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Automated Fitness for Service Assessment and Report Generation for Corrosion Within Pressure Vessels

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ABSTRACT

The process of assessing a pressure vessel's fitness for service (FFS) is a time consuming process with trade-offs made between a maintenance engineer's time and the conservatism of the conclusion. We report progress on developing FFS_Assess software, which encodes ASME FFS 579 and BS EN 7910 assessments of localised and widespread corrosion to allow for an automatic production of more consistent and detailed inspection report, which contains less conservative recommendations. FFS_Assess can identify areas of localised metal loss and use vessel parameters and ultrasonic C-scans to carry out the ASME FFS Level 1 assessment (and, if required, the more detailed Level 2 assessment) to calculate the maximum allowable working pressure.

OBJECTIVES

We have addressed a challenge of building a system capable of applying the BS EN 7910 & ASME FFS 579 Level 1 & 2 assessment of locally occurring wall thinning, by utilising the ultrasonic C-scans and vessel parameters. By automating this process the man-hours required to assess the vessel's fitness for service are reduced to the time needed to perform the scan, import these data and input vessel parameters.

As far as we know, there is no single package on the market, which would allow for an automated generation of an inspection report that includes a fitness for service assessment. The existing packages are capable of generating automated reports, which contain ultrasonic scans, but it is still left to human inspectors to perform the relevant assessments and produce reports, which give details of the overall inspection, suggest changes to operating conditions or else describe required repairs. If all areas pass the inspection they use the corrosion rate estimated using the previous vessel records to generate recommendations for reinspection. By necessity, the resulting reports are often cursory. FS_Assess is capable of carrying out all these tasks and produce much more detailed reports.

METHODS

The current version of FFS_Assess encodes parts of two common inspection standards produced by relevant UK & European bodies [1] as well as ASME [2]. Additional documents have been sourced for critical stress values based on the grade of steel [3] and for the maximum pressure, which the vessels were designed to withstand [4]. This eliminates the need for related searches and therefore results in further time savings by an FFS_Assess users.

In order to design the software we converted the assessment process described in the assessment standards into a flow chart. The software can be tailored to process data from any suitable scanning equipment as soon as these data have been exported in text format. The only other input expected by FFS_Assess are the pressure vessel design details, such as its geometry, design specifications and working pressure. This input should be provided by a human inspector via a text file or GUI.

METHODS (CTD)

The software is capable of stitching individual scans into a large scale image of the vessel wall and then decide which areas of the wall require assessment based on a minimum allowable thickness process (Fig 1).

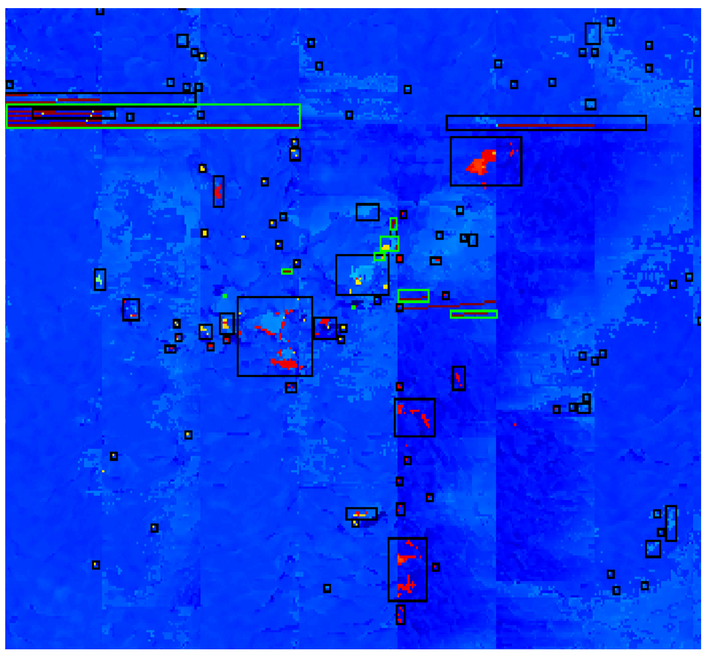

Figure 1: An image of a vessel wall processed by FFS_Assess to show areas to assess (black boxes) and areas where data quality is suspect (green boxes).

Any area identified as needing assessment and containing no data corrupted by failed scans are assessed individually as per the standards.

In the event of an area failing to meet the requirements, an image of this area and details of the assessment are added to the report, along with recommendations for rerating the vessel or else recommendations for vessel repair. A remaining life calculation is presented, based on the corrosion rate as identified by a human inspector, to provide a recommendation for the next inspection date.

RESULTS

We have built an FFS_Assess package capable of applying the BS EN 7910 & ASME FFS 579 Level 1 & 2 assessment for locally occurring wall thinning on the basis of ultrasonic C-scans and vessel description provided by a human inspector.

The current version has been successfully tested against one real-life FSS report as well as various training examples offered within the ASME FSS standards.

The real-life inspection report was provided by TWI (The Welding Institute) and related to a chlorine storage tank. The report used a simplistic minimum thickness process described in the ASME standards. Using a more sophisticated maximum allowable working pressure approach FFS_Assess came to the same conclusion as reached by the human inspector behind the TWI report.

The automated reports produced by FFS_Assess give details of the overall inspection and describe changes required to its operating conditions or else suggest repairs of individual areas of metal loss - see Fig 2.

RESULTS (CTD)

If all wall areas pass the requirements laid out in the standards, then FFS_Assess makes a recommendation for reinspection, based on the corrosion rate as input into FSS_Assess by a human inspector after (s)he examined past vessel records.

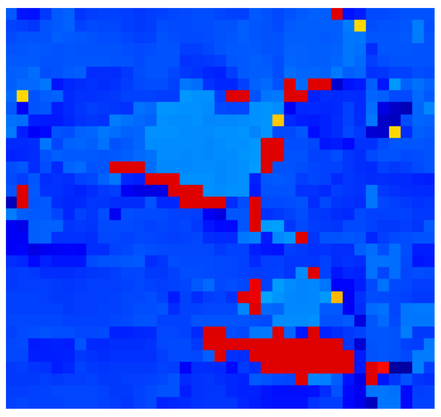

Figure 2: An image of a vessel wall processed processed by FFS_Assess showing an area identified as needing to be assessed.

CONCLUSIONS

When running FFS_Assess most time would be consumed reading the data files and processing and stitching many C-scans collected by ultrasonic equipment. The subsequent time required to generate a report is under 20 seconds and such report would highlight areas of localised material loss and loss of signal from scan; estimate the remaining life of the vessel; and, when relevant, specify the dimensions and locations of any areas requiring repair.

The current version of FFS_Assess is being developed under the auspices of the Chimera project carried out in collaboration with Forth, Headlights, RACE, Roll-Royce and TWI within the InnovateUK framework of Robotics and AI in Challenging Environments. It lays the foundation for the automation of assessing vessel fitness for service and will be integrated into the Chimera robotic system. However, it can also be easily developed into a stand alone application. The future work on weld crack detection and characterisation will expand the scope of the software.

BIBLIOGRAPHY

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