A proven approach to achieving better equipment

Authors

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Introduction

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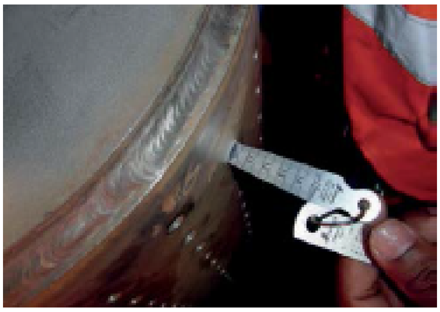
Saipem draws upon its experience in plant and equipment design spanning a wide spectrum of fields, ranging from green technologies to the oil and gas industry, to find the most appropriate solutions for the optimisation and improvement of equipment design.

By establishing close and enduring relationships with manufacturers, equipment can be designed with the knowledge of any associated construction issues, ensuring that the proposed solutions are technically viable, thus avoiding unexpected, expensive and time-consuming reworks aimed at finding alternative solutions which, in the rush to meet the project schedule, may not be the optimal ones.

It is these experiences and bonds with manufacturers that are the basis for the continuous development of the equipment design, as well as, for the definition of criteria, the renowned confidential and proprietary Saipem's "510 & 516" series of specifications. These criteria consist of a collection of requirements regarding materials, methods of construction, examinations and inspections during manufacturing that are periodically updated based on the feedback from manufacturers and operating plants to ensure and to improve the quality of the equipment. The presence of Saipem's quality inspectors during the main steps of construction of its equipment, either in the manufacturer's workshop or, in case of constraints (as experienced during the recent pandemic) remotely, ensures that all fabrication steps are monitored, providing the smooth and timely manufacture of equipment according to Saipem's design requirements and criteria.

Once equipment is installed, Saipem is proud to assist end-users by offering its post-sales assistance, which covers a wide range of services with the target of monitoring the status of the equipment, ensuring (if not prolonging) its expected life time and boosting its performance. In this way Saipem has acquired and developed a deep knowhow for all the different pieces of equipment, specialising in performing the inspections, understanding the best approaches to attend the required maintenance and, last but not least, getting a feeling on how to intervene if features of equipment design require improvement.



Inspection of equipment internals.

HP tubesheet.

PHOTOS: SAIPEM

A demonstration of the benefits of this approach is the development of the design of the ferrules of the urea stripper. Ferrules are the distribution devices for the urea solution, installed over the head of the tubes, that generate a falling film flow along the tubes of the heat exchangers (in this case the urea stripper) thus providing optimal heat transfer and efficient decomposition of the carbamate and consequent release of the vapours.

By performing the inspections on different plants and relevant strippers, it has been noticed that the portion of the bimetallic tubes heads from where the zirconium was removed was more prone, long term, to corrosion issues; corrosion was due to 25/22/2 Cr/Ni/Mo material (in proximity of the weld) being directly exposed to the process fluid and to the higher temperatures of the tube-sheet.

After a joint discussion among process and mechanical engineers and quality experts, the design of the head of the tubes was modified by increasing the length of the protrusion of the tube ends over the tube-sheet to allow for maintaining the terminal zirconium and consequently avoiding, over long periods, the risk of corrosion on 25/22/2 Cr/Ni/Mo tubes. The proposed design was then presented to the stripper qualified manufacturers to check whether from a construction viewpoint the studied improvements were feasible and, in particular, to what extent. Manufacturers confirmed the weldability of the tubes to the tube-sheet and defined limits for the length of the tube protrusions.

The design was also updated by switching from internal to external ferrules, as it was no longer possible to maintain an internal ferrule without reducing the passage area inside the tubes. The ferrules were also subject to other modifications aimed at improving the sealing over the tubes and their stability; based on feedback from manufacturers and end-users, the design of the hold-down grid for the ferrules was also updated to improve its duty and to facilitate its installation.

Another aspect, which is a high priority for end-users worldwide, is the importance of inspections for proper maintenance of the equipment: a well scheduled inspection and maintenance plan for the equipment is of fundamental importance to meet the current practice of having turn-arounds every three or even four years.

Saipem recommends that the maintenance of the HP equipment should be performed by specialised and qualified companies (including, but not limited to, the equipment manufacturers) so that the quality of the repair activities is ensured with a beneficial effect on equipment life. By hiring specialised contractors with a deep knowledge of the equipment to attend the maintenance, the risk of catastrophic failure due to a repair activity not being performed properly is minimised.

It is important to note that equipment failure can have dramatic consequences, firstly from a safety viewpoint considering the operating conditions (temperature and pressure) and the toxicity of the fluids circulating in the equipment and, secondly, from an economic point of view considering the loss of production while the equipment is repaired (even if temporary) or replaced.

Maintenance is of particular importance for equipment close to the expected end of life where each small repair and maintenance activity can lead to important extensions of equipment life. The lack of appropriate inspection and maintenance is what has led to the failure of some older reactors in recent years that were close to the end of their expected life.

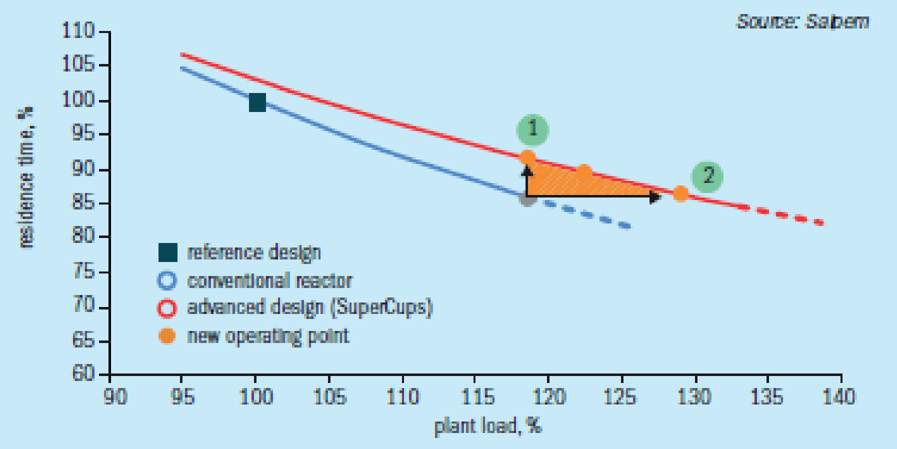
During the investigation into the causes leading to failures, Saipem was able to identify a series of common causes, different in nature, but all leading to the final failure of the reactors.

One of the main causes was the lack of appropriate inspections and data collection. Apart from the frequency and thoroughness of the inspections, it is important that proper and reliable measurements (e.g., for thickness) are taken using the correct tools, which should be properly handled and calibrated.

Another cause was the selection of a non-specialised contractor to attend the repair activity which, as already discussed, is a risk. It is of utmost importance that the contractor selected by the end-user, while performing the repair job, is fully aware of the design and characteristics of the equipment and of the consequences of a poorly executed repair job. It was also noted that proper supervision of the repair activities and the correct processing of the errors that occurred during the repair activity could have avoided the failures. For these reasons Saipem, as urea licensor, provides assistance and support services for the review of the procedures, qualifications, and drawings to be used during maintenance activities and invites all end-users to take advantage of such services with the aim of minimising the occurrence of issues during the execution of the activities they carry out themselves.

It is worth saying that, while it is the course of action by inspection and maintenance staff, being actively involved during the turnarounds, that probably has the most impact on prolonging the life of equipment, the operation team also has a share of the responsibility. The plant operators working in the plant every day are in fact best placed to be the first to detect possible leakages by performing a correct inspection of the weep holes. Weep holes are the mechanical expedients with the function to detect any leak from the lining welds (the welds performed between the different lining sectors) by providing passage of the leak across the pressure retaining wall of the equipment, via dedicated grooving and tubing, thus saving the equipment from carbon steel corrosion issues. The inspection of weep holes must be performed regularly, on a daily basis, taking care to also periodically verify that the weep hole circuits are free from plugs and, if any plug is found, to carefully remove them. Considering the total number of weep holes and their location on the plant, many end-users opt for an automatic leak detection system which ensures continuous monitoring, sparing the operators the time required to check the weep hole, allowing them to attend other activities providing better time management.

Fig. 1: Improvements in reactor performance with SuperCups



Various automatic leak detection systems are available on the market, proposed by different vendors and having different operating schemes and working principles (e.g., operating under vacuum or pressurised conditions). Saipem advocates the use of automatic leak detection systems provided that they are designed considering the peculiarities of the urea environment with particular attention to avoid the formation of plugs and to ensure that leaks are promptly detected. Saipem has not developed its own proprietary solution, preferring instead to rely on a proven and qualified solution already available on the market. This solution, based on the vacuum operating principle, has been jointly developed and commercialised by renowned and esteemed companies and it was technically approved by Saipem, after a thoughtful review involving both its capabilities as licensor of Snamprogetti™ urea technology and as EPC contractor.

To conclude, Saipem encourages end-users to exploit the scheduled maintenance activities and/or the replacement of equipment to boost the performances of their plant(s). Replacing equipment that has reached end of life with the latest updated design of equipment can also provide an opportunity to debottleneck the plant e.g. by increasing the exchanger surfaces or by increasing the reaction volumes. Variations to exchanger surfaces and volumes may, however, be limited by structural constraints. In fact, a bigger piece of equipment may not have sufficient space due to existing structures, piping and other equipment or it may require modifications to the structures or foundations due to the increased weight.

A solution to this for both existing reactors and new replacements is to install SuperCups. By means of their triple fluid-dynamic effect, SuperCups can easily boost the performance of an existing plant by promoting contact of the reagents and enhancing reactor conversion. It has been demonstrated that the characteristic "plant load vs residence time" curve of a reactor installed with SuperCups is higher than one with sieve trays (Fig. 1). By switching from sieve trays to SuperCups, the residence time of the reactor for a fixed capacity is increased allowing higher conversions rates to be achieved. Higher conversion rates in the reactor mean lower decomposition (primarily in the urea stripper), condensation (e.g., in the carbamate condenser) and recycling loads to the downstream equipment, enabling the plant to reduce its power consumption, and therefore its carbon footprint, or to increase its production without further and more expensive interventions.