INTRODUCTION

TECNATOM has been performing inspections on steam turbine blade attachments for more than 10 years. The main characteristics that make these areas so special when addressing inspections are their geometric complexity and the rapid growth of cracks due to the physical phenomena that take place in them. This difficulty translates into the following fundamental issues:

- It is essential that cracks be detected in their initial phase in order to prevent catastrophic ruptures.
- Access to these areas is particularly difficult, this preventing the performance of complete surface tests unless the blades are previously disassembled.
- In most cases, ultrasonic volumetric inspection is complicated because of the scarcity of space available for positioning of the ultrasonic probes.
- The special geometry of this area gives rise to highly complex ultrasonic responses that complicate the interpretation of inspection results and may generate false calls.

Although, prior to the development to a usable level of the current phased-array technology, certain inspections had already been carried out using conventional probes for the inspection of blade attachments, especially of the dovetail tangential entry, the time taken to perform these inspections, or even the time invested in preparing the technique to be used for each particular geometry, was excessive, as a result of which the associated costs were high. Another unfavourable issue was the number of false calls in defect detection, this meaning that at times it was necessary to dismount blade wheels when there was no actual indication. Despite the above, the advantages of detecting defects in the initiation phase more than justified the performance of ultrasonic inspections in these areas, with respect both the high and low pressure rotors.

The use of phased-array technology linked to a good simulation software allows a fairly wide range of geometries to be covered with one same probe and, given the characteristics of these probes - allowing angular sweeps to be performed and focussing at different depths – it is possible to appreciably improve the quality of ultrasonic inspection, preventing false calls, the use of heavy multiple probe modules complicating ultrasonic coupling and the time-consuming and inefficient task of changing the probes for each area to be inspected, even for one same blade wheel.

CERTAIN SOLUTIONS PROPOSED / ADOPTED BY TECNATOM

In 1996, TECNATOM began to carry out inspections of blade attachments in high pressure turbine rotors which, given their geometry, implied especially complicated accesses for any type of ultrasonic inspection.

Using the advantage that the performance of BORESONIC ultrasonic inspections of the central boreholes of these rotors implied, this meaning the destruction of the lateral plugs, thus facilitating access to a zone from which access might be gained to the area to be inspected, the idea arose for the system that was presented by Tecnatom under the name of SIRENA. This allowed for the ultrasonic inspection of the blade attachments of any blade wheel without an excessive cost in terms of time, taking advantage of the performance of the BORESONIC inspections that were carried out periodically on rotors with a central borehole.

This system made full use of the advantage implied by the phased-array technology in achieving relatively narrow (< 12 mm) focussing of the ultrasonic beam on the different blade wheels from the central borehole. This technology allows for the inspection of both axial and tangential entry
blade attachments without the need for modifications to the equipment, the only requirement being that the focal laws be varied in order to achieve ideal focussing in each case.

In order to achieve such focussing, probes were designed with a diameter sufficient to be able to focus at fairly large distances and with shapes (“Fermat surfaces”) compensating the distortions caused by the curvature of the internal cylindrical surface (See figure 1). It was also necessary to manufacture blocks for the calibration and validation of techniques simulating the exact geometry to be inspected (See figure 2).

This technology has been used to monitor the status of multiple high pressure rotors of both Mitsubishi and Westinghouse technology, until the owners replaced them with solid rotors in order to achieve power upgrades in their facilities, thus obviously making inspection with this system impossible.

Another application developed by TECNATOM and implemented in its inspections is the inspection of dovetail type blade attachments, this being performed jointly with “wheelsonic” disk inspections. The difficulty in this case is the lack of space available for the location of probes of an adequate size on the wall of the disk, allowing for a degree of freedom ensuring sufficient sweep to guarantee the complete inspection of the area.

In order to achieve this degree of freedom and thus avoid having to continuously change probes, phased-array probes are used, these performing an angular sweep covering the entire area to be inspected and making it possible to inspect a complete wheel in a single run.

Evidently, in order to fine-tune techniques allowing for the performance of these inspections, it has been necessary to manufacture validation mock-ups simulating the areas to be inspected as accurately as possible.
However, given the large number of existing geometries, it has been necessary to have available a “CIVA” simulation programme to optimise the probes to be used and their focal laws in each specific case.

This simulation programme makes it possible to calculate optimum focal laws for complex geometries and simulate the ultrasonic response for postulated defects. Figure 4 shows the simulation obtained from the defects of one of the validation mock-ups.

The results actually obtained are similar to those obtained from validation mock-ups and in the simulation programme with one exception: neither in the mock-ups nor in the simulations are there blades that have been operating for years, oxides, etc. that might in some way alter the expected results and give rise to false interpretations. Nevertheless, through the use of these techniques, along with an ultrasonic analysis programme, it is relatively easy to discriminate geometric indications from those coming from actual indications.

Figure 5 shows an actual indication found in the attachment of the first blade wheel of a high pressure turbine with T-slot type attachments, which is similar to the defects postulated in the validation mock-up for inspection from the SIRENA central borehole.
Figure 5: Actual T-slot indication

Figure 6 shows a series of actual indications found in a tangential entry blade attachment of the dovetail type, with a response similar to that obtained from both the simulation programme and the validation mock-up.

TECNATOM is currently in the phase of developing a system for the performance of mechanised bladeattachment inspections using the phased-array technique in solid rotors, in order to be able to replace the inspection performed to date using SIRENA. The inspection will also be carried out in little time, but with the advantage of not having to eliminate the plugs to gain access to the area of interest.

Figure 6 - Actual indications in dovetail type attachment