

Root cause analysis for generator failure



Sulzer's repair specialists were tasked with minimizing the idle time in the harbor of Aberdeen, Scotland, and speeding up the repair of an icebreaker. The failure of an exciter pack within the shaft generator put the working vessel out of order. Sulzer performed a root cause analysis and in-depth investigations. To prevent further failures, the company that owns the icebreaker plans to implement the solution on similar generator units across the fleet.

1897

The first modern seagoing icebreaker, Yermak, was built in England.

An icebreaker's time at sea is valuable, and any time spent at the dock needs to be minimized. A Scandinavian shipping company that owns and operates several ships and icebreakers contacted Sulzer to repair the shaft generator of the working vessel. The vessel itself supports the icebreaking function, and, at the same time, works as an anchor handling tug.



Fig. 1 Sulzer delivered a fast solution to minimize the time the icebreaker was in the harbor of Aberdeen, Scotland.

A non-exciting exciter pack

Sulzer's field service engineers were invited aboard to investigate the failure of the exciter pack on one of the vessel's shaft generators. The need to repair the generator was immediately apparent. The damaged components were taken from the port in Aberdeen, by the Local Service Center field technicians (Fig. 1), then on to Sulzer's Falkirk Service Center, where they were overhauled and rewound.

Following discussions between the customer and the Sulzer technical team, the refurbished exciter pack was tested under load in the presence of the customer and its insurance company. Following a successful load test, the components were refitted by the same engineers that removed them from the ship.

However, to find the root cause of the exciter failure, investigations into the other component parts of the generator setup were necessary. A root cause analysis is a systematic approach used to identify the reasons for a failure and to define corrective actions for the future.

Some interesting facts about icebreakers

Icebreakers are ships that are specially designed to break through ice-covered waters, thus creating safe waterways for other boats and ships. To be considered an icebreaker, a ship requires three characteristics lacking in most normal ships. These properties are a strengthened hull, an ice-clearing shape, and the power to push through sea ice. The first modern seagoing icebreaker, Yermak, was built in 1897 in England.

There are two different types of icebreaker constructions. Conventional icebreakers use the bending fracture method, moving their bow upon the ice and breaking it under weight load (Fig. 2). Other icebreakers are built with a Thyssen-Waas-bow and with three sharp skids below the vessel. The skids break the ice with a shear fracture and the ice is moved then to the side of the icebreaker (Fig. 3). Because the shear fracture force of ice is lower than the bending fracture force, conventional icebreakers need more energy to clear a path through the icy surroundings. In rough seas with no ice, conventional icebreakers are easier to steer and navigate.

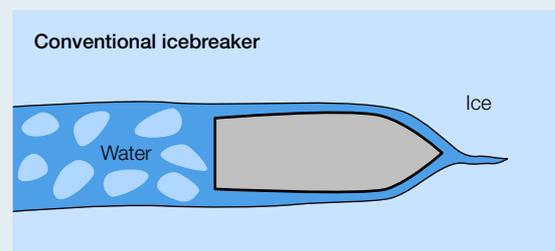


Fig. 2 Working principle of a conventional icebreaker.

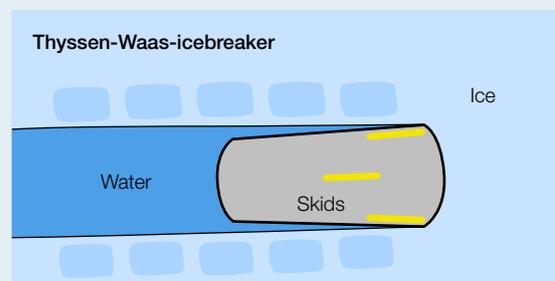


Fig. 3 Working principle of a Thyssen-Waas-icebreaker.



Fig. 4 The damaged components were rewound while the investigation into the cause progressed.



Sulzer Service Centers in the United Kingdom

Sulzer is a leading independent service provider for large rotating equipment around the world. With technically advanced and innovative service and maintenance support solutions, Sulzer provides a turnkey service that provides its customers with the peace of mind to focus on their core operations. Sulzer service centers cooperate very intensively. Customers of the Sulzer Service Centers benefit from the highly efficient and dependable high-voltage coil manufacturing and supply service from the Birmingham Service Center, UK. It is recognized for producing high-quality coils for high-voltage motors and generators. These are designed, manufactured and shipped by a highly skilled and dedicated team to ensure fast and reliable service.

Due to the breadth and depth of the UK Service Center network, customers can receive fast and expert electromechanical services regardless of their location. With large field service teams coupled with comprehensive workshop facilities, Sulzer Electro Mechanical Services can meet even the most stringent of customer requirements at any time of day or night.

Ross Barraclough, Regional Operations Director (North) at Sulzer Electro Mechanical Services

Investigations with ice-cold and sharp minds

Immediately after the commissioning process of the revised parts was completed, Sulzer launched in-depth investigations that focused on three main areas: the winding configuration, the serviceability of the automatic voltage regulator (AVR), and the electrical control system. Throughout both processes — the investigations and the repair — the Sulzer teams communicated intensively with the customer. Sulzer's technical design team looked at the evidence and concluded that the failure mode was consistent with a sudden spike in exciter load. This peak had led to the catastrophic failure. One important clue came from the commissioning engineer who reported that the only active alarm during the installation related to low voltage.

Finding the culprit

Sulzer engineers thoroughly examined and systematically eliminated every possible failure mode associated with the winding. The stator and rotor coils (Fig. 3) were copied and produced as closely as possible to the original design, so they were not the culprit. As part of the analysis,

the automatic voltage regulator (AVR) was sent by Sulzer to the local UK agent for testing. Although it was not possible to carry out the tests under load, the unit passed the tests that were performed, and it delivered the correct performance. Not being able to fully load test the generator/AVR combination outside of the vessel itself, the AVR remained the most probable cause of the failures.

Implementing and spreading the solution

At the same time, Sulzer engineers inspected and tested the electrical control system, including the switchgear, and found it to be within the manufacturing tolerances. This continued to indicate that the automatic voltage regulator (AVR) was, in some way, responsible for the failure. Further investigations were carried out using the drawings and operating manuals provided by the customer. Sulzer engineers studied the original AVR manual: It specified a minimum field resistance of 9Ω , which conflicted with the onboard installation value of 6.753Ω . Operating below the indicated resistance, the AVR had the potential to become unstable and fall below optimum performance.

To resolve this situation, Sulzer provided 2.2Ω resistors that could be fitted in line with the DC exciter field. During the commissioning of the newly repaired exciter pack, the AVR manufacturer sent an engineer to supervise the installation. This engineer confirmed that the shaft generator displayed excellent voltage control. Another conclusion from the investigation related to the overcurrent protection offered by the AVR. At the time of the failure, this protection was not being utilized. Sulzer engineers recommended using the overcurrent protection and several other safeguards on all generators of the company's ships to prevent similar failures in the future.



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All marine vessels need to minimize their time in the harbor, and Sulzer worked closely with all of the stakeholders to deliver a reliable and long-term solution within the shortest time frame. The customer was pleased with the overall project conclusion. Once the ship was back at sea, the ship's chief-engineer placed a separate order with the Sulzer service center to cover further electrical maintenance.