Alloy (AISI 1040 – Annealed @785 °C)



(a) Experimentally Collected Data (b) Data fitted with schematic trend line

Fig 3. S-N Curve for Aluminum 6061



(a) (b)

Figure 4. Discrepancy on the Stress-Strain of
(a) Steel & (b) Aluminum using Strain Gage on a Fatigue Testing Machine

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