Advanced Solutions for UT of Aircraft Engine Run Hardware

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Abstract. UT inspection of engine run hardware or in-service parts, in particular the 2-6 and 3-9 stage engine spools, present different complexities to those found in the UT of engine components. These complexities arise from part geometry, surface condition and the UT operator to visualize the area being tested. ScanMaster has created a sophisticated yet user-friendly solution consisting of innovations in hardware and software for this application. The inspection is performed in a large immersion tank with high precision system mechanics. Specially developed mechanical devices are used to access the web areas and to permit scanning at various angles. Advanced software tools are used for part programming, scan supervision and data analysis. A 3D display of the robot and part, which can be displayed in sections, rotated and zoomed, allows for predicting future robot position.

Introduction

UT of engine run hardware or in-service parts, present different complexities to those found in the UT of engine components prior to engine assembly. These complexities arise from part geometry, ultrasonic complexities, surface condition, type of inspection, the amount of tools and the limitation placed on the UT inspector to visualize the area being tested.

ScanMaster Systems has created a user friendly yet sophisticated solution consisting of innovations in hardware and software for this application

1. Complexities in UT of Engine Run Hardware

1.1 Part Geometry and Surface Condition

Engine spools require that most of the UT will be performed on areas that are difficult to access. Typical spools are the 2-6 or 3-9 stage spools. The areas that are difficult to access include the web areas, the stage areas between the webs (bore faces), entry areas to webs and the I.D areas between the webs. The web areas include two concave sections requiring a contour following, with a planar area between them (Figure 1). These areas must all be accessed via the I.D. or bore area. The bore area is rather small in diameter, thus limiting the introduction of the necessary tools required to perform the various UT scans.

The surface condition in many of the web areas is generally not smooth and often as small holes, creating problems for a web following tool.

The 2-6 spools propose a unique problem as the bore is smaller in diameter than the web (Figure 2).

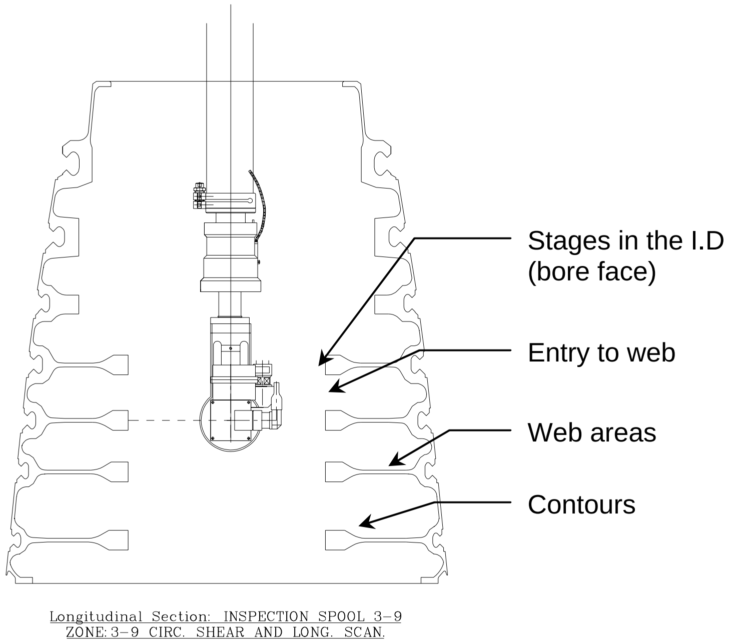

Figure 1: Geometric complexities

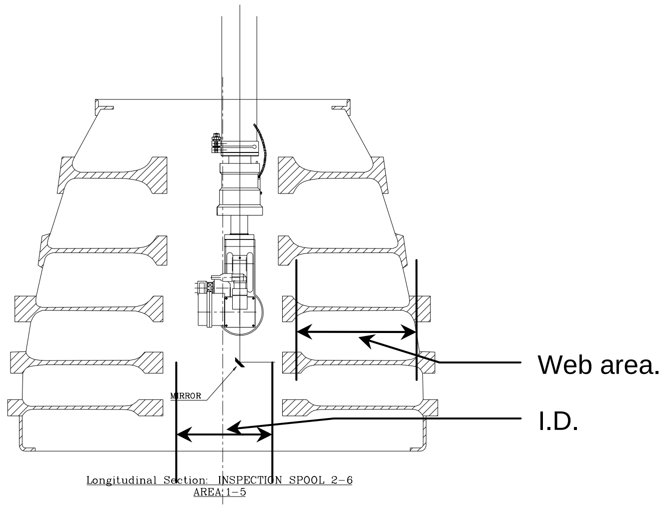

Figure 2: Spool 2-6

1.2 Ultrasonic Complexities

Complexities arise with the ultrasound due to stray echoes off the probe holding device and the surface of the web. The water path is only 20mm, thus all sorts of issues with ghost echoes arise.

1.3 Type of Inspection

Due to the orientation of possible defects, many different inspections are performed on each surface. Incident angles of 0, 20, 22, and 25 degrees are required in the clock wise and counter clock wise directions both axial (Figure 3) and circumferentially. Therefore each area is scanned more than once. In addition, after each scan where an indication is found, calibration verification must be performed in order to validate results. Sophisticated tools and software are required for the automation of the process.

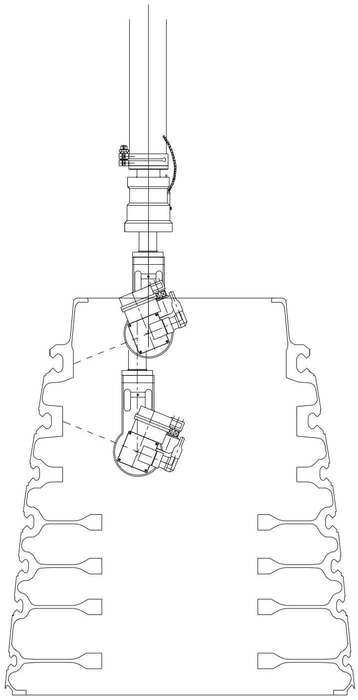

Figure 3: Axial scans

1.4 Inspection Tools

Tools required for inspection include mirrors that create various incident angles, elongation devices for lengthening the distance between the robot manipulator and the transducer and most importantly a mechanical web following tool.

1.5 Limited Visibility of inspected areas

Given that all of the inspection takes place within the I.D. of the part, there is no way for the inspector to be able to see where the robot manipulator is currently located and whether it is positioned precisely between two disks to allow for entry into the web area.

2. ScanMaster Systems' Solutions

2.1 General

The UT is performed in a large immersion tank with high precision system mechanics. The system software has been specially designed to allow for increased production and safety while remaining user friendly. The UT instrumentation is reliable and has the necessary resolution for detecting flaws according to the manufactures specifications (Figure 4).

Figure 4: Immersion tank

2.2 Hardware Solutions for Web Areas

Access between two adjacent web areas is limited. In addition the web areas of the 2-6 spool have a larger diameter than the bore access area. The web area includes two concave radii on either end of a planar surface. The incident angle required is 25 degrees with a 20mm water-path, thus a mechanical surface following device that maintains both requirements is employed. It is required that scans be performed in both the clock wise and counter clockwise direction.

ScanMaster has resolved these issues by creating a telescopic device which is attached to a special yoke adapter connected to the system search tube. (Figure 5 and Figure 6). This device is retracted during entry into the bore. The part of the web including the contour near the I.D is scanned with the telescopic device in the retracted position. The part of the web including the contour near the O.D is scanned with the telescopic device in the extended position.

The probe holder is manufactured from a specially adapted absorbent plastic material. This material resolves the problem of stray echoes which reflect off the surface back into the probe by attenuating the sound. The probe holder positions the probe at the required incident angle (25 degrees), thus creating a circumferential shear scan. The probe holder can be revolved 180 degrees, thus allowing for both clockwise and counter clockwise scans. The probe holder also allows for following contours.

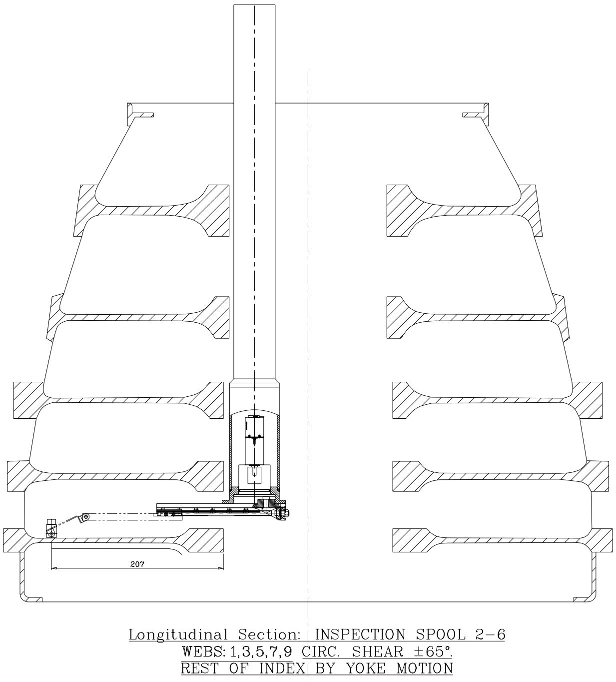

Figure 5: Yoke with telescopic device extended

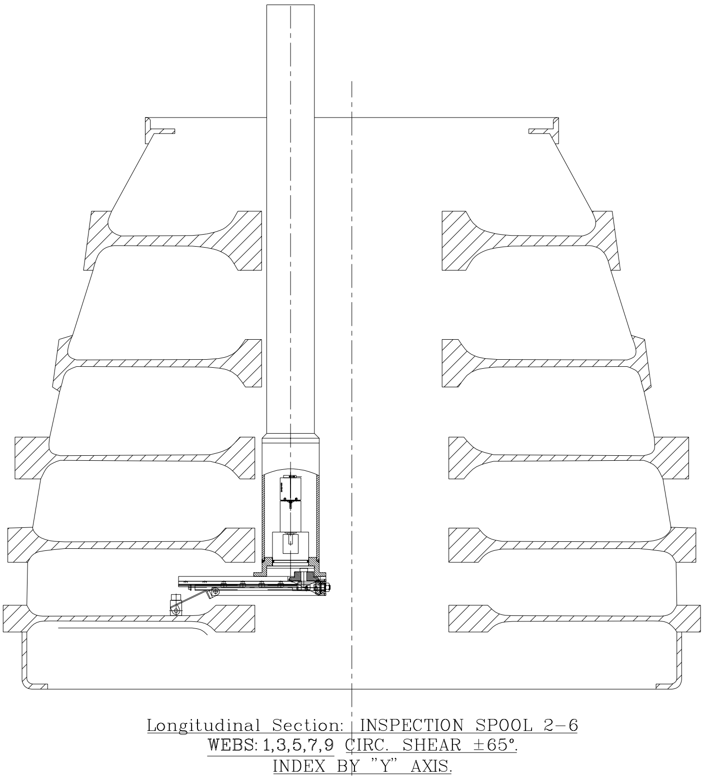

Figure 6: Yoke with telescopic device retracted

2.3 Software Solution for Web Areas

Unique software tools have been created for aiding the inspector during the scanning of webs.

Due to the fact that the entrance to some of the web areas is only around 14mm and there is a tolerance in manufacture, the software allows for pre-programmed pauses with interactive messaging for the inspector. The software also displays a 3 D image of the part, robot, yoke and telescopic device (Figure 7). The graphics are a true representation of the objects, which have all been imported from CAD drawings. The part as well has been imported from a CAD drawing. This display can be zoomed, rotated and viewed from various essential positions such as the top view during entry into the bore or the side view during entry into the web. The display updates with each movement of the robot and gets its position information directly from the positional encoders on the mechanical axes.

In addition the software has a future position predictor, which allows the inspector to see where the robot will be in (*n*) seconds. This time is user definable (Figure 8).

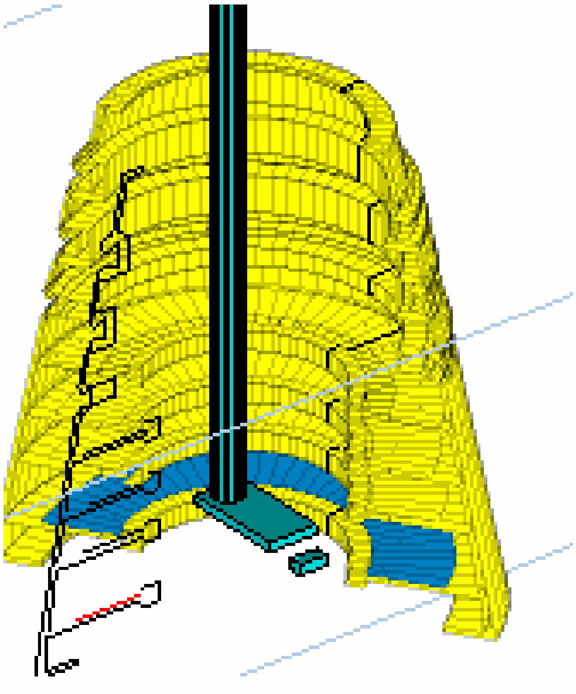

Figure 7: 3D Graphics display

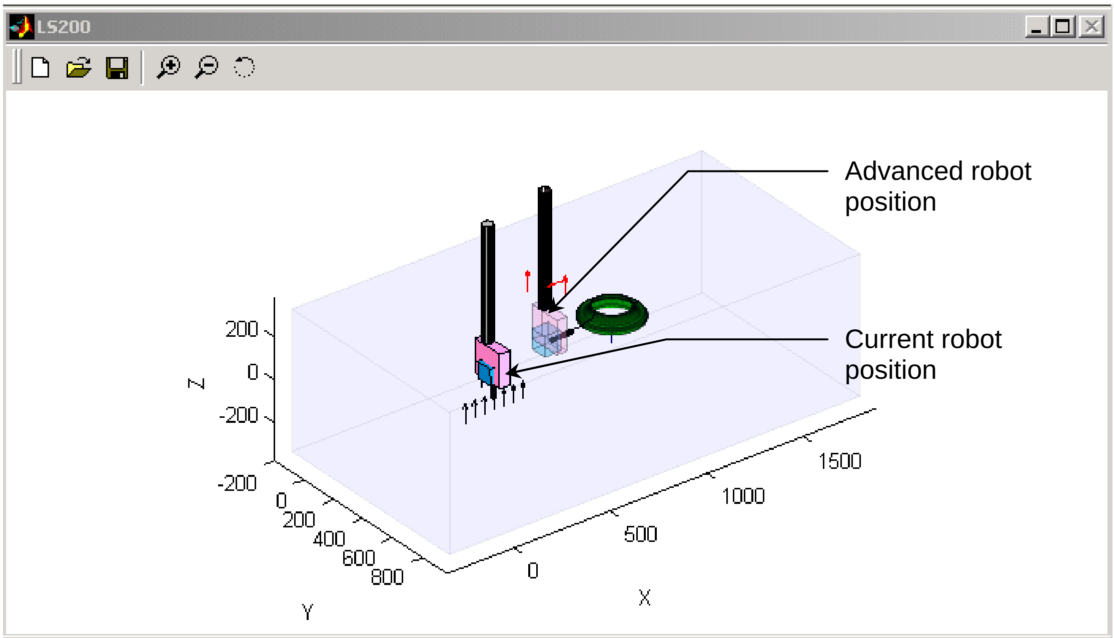

Figure 8: Advanced movement prediction

2.4 Hardware Solutions for Bore Areas

Inside the bore there are surfaces that require up to seven types of scan, each implying a different incident angle. A detachable multi position mirror is used for this. The various positions can be accessed without removal from the water thus allowing for less time required for production (Figure 9).

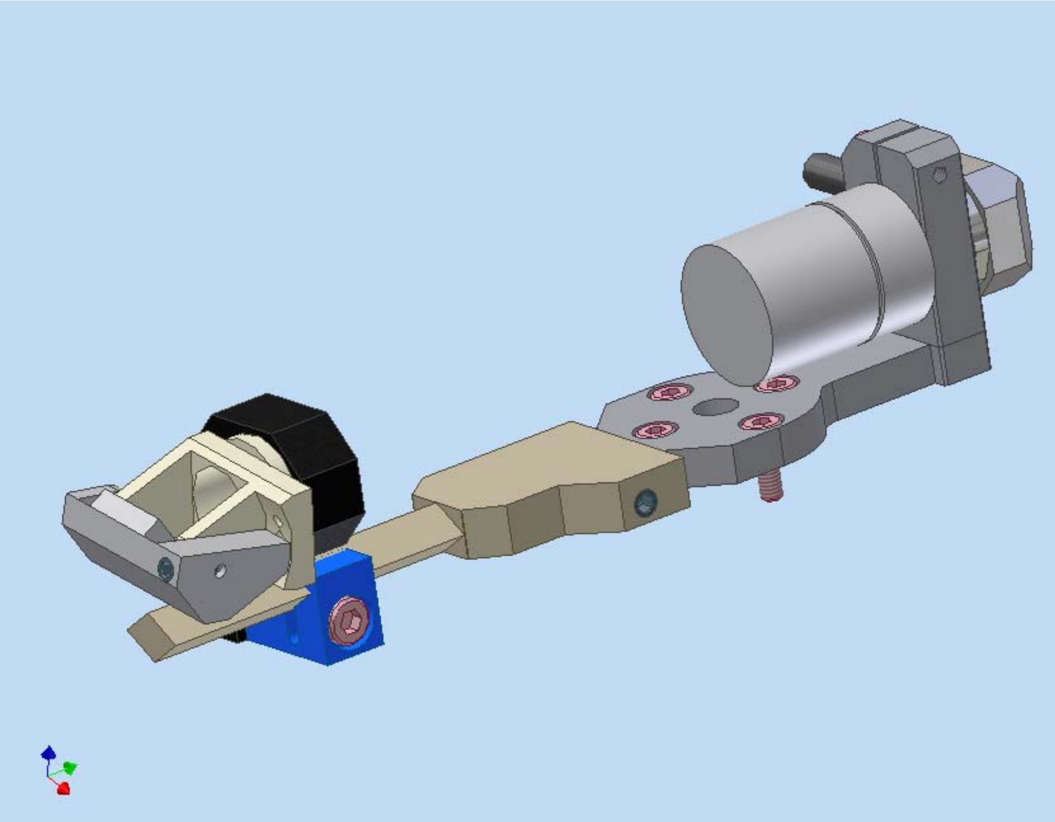

Figure 9: Multiple position mirror

2.5 Software Solutions for Bore Areas

The software allows pausing for incident angle verification. In addition the software provides a graphics representation of the beam exit angle from the mirror and the position of the beam on the surface being inspected. This position updates as the scan progresses.

2.6 Additional Software Solutions for All Inspected Areas

The software allows for flaw size verification. This is accomplished by allowing the robot to move during the scan phase, to a pre-programmed position on a calibration standard. The software remembers the last position of the robot during the scan and can be returned automatically to this position.

All information such as position, amplitude, time of flight, surface name, incident angle, part serial number and many other custom fields are automatically stored in the report.

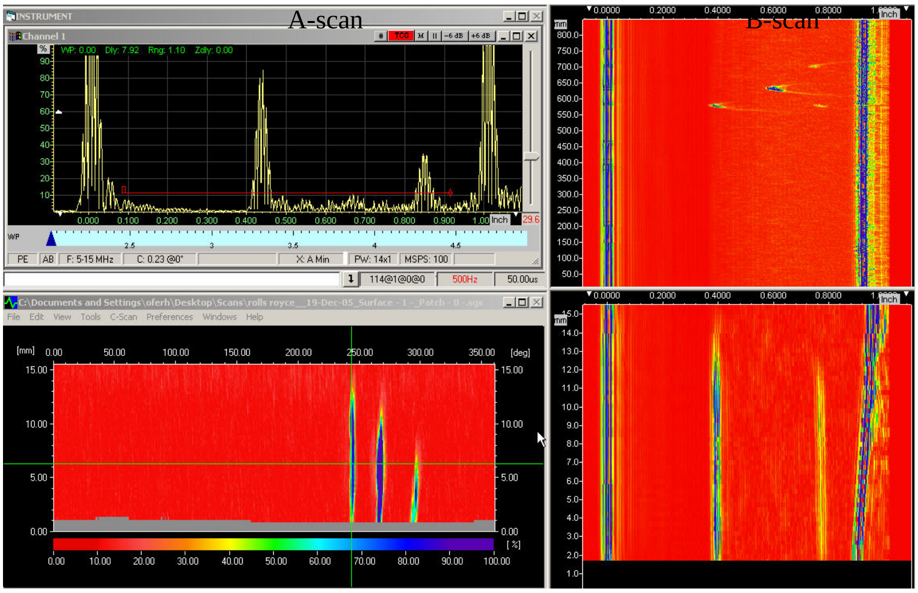

Figure 10: A-, B- and C-scan

Full A-scan capture allows for replaying the A-scan from a particular point during the scan, while C-scan and B-scan are generated by using the saved A-scans
(Figure 10).