SUCCESS STORY

Turbo Stress
Basler pilot GigE Cameras Help to Inspect Turbine Blades in Aircraft Engines

Customer

- Customer: Orus Integration Inc.
- Location: Laval, Quebec, Canada
- Industry: Automated Inspection

Application

Turbines housed in aircraft engines are subjected to extremely tough conditions. They must perform at speeds of 30 thousand rpm in temperatures greater than 800° C for hours at a time. Engine manufacturers fully understand that even small surface defects can reduce performance, increase maintenance costs, and reduce the useful life of an aircraft engine. They need to inspect turbine blades very carefully to maintain the efficiency and reliability that the air transport industry requires.

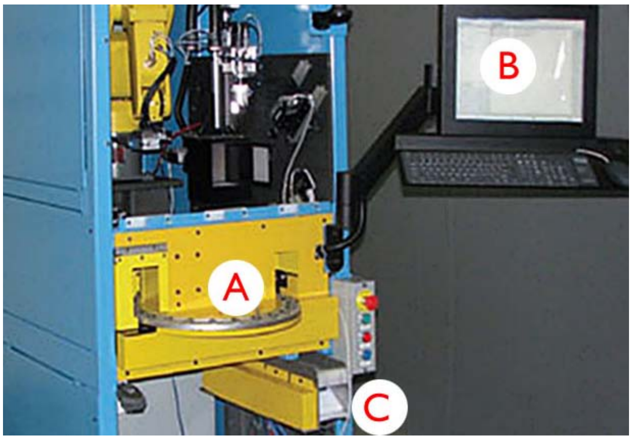
One particular North American manufacturer inspected their blades both by hand and by human eye. The highly-trained inspectors measured hundreds of features and checked for surface defects at depths on the order of thousandths of an inch. Manual inspection was not only costly in terms of time and labor, but subjective as well. Results were variable and even differed between inspectors. Finally, because manual inspection was so time consuming, there was no systematic inspection of every blade; only a sampling of blades was inspected. Clearly, the manufacturer required an approach that would allow systematic inspection of the blades, save time, and yield consistent and repeatable results.

They asked Orus Integration Inc. (Laval, Quebec) to design a turbine inspection system. Project Manager Louis Dicaire says that early in the project, the development team learned that flexibility, repeatability, and precision were absolutely necessary for success. During development, the Orus engineering team relied on their previous experience - they designed vision-based metrology systems for the Canadian military and aerospace industry. They also worked closely with Genik Automation for parts handling and the machine's mechanical engineering.

According to Dicaire, the challenges involved in designing metrology machines are always the same: repeatability, precision, and linearity. To get the system to return predictable, repeatable results, the software must exhibit fine sub-pixel accuracy; the machine exhibits +/-3 sigma under five microns. Of course, an image is only as good as its lighting, and Dicaire notes that the system requires a stable, high performance optical system. To achieve the required precision, Orus used a military-grade calibration target to calibrate both cameras in the metrology station at the same time. Though the INL-1900x2T saves thousands of hours of labor, its main advantage is its ability to perform very complex analyses while offering a simple interface and a very easy to-use concept for the operators.

Solution and Benefits

Orus calls the system the INL-1900x2T. A single enclosure houses two stations that perform the inspections. The metrology station features two Basler pilot GigE cameras with 1920 x 1080 resolution, each fitted with a large field of view telecentric lens (non-perspective lens) and two collimated blue LED (520 nm) lights. The surface inspection station uses four Basler pilot GigE cameras. The resolution of the first surface inspection camera is 1920 x 1080, and the remaining three cameras offer 640 x 480 resolution for surface inspection of areas that are hard to reach with a single camera. Two CCS diffuse on-axis lights and one CCD diffuse backlight illuminate the surface station. A Fanuc 6-Axis LR Mate 200iC robot, a 4U controller, and an Omron PLC round out the hardware components. The software is based on the Matrox Imaging Library (MIL) 9.0 with Processing Pack 1.

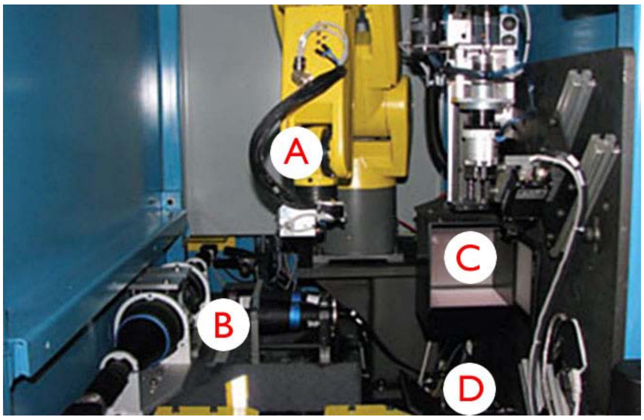


The carousel that holds the parts lies in the vertical center of the INL-1900x2T (A). The operator interface and the inspection results are displayed on a monitor (B). Non-conforming parts are returned to the operator through the reject chute so they can be re-machined to tolerance (C).

The blade’s journey

The INL-1900x2T has three inspection roles to fill: verify several hundred metrology features of the blade, inspect both sides of the turbine blade and other critical surfaces for defects, and validate the part‘s character markings. The entire inspection procedure takes 15 seconds per part.

To perform a batch inspection, an operator first scans the barcode on the job sheet and loads the pocket wheel with the carousel that holds the parts. Then the wheel indexes the first part while a height detector validates its Y position to ensure the part was properly loaded. The robot picks up the part by its blade section and carries it to the metrology station, which is illuminated by the two collimated lights. With the camera‘s telecentric lenses and a four inch slab of granite to absorb heat and vibrations, the INL-1900x2T has a very stable optical system. ”Under these conditions, the contrast of the round sections of really shiny objects appears super sharp,” explains Dicaire.



First the robot (A) brings the part to the metrology station where it is subjected to collimated illumination and rotated for image acquisition (B). Then the robot places the part in the gripper of the surface inspection station (C). While the gripper rotates the first part, the robot picks up the next part from the carousel. If the first part passes inspection, the gripper drops it in the “good parts” chute (D). If it fails, the gripper drops it in the reject chute.

Precision is extremely important in this application. ”The robot is very repeatable, but cannot place the blade with the precision that we need, which is smaller than 10 microns,” he says. Orus´s solution was to rotate the part and acquire the images at high speed. Depending on the feature that needs measuring, the software minimizes or maximizes a specific feature. When an image of a particular reference point, called the datum, matches the original CAD drawing, the software identifies it as the reference image. Then the metrology software measures the part´s parallelism, length, radius, angles, and other features. Since there are many datums to optimize, this step is performed more than once. The software records results for hundreds of features and 50 tolerances.

After the software records the metrology results for all of the blade‘s features, the robot places the blade in a three-pronged gripper that is mounted on a Y-Theta station. The gripper rotates the blade 360° to inspect both sides for surface defects. Next the software verifies the part´s character markings, first by stitching together several images to form a complete image and then by performing the OCR algorithms that recognize the characters.

When the inspections are complete, all results for the part are logged and all data is available for reporting. If the part passes inspection, the robot puts the part in a ”good parts” chute. If a feature has failed, the part is held in the clamp, information is displayed on the screen to let the operator know what to correct on that specific part, and then the gripper releases the part into a reject chute. The wheel turns, indexes the next part, and the process repeats for all parts in the carousel.

Technologies Used

- 2 Basler piA1900-32gm GigE cameras for the metrology station, with telecentric lenses and collimated blue LED (520 nm) lights
- 1 Basler piA1900-32gm and 3 piA640-210gm GigE cameras for the surface inspection station
- 4 standard lenses for the surface inspection station
- 2 CCS diffuse on-axis lights
- 1 CCD diffuse backlight
- 1 Fanuc 6-Axis LR Mate 200iC robot
- 4 U controller
- Omron PLC
- Customer-specific software based on the Matrox Imaging Library (MIL) 9.0 with Processing Pack 1

More Information

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www.matrox.com/imaging/en/press/feature/robot/stress

The Basler pilot GigE camera is a perfect fit for this application

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