

for an Aged Turbine

New Life

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Repairing and performing maintenance work on rotating equipment of various builds and ages requires specific expertise, which can only be acquired in the field. Sulzer Elbar, a company of Sulzer Turbo Services, refurbished an unusual set of turbines, including a radial-flow steam turbine, in a northern European coal-fired power station. As the power output of this rare type of turbine is limited, it is not used in modern steam power plants. This exacting task required the reverse engineering and manufacturing of many turbine parts.

► The Ljungström steam turbine was developed by the Ljungström brothers from Sweden early in the 20th century. In this turbine, the steam flows in a radial direction, as opposed to the more common axial flow in other turbines (Fig. 1). It has 2 counter-rotating rotor sections and no stationary parts. The blades are arranged such that the blades of the one runner act as guides vanes for the other. As the 2 shafts rotate in opposite directions, this turbomachine usually

drives 2 generators or else is coupled to a subsequent gear unit.

In late 2005, Sulzer Elbar was awarded a contract to refurbish a 400-MW steam power plant in Northern Europe. The 300-MW medium- and low-pressure section of this plant consists of 2 units of 150 MW each. The train comprises one intermediate pressure (IP) Ljungström turbine and 2 axial-flow, low-pressure (LP) turbines that drive two 75-MW generators sharing one exciter (Fig. 2).

Sulzer Elbar had just 4 months to reverse engineer and manufacture over 500 different parts including consumables and major turbine components, such as labyrinth seals, hydraulic bolts, studs, and axial pads for the thrust bearings. A specially formed engineering team completed this challenging task. The experts in the Sulzer Elbar laboratory analyzed material samples taken from the original turbine. The team prepared new drawings as well as manufacturing process documents and selected and qualified subcontractors. All parts had to be ready before on-site work began.

Hazardous Chrome Replaced

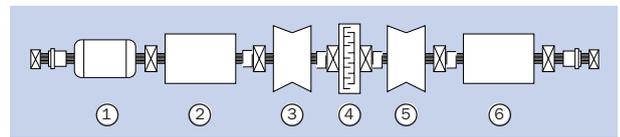
Overhaul of the steam stop and regulation valves, including reverse engineering of the valve spindles, was a crucial part of the order. New techniques were applied for the manufacture of these components. The valve spindles were coated using the high-velocity oxygen fuel (HVOF) process, which replaces the normal elec-

trolytic chrome process. The HVOF process enables the use of metallic powders with improved metallurgical properties. As a result, the new valve spindles perform better than the original ones. The steam stop and regulation valves were disassembled, inspected, and repaired in the Sulzer Elbar rotor shop. Of all 4 stop valves, the pilot valves had suffered the highest level of erosion. The old material was removed and the seats were rebuilt with an improved hard-facing material. The valves were assembled with the new spindles and hardened bushes.

Special Tools Designed

The realignment of the units was a major issue due to their unique characteristics, age, and state of degradation. The alignment process necessitated the design of many special tools. After the alignment, assembly began (Fig. 3). During the assembly clearance checks, significant deformation of the steam chests was discovered.

1 Sulzer Elbar carried out repairs on a steam turbine train containing an uncommon radial-flow steam turbine. The picture shows the rotor of this Ljungström turbine in the casing.



2 Schematic overview of the steam turbine and generator train with the Ljungström turbine in the center.

- ① Exciter
- ② Generator
- ③ LP turbine
- ④ IP turbine
- ⑤ LP turbine
- ⑥ Generator

The engineering department of Sulzer Elbar's new-parts manufacturing group and the machining department worked around the clock on all 4 steam chests to repair and restore them to within operating tolerances.



3 Assembly of the radial turbine before installation.

New Process Provides High Quality

The refurbishment of the 4 low-pressure double-flow rotors was carried out in the Sulzer Elbar workshop in Lomm. This task included replacing the erosion shields of 8 sets of stage-6 blades and reducing the excessive clearance in the dovetail on the same stage. It was necessary to complete all this work within 4 weeks. The airfoil shop carried out the replacement of the erosion shields. To process 828 blades in the required period was an extremely difficult target to achieve. It was accomplished thanks to a new re-



4 Removal of the generator rotor.

pair process using an automatic laser welder. This process has great advantages in providing the highest level of quality and consistency for critical repairs.

To solve the dovetail clearance problem, 2 steps were taken. Between the root of the blade and the rotor disc, a pin was inserted and a new tie wire was brazed through the airfoils. These actions required extreme precision by the team performing the task to ensure the correct temperature and thereby minimize material degradation from overheating. The tie wire replaces the top shroud of the blades, which was removed several years before after a failure. These measures limit the movement of the blades in the dovetail when the unit is running on the turning gear, and they thus reduce the wear in the root.

Additional Work Carried Out

At the customer's request, Sulzer Elbar manufactured new erosion protection shields for the preheaters in the condenser within only 5 weeks.

The generators are hydrogen-cooled units. First, Sulzer Elbar inspected them in situ (Fig. 4). Second, following the inspection of the bearings, the H₂ seals had to be reverse engineered and replaced. Then, comprehensive stator electrical tests were performed. The wedges and, after removing the rotors, the end-bell were inspected. During operation, considerable amounts of hydrogen leaked from the generators, which had not been operating to their design specifications for many years. A main target of this outage was to reduce the leak rate down to that of the original design. A major issue was to change the O-ring and the pressure ring of the vertical flange between turbine casing and generator stator, which had to be lifted from its foundation in order to replace the O-ring.

Leakage Reduced

Another challenge was to replace all of the hydrogen shaft seals on the generators. The seals and covers were reverse engineered and manufactured using the new

plans. The Sulzer Elbar team succeeded in reducing the leak rate on both units to the original design criteria. The client can now operate the generator under normal pressure, a condition that had been impossible for the last decade. Following final assembly, the unit was field balanced to bring all vibration responses into specification (Fig. 5).

Repair Specialists

When it comes to repairing non-standard turbomachinery, the specialists at Sulzer Elbar can draw on experience from many projects. They displayed engineering knowledge and project management skills and finalized a very challenging project successfully despite intense time pressure and significant on-site problems that required an extension of the agreed scope of work. The ability of Sulzer Elbar to manufacture new parts for old machines makes it possible to repair machines that would have previously had to have been scrapped. ◀

5 Overview of both units after mechanical completion.



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