

Abstract

ATK Space Systems builds lightweight deployable structures for spacecraft using long, thin carbon fiber reinforced polymer (CFRP) rods. These rods undergo non-destructive tests for internal defects and the current testing method requires technicians to listen by ear for any acoustic emissions from the CFRP rod as it is strained to 1.2%. This method is prone to inconsistencies due to the variance in the human threshold of hearing and due to human fatigue. It was ATK's desire and the project objective to build a system capable of testing the CFRP rods for internal defects, while ensuring accuracy, reliability, repeatability, and robustness.



Figure 1. ATK technician using current testing method.

Design Considerations

In order to meet the desired goals several key design parameters were established and verification methods created. The system had to reliably meet these design parameters (Figure 2) while remaining within the pre-set budget, taking up minimal floor space, using minimal power consumption, and proving the feasibility of the defect detection method.

Design Parameters	Value	Verification Method
Detect defects that benchmark is capable of detecting	100%	Compare defect detection capabilities with benchmark.
Feed rate	4 ft./min	Calculate feed rate of system.
Maximum strain	1.2%	Calculate strain on rods imposed by system.
Test various diameter rods	0.084" - 0.125"	Test various rod sizes.
Capable of operating in a noisy environment	40 dB	Operate system in a greater than 40 dB environment.

Figure 2. Key design parameters.

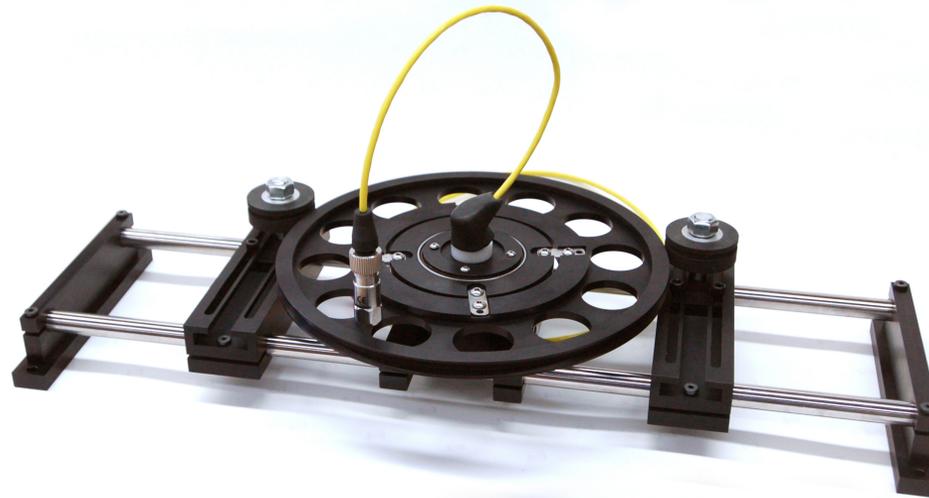


Figure 3. System assembly.

Analysis

Initial strain testing in a three point flexure revealed that the acoustic emission generated by a "defect event" was the result of the CFRP rod resonating within the flexure. In order to incorporate this phenomenon into a continuous feed process, it was decided to design a mandrel with a known natural frequency. A contact transducer would be used to detect the resonance of the mandrel when the strain energy released during a "defect event" was imparted onto the mandrel. A test mandrel was manufactured to confirm these results before the final prototype was built.

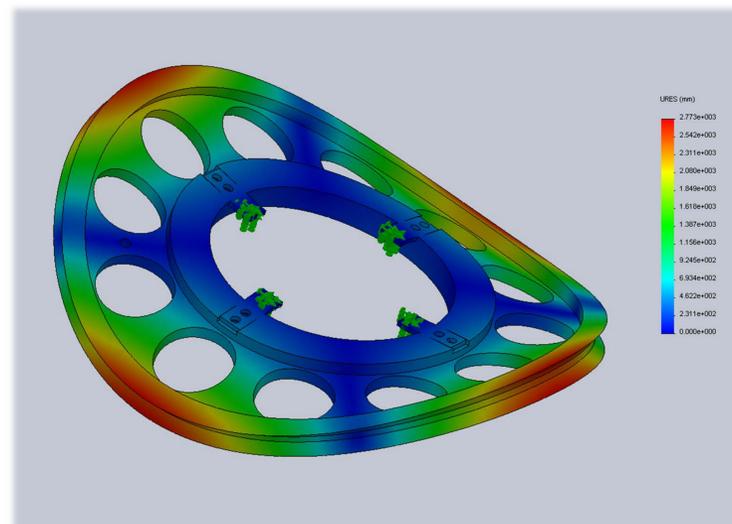


Figure 4. Simulation of mandrel resonating at its natural frequency.

Design Features

Adjustable Detection System

- The natural frequency of the mandrel and sensitivity of detection can be adjusted in the user interface.

Multi-Rod Diameter Compatible

- Rods of various profiles and diameters can be tested with system using an appropriately sized mandrel.

Impervious to Ambient Noise

- System can function properly in an environment with considerable ambient noise.

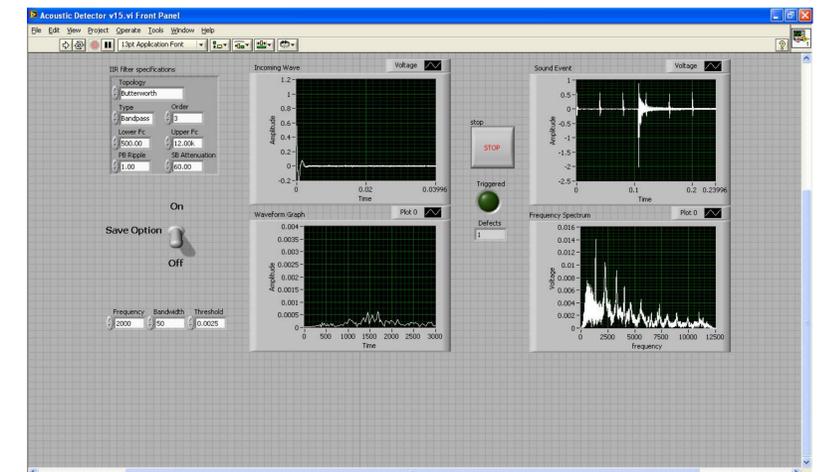


Figure 5. LabVIEW user interface.

Results / Conclusions

Testing of the system confirmed that nearly all design parameters were met and surpassed. The system was able to obtain a feed rate greater than 4ft./min; it induced a strain of 1.2%; it was able to test various rod profiles and diameters; it showed no decrease in functionality in an environment of 70dB easily passing the mark of 40dB. The system was able to detect 97% of the defects detected by the current method falling, short of the set value of 100%, however the system was able to detect defects that the current method did not. The shortcoming may possibly be due to the heightened sensitivity of the acoustic emission of a defect in our system that may possibly not be heard in the current test method.

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