Manufacturing of Power Turbine Casings

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In the past few years, Sulzer Elbar, a company of Sulzer Turbomachinery Services, has developed the technologies for repair, modification and manufacture of power turbine casings and vane carriers. The manufacturing procedure of welding instead of casting offers distinct advantages in turn-over time, cost and material quality.

Power turbines use the outlet gases of a gas generator to produce energy. The temperatures of these gases are around 700 °C, while pressures are usually found to be between 4 and 6 bar.

The gas generator is quite often of the aero-derivative type, which has been manufactured by a different manufacturer than the power turbine. As a consequence, the amount of cooling air available for the power turbine is often found to be limited.

The casings of power turbines are generally produced from cast low-alloy steels that can be used up into the 400–500-°C range. The lack of adequate cooling can result in premature deformation, cracking and other failures.

Sulzer Elbar can manufacture high-quality turbine housings to replace cast structures. Especially the replacement of low-grade cast components by very creep-resistant ferritic/martensitic or by superalloy type materials offers an

1 Cracks in an original turbine casing after many years of service. The casing was replaced by a new casing, reverse-engineered and manufactured by Sulzer Elbar.

opportunity to increase the lifetime of turbine housings.

Replacement of Four Casings

A Sulzer Elbar customer was relocating his Pratt-and-Whitney-powered peak-load power plant from New Zealand to Australia. The power turbines were manufactured by Curtiss and Wright.
Target for Sulzer Elbar was to refurbish the rotor, as well as to reverse engineer and manufacture four new and more durable power turbine casings. All this was to take place within the limited time-frame of the relocation. In addition to that, Sulzer Elbar was to come up with a number of design improvements to overcome problems encountered during the many years of service of these turbines.

Welding Instead of Casting

The original cast casings showed numerous cracks and were heavily deformed (Fig. 1). The casings were in no condition to start a second life that was destined for them on their new site, so they had to be replaced. It was decided to manufacture new casings out of Inconel 625 material, which would result in more durable casings.

Because of the time-frame in which the replacement was to take place, casting was not an option. Also, casting of Inconel 625 was not taken into consideration since it would not produce homogeneous and reproducible properties in this alloy. Therefore, the casings were manufactured out of a number of forgings that were joined by welding.

Reverse-Engineering of the Original Casings

To reverse-engineer the right dimensions out of the deformed casings was not an easy task. The stator vanes were tilted downstream as a result of creep deformation of the carrier teeth, caused by the continuous downstream gas force on these vanes. Based on the measurements on the deformed casings, the internals, and the rotors and by analyzing the clearance data provided by the customer, the Sulzer Elbar engineers reconstructed the original dimensions of the casings.

2 Final quality check of a repaired turbine casing.

Demanding Production of New Casings

Inconel 625 bar stock was forged to the appropriate dimensions. Fitting edges were machined on the axial faces to ensure a concentric stacking of the five separate forgings. A special welding manipulator was designed and built to slowly rotate the 2.5-ton casing with 1.9 m in diameter. The separate forgings were then joined by argon arc welding. After machining of the welded casing on the outside, the casing was split, and the split flanges were welded in place. After machining of the split flanges, the two halves were connected, and the internal carrier teeth were turned. Finally, all additional features like flange bolt holes, vane stopper holes and lifting lugs were machined.

Inconel 625, apart from being very tough to machine, is extremely prone to deformation during machining. Therefore, the casings were subjected to a strict procedure of machining phases, intermediate heat treatments, and dimension checks.

After completion of the machining operations and installation of the internals, a clearance check was performed to ensure that the clearance criteria were met (Fig. 2). The casings were now ready to be shipped (Fig. 3).

In Addition: Rotor Blades Repair

Along with the manufacturing of the four casings, Sulzer Elbar repaired the rotor blades, the stator vanes, and the inlet housings of the casings (Fig. 4). The original design of these inlet housings featured an elaborate flange design to allow thermal differences between the flanges whilst maintaining concentricity. This design however suffered from distortion and subsequent flange leaks. Therefore, the inlet housing exit flange was replaced by a flange with a volume comparable to the casing inlet flange, resulting in comparable heat-up and cool-down gradients. A heat shield, which in fact only aggravated the problem, was discarded from the design. The new material choice made the heat shield obsolete anyway.

The four rotors belonging to the power units, as well as two spare rotors, were dismantled in Sulzer Elbar's rotor shop, after which the blades were repaired. The rotor disks as well as the tension bolts were inspected.

One Step Beyond: Welding with Preheating

All four casings were installed in February 2002 and are running in full service to full customer satisfaction since then. Sulzer Elbar has now accepted the next challenge, which is the manufacturing of an IHI IM5000 casing out of X20CrMoV12.1 material. This material can only be welded with preheating. The final heat treatment will be performed once welding has been completed in a furnace built on site. ◀

3 Casing ready for shipping to Australia.

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4 Welding of newly designed inlet housing exit flanges.