LASER Scanning of flaws inside the Pressure Tubes of a CANDU Reactor

D. Egerter, J. Gilbert, H. Graham and C. Verstegen
[1] University of Ontario Institute of Technology, Ontario, Canada
(hannah.graham@uoit.net)

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Summary

The purpose of this project was to create a device that would allow the rendering of a 3-D model of cracks within a CANDU pressure tube. The designed device uses a waterproof laser and the CIGAR driving mechanism. The system was designed with the reactors at Darlington in mind, but it could be modified for other CANDU systems.

1. Introduction

One of the challenges faced in the maintenance of the CANDU reactor is repairing cracks inside the pressure tubes. The current method uses an injector to create a mold; which is than extracted, and a 3-D model is made of the mold. This process is time consuming and needs to be updated. This project is the creation of a laser scanner that can render a 3-D model promptly without the additional molding steps.

2.1 Background

A typical CANDU reactor contains hundreds of pressure tubes; these tubes are prone to scratches and fretting marks. Not all cracks are large enough to cause a pressure tube to need to be changed, but if they are left it is important to have a model of the cracks that changes over time can be observed. This device was designed with the Darlington Reactors in mind, but it could potentially be modified for other CANDU reactors. Also this scanner is inserted into the pipe when the reactor is offline. There are several constraints that affected the construction of the device. First, there is coolant in the pipes during the scan. This coolant is heavy water (D_2O), it has a bilateral flow, and it contains particulate matter making the water cloudy. Second, the tubes have a very small

diameter. There is a diameter of only 103 mm to work with. 10 cm^2 must also be left around the most restrictive part of the device to allow the coolant to flow around it. Third, laser systems have a minimum off-set distance; this means that the laser must be back from the wall by a distance that can range from 15-30 mm. Fourth, there is the radiation field to consider. The dose from neutrons is negligible, but there is a dose from gammas. This dose limits the life of components, so components that are easy to replace are beneficial. Fifth, pressure tubes are prone to sag. Pressure tubes are 6.35 m long, and can sag up to 90 mm. There are other factors that factor into the design of the project, but these ones impacted the design the most. [3]

2.2 **Problem**

There is currently a system to create a 3-D model of any substantial cracks in the pressure tubes. This system injects a molding compound into the crack, and it is held in place until the shape is set. This mold is than removed from the tube, and scanned to create the 3-D model of the crack. Once an accurate representation of the crack is available it can be determined whether to replace or to repair the tube. This system is time consuming. Also, withdrawing the mold quickly can damage it, making this system more prone to errors. The purpose of the new design is to eliminate the step with the mold, and scan the pipe directly. This will result in both saved time and less error.

2.3 **Design**

The laser scanner is designed to attach to the CIGAR (Channel Inspection and Gauging Apparatus for Reactors) drive mechanism. The device has a cylindrical housing, and is no longer than the current CIGAR head. The housing is made of 300 series stainless steel. The housing can rotate allowing any crack to be scanned. The actual laser scanner is attached to a sliding mechanism that allows accurate measurements of flaws. There is a section of the device that acts like a dam. The dam section lifts up and attaches to the wall of the pressure tube creating a seal, and the dirty water within this section is replaced with clean water. The water is cleaned using a filtering device and water pump.

The laser is attached to a lead screw and linear guide rail, the screw is powered by a motor; this allows for accurate positioning of the laser. The electronic connections are passed out of the pressure tub through the end-cap; since the pressure tube must be sealed. Parts were chosen that were easy to replace; since the radiation field will degrade components over time. [1], [2]

3. Conclusion

This system fills a need in industry by creating a scanner that can create without the middle molding step. This will result in time and money saved. The device is also kept as simple as possible to allow for periodic refurbishment of the scanner parts that are prone to radiation damage.

4. Bibliography

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