Steam turbine repair in a geothermal power plant

The heat is on

The heat from inside the earth is a source of energy with huge potential. More and more countries are investing in geothermal power generation. However, the maintenance and repair of geothermal power plants is challenging. Recently, Sulzer Turbo Services Indonesia faced a major emergency repair of a 60 MW steam turbine and managed the seemingly impossible: blade replacement in less than a month. In this project, the heat was definitely on…

Sulzer Turbo Services Indonesia was awarded a contract to overhaul a steam turbine unit in a geothermal power plant at the end of 2011. The power plant is located in West Java, Indonesia, and belongs to a state-owned energy company, which has recently started developing business in the geothermal power industry. The Japanese-made unit is a single-casing double-flow condensing type with 2×12 stages and has a 60 MW capacity. During the scope of the overhaul, the unit was disassembled, cleaned, inspected, reassembled, and commissioned. The OEM engineers were also available on site to supervise the job.

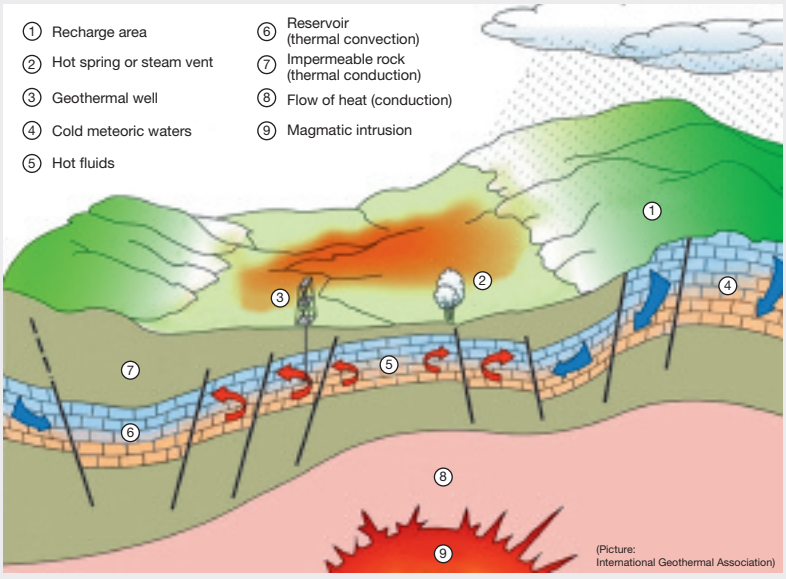
Serious findings and utmost urgency

During rotor inspection, serious damage was found: all stage-1 blades had been damaged by a foreign object, and nine last stage, or stage-12, blades were cracked. The cracks started at the leading edges. This was a difficult situation for the customer, as shutting down the turbine would result in production losses

Indonesia is located along the so-called Ring of Fire and hosts some of the largest resources of geothermal energy in the world. The picture shows Mount Papandayan, West Java.

Principles of geothermal systems

When water is heated by the earth's heat, hot water or steam can be trapped in permeable and porous rocks under a layer of impermeable rock, and a geothermal reservoir can form. This hot geothermal water can manifest itself on the surface as hot springs or geysers, but most of it stays deep underground, trapped in cracks and porous rock. This natural collection of hot water is called a geothermal reservoir.



of about USD 70 000 per day. Therefore, the customer was interested in a quick solution for repairing the rotor.

The OEM had offered to replace the stage-1 and stage-12 blades of the governor side with a delivery time of five months. An alternative solution that the OEM proposed included only the replacement of the stage-1 blades and the cutting of the last stage blades' airfoils. With this alternative, the unit would be able to run again after a month while waiting for new sets of stage-12 blades. However, this option would cause significant performance losses.

Shutting down a turbine is costly; in this case, USD 70 000 per day.

Sulzer Turbo Services proposed a better solution and offered to remove the stage-12 blades from the rotor and to repair the cracked ones by welding, while the others would become the models for reverse engineering and manufacturing of replacement blades. In parallel, the stage-1 blades could also be procured within the timeframe, which was less than one month. With this option, the downtime could be minimized without losing the power capacity. Sulzer also advised the customer to upgrade the material of the blades from 13% chromium to 17-4 PH stainless steel for better mechanical properties and corrosion resistance. Faced with production demand and time considerations, the customer accepted all of Sulzer Turbo Services' recommendations. In addition, the customer awarded Sulzer another contract to supply the new blades, repair the cracked blades, and perform the reinstallation.

1 The customer decided to go with the Sulzer solution, which provided better delivery time and an improved blade as a replacement. This picture shows the reloading of the repaired last-stage blades.

Rapid repair activities, on-time delivery

Because of the tight schedule, the Sulzer crew was mobilized to conduct the deblade inspection on site; it then continued with blade removal. Blade samples were removed for reverse engineering and manufacturing. Meanwhile, the cracked stage-12 blades were to be laser-welded in Indonesia. Laser welding was selected as the welding repair method for the cracked blades because of the low heat input it requires. With low heat input, residual stress, the heat-affected zone (HAZ), and deformation can all be minimized. After the welding was completed, the blades were soaked for post-weld heat treatment to restore the original properties.

The manufacturing of the new stage-1 blades was completed in only ten days, including the reverse engineering. The new stage-1 blades were ready even

before the cracked-blade repair was complete. All of the blades—the new stage-1 blades and the repaired stage-12 blades—passed several inspections—such as dimensional testing and non-destructive examination. After that, they were finally installed on the rotor 1. The completed rotor was then low-speed balanced to ensure that the residual unbalance was within the specification. All repair shop activities were completed within 28 days—two days earlier than committed to in the contract schedule.

Sulzer Turbo Services outpaces the competition with better solutions.

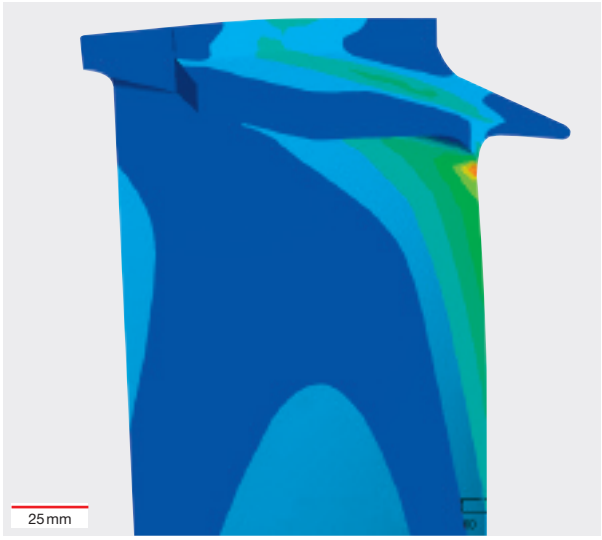
Root cause analysis supported Sulzer's recommendation

Sulzer Turbo Services Indonesia was further requested to perform failure analysis on the failed/cracked blades. The stage-12 blade was modeled in finite element software, and a static stress analysis was completed. The result indicated that the high-tensile stress location matched the location of the crack 2. The metallurgical examination revealed that the crack was from stress corrosion cracking (SCC) 3. SCC is the combined action of stress and a corrosive environment, which leads to the formation of cracks under tensile load. The examination found that the crack was rough and branching. This root cause analysis result supported Sulzer's recommendation to upgrade material from 13% chromium to 17-4 PH stainless steel. Sulzer Turbo Services Indonesia is currently testing a possible blade redesign that may help reduce the stress level on the blade in the future.

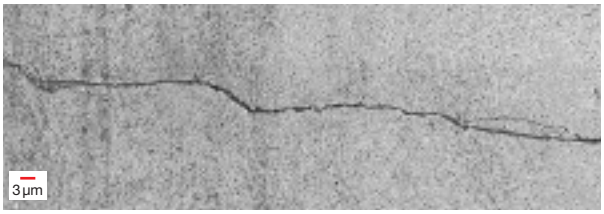
Back to service, strong customer partnership

After all the shop-side repair activities had been completed, the rotor was shipped back to the site for installation. No vibration or performance issues were recognized during startup. The turbine reached 60 MW not long after startup and is now generating electricity for the region. The upgraded stage-12 blade replacements were completed only two months after the initial delivery.

Thanks to experience, good preparation, and foresight, Sulzer Turbo Services Indonesia once again succeeded in providing a rapid and economical solution for a customer challenge. In addition, Sulzer Turbo Services Indonesia helped intensify customer partnership by offering forward-looking suggestions for improvements to the rotor. These upgrades will save the customer on maintenance and repair costs in the future.



2 Finite element modeling and static stress analysis of the stage-12 blade showed that the highest tensile stress (red area) is located at the area of the crack.

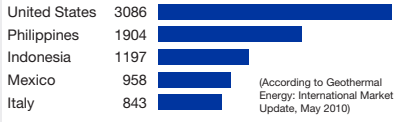


3 The crack path indicates stress corrosion cracking (SCC).

Geothermal energy in Indonesia

With an impressive 28100 MW potential, Indonesia has approximately 40% of the world's geothermal energy reserves. Of that, 1197 MW has been leveraged. Indonesia ranks third in the world in terms of geothermal energy consumption after the US and the Philippines. The Indonesian government recently announced that it has signed USD 5 billion worth of geothermal energy deals. It aims to reach 9000 MW from geothermal resources by 2025 and to be the world's largest producer of geothermal energy.

Top five countries generating geothermal power in 2010 (installed capacity in MW):



(According to Geothermal Energy: International Market Update, May 2010)

Sulzer Turbo Services Indonesia is a well-established, state-of-the-art rotating-equipment service center. It was founded in 1994 as a joint venture. The company operates comprehensive, well-equipped workshop facilities that offer a wide range of quality services to the rotating-equipment market.

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