Customized Descaling Robot Arms
Still today, Descaling Robot Arms improve Health and Safety while increasing productivity

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Abstract

Over the years, Mecfor's Engineers came to a thorough understanding of the Bayer process having dealt with many customers' requests to find optimized solutions for their descaling operations. In fact, Mecfor has designed customized solutions for almost every type of reservoirs that can be found throughout the process. Alumina producers are facing operational challenges where Occupational Health and Safety, productivity and maintenance costs criteria are putting stress on the final cost/ton sold. Everyone knows that alumina production capacity decreases as residue and scale build in production vessels, whether it be on a digester's shell or a thickener's wall. Nevertheless, descaling operations often delay or limit operations because of the necessary downtime required to perform this maintenance operation. The purpose of this paper is to highlight the many advantages of descaling a reservoir, such as a desilication tank, bauxite digester or red mud thickener, with a remotely controlled descaling robot arm, rather than by installing scaffolding and having workers manually remove the scale with jackhammers or using a remote-controlled vehicle. In large tanks, such as thickeners and washers, remote-controlled vehicle can work well. In other instances, both methods generally present hazards and create damages. For 25 years, Mecfor has designed, manufactured and commissioned many descaling robot arms for various vessels' model. Mecfor's field of expertise reveals that the use of a descaling robot arm dramatically improves the workers' working conditions, greatly reduces downtime required to perform this critical operation, and also improves production capacity. Furthermore, Mecfor descaling robot arms are highly adaptable to a variety of reservoir configurations and sizes and integrate many descaling methods.

Keywords: Desilication and Descaling, Bayer process, robot arm, alumina production, Health and safety.

1. Introduction

In the early 90s, customers were concerned about descaling operations performed on large thickeners. Plant management would no longer allow operators to go inside reservoirs to remove the scale manually as this operation was unsafe. The normal descaling procedure involved the installation of scaffolding inside the tanks, and workers had to remove the red mud residue with jackhammers. Depending on the configuration of the reservoir, this descaling operation could also require that the descaling be carried out in confined spaces with poor ventilation. Needless to say, the workers were subjected to intensive physical labor in difficult conditions, which in turn posed major safety hazards. Clients sought for improved working conditions by integrating mechanized solution to reduce human exposure to dangerous work environment.

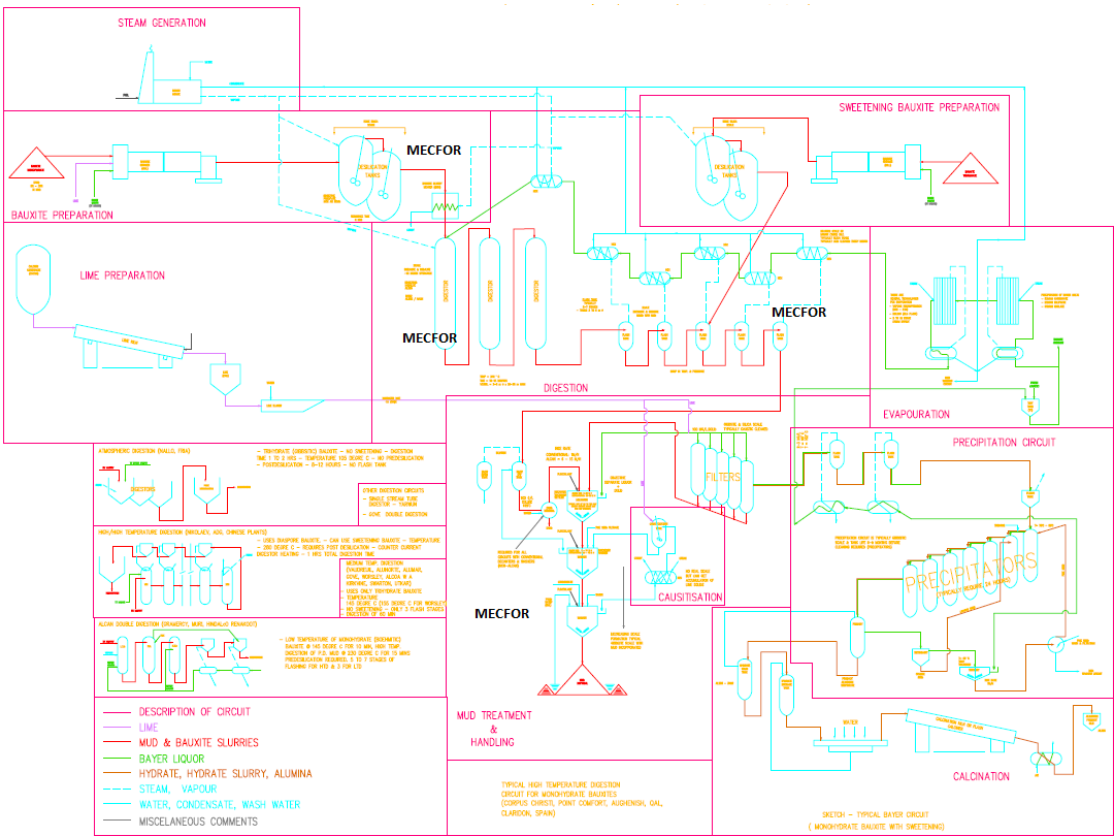

Figure 1. Bayer process: Alumina production.

While studying the previous descaling procedures, it became clear that the alumina production and capacity were also at stake. The downtime required to perform descaling operations on a large reservoir was between four to six weeks and required two to five workers. In addition, the descaling time was often extended due to unforeseen scale conditions. Such delays disrupted and extended the entire descaling program and resulted in even more scale accumulations within the operating vessels.

Several factors were taken into account during the concept development. The chosen equipment had to be user-friendly, reliable, accurately positioned, and it had to significantly reduce downtime while improving the operators' working conditions. The challenge was definitely worth it as it resulted in downtime being reduced from over four weeks to less than one week, and only one or two workers were required to perform the descaling duties. The operators remotely controlled the robot arm from a comfortable and ergonomic state-of-the-art station.

Nowadays, more descaling methods can be looked into, but robot arms were found to be the safest and most efficient one. Mecfor Descaling Robot arms can come with either a mechanical or water jetting solution. Also, our Electrical Engineers can automate the descaling process sequences. All these aspects are studied and discussed with the client when working with Mecfor.

2. Mechanical or Water Jetting

Descaling technologies have been upgraded and improved. Mecfor's design has been adapted to many descaling methods, such as high-pressure water jets 20 000 psi (1400 bars), hydraulic hammer and flails. Although all descaling methods have their own merits and limitations, the flail method presents undeniable advantages for pressure vessels. Since the flail's chains remove scale in a manner completely different than the perpendicular and direct impact of a conventional

hydraulic hammer, the descaling operation does not affect the integrity of the shell of the pressure vessel. Mechanical descaling using flails can help bringing down the large amount of caustic soda some facilities are using to clean their reservoir. Furthermore, the flail method presents other advantages when compared to high pressure water jet systems, as it does not require a water supply nor the collection and strenuous treatment of the used water. On a long-term analysis, low costs of operation of a mechanical descaling robot arm can be somehow advantageous.

In other instances where the reservoir requires special care, water supply is readily available and subsequent drainage can easily be achieved, the high-pressure water jet systems may be selected as an attachment for the robot's descaling arm. It is understood that water jetting can be less damaging, especially if vessels have special treatment such as Inconel.

3. Desilication Robot Arm

Using water jetting, this robot has articulated arms that ensure rigorous cleaning in all zones of the vessel using a 3D head and rotating nozzle. It is operated from a remote operator's station using a camera to manage the operation. This concept allows to clean nearly 100 % of a 14 m diameter x 24 m high tank from the top.

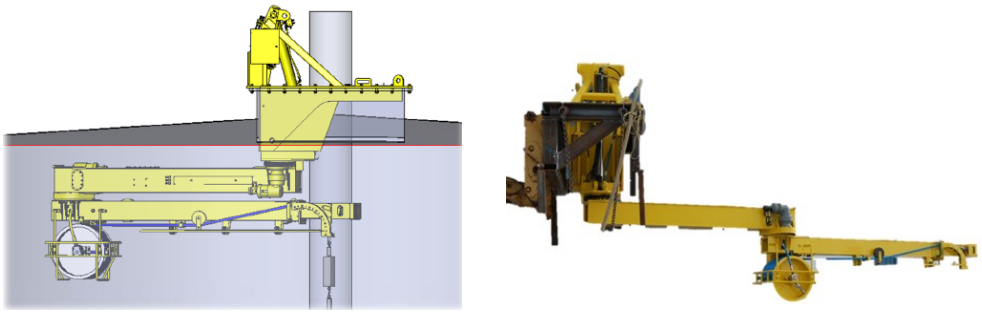

Figure 2. Desilication robot arm.

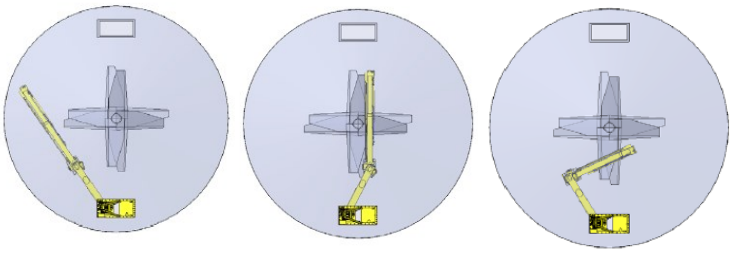

Figure 3. Simulation: Covering zone.

4. Horizontal Digesters

Mecfor also designed an unprecedented type of descaling arm robot, the "Scorpion", for horizontal digesters of a maximum length of 7.3 m and a maximum diameter of 3 m.

These digesters have internal rakes that are mounted every 45 degrees on a central shaft. However, the main challenge was the limiting size of the access door through which the robot had to enter. Indeed, the robot's maximum cross-sectional dimensions had to be no greater than 21 cm by 21. 6 cm.

This robot has eight arm sections; three of these are telescopic and five are articulated. In order to achieve this compact, fold-up design while maintaining a highly rigid and sturdy unit, the equipment is fitted with sophisticated and unique hydraulic block valves designed and manufactured by Mecfor. The descaling robot arm is equipped with sensors and camera system. The position and angle of each arm is displayed on a monitor located outside of the digester. In the operating cabin, a dedicated screen displays all of the information sent from the cameras and sensors. Once again, the downtime has been significantly reduced, and this concept greatly improved the operators' working conditions.

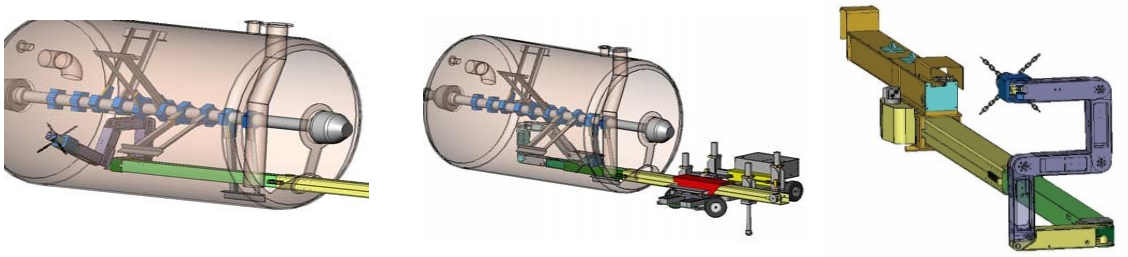

Figure 4. A descaling robot in operation in a reservoir with central shaft and rakes. The descaling robot is supported by a mobile power unit to descale a horizontal digester.

5. Vertical Digester, Flash Tank and Blow off Tank

Mecfor also has many designs for the digestion process. It consists of a number of variations of tripods with and articulated lower arm. Flail descaling is effective for the type of scale present at this stage in the process since it is generally hard and relatively thin. The tripod robotic arms are suspended from the top and fit small openings as low as 250 mm diameter.

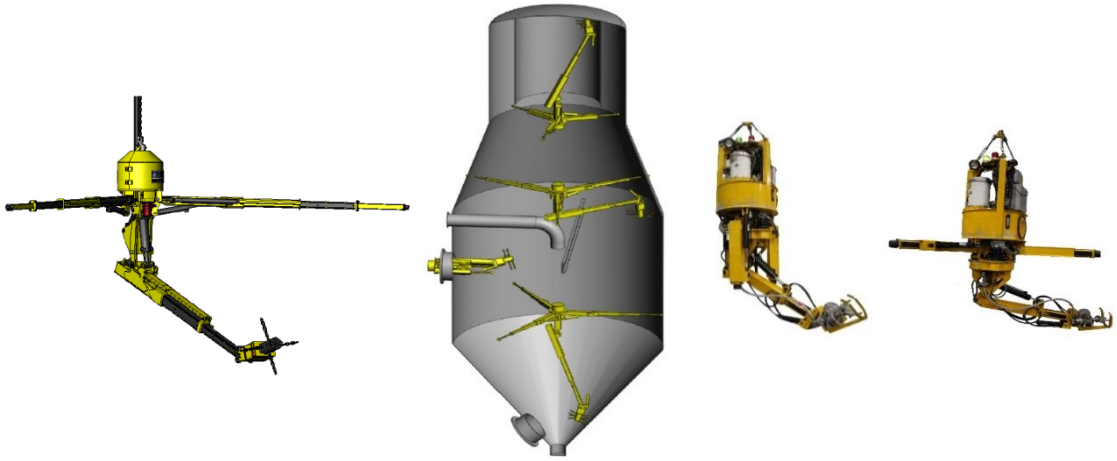

Figure 5. These robots fit narrow apertures and offer malleability while cleaning gently thus preventing wall damage.

6. High Rate Decanter (HRD)

Mecfor worked on robotic descaling of High Rate Decanter (HRD) tanks. The robot designed for this application was an entirely different design. Indeed, Mecfor's engineering team had to work with significant size and weight limitations. The equipment had to travel across production floors and walk-ways, and some components had to be transported using existing elevators. The use of this robot enabled the descaling operation time to be reduced by more than 75 %.

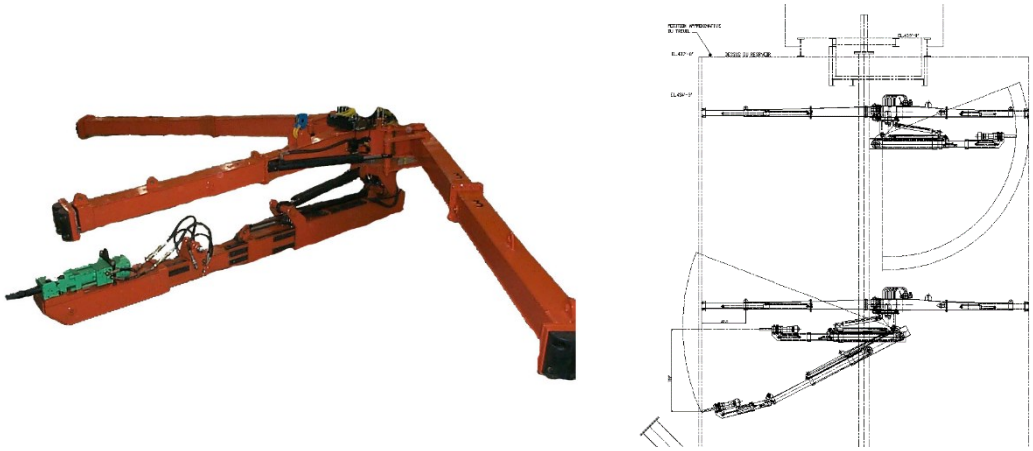

Figure 6. The robot is lowered inside of HRD reservoir where it secures its position with three telescopic legs. Once the descaling operation is completed, the robot is folded and stored.

7. Red Mud Thickeners & Washers

These reservoirs often have diameters up to 24 m and heights up to 22 m. The equipment's maximum extended reach is at least 20 m. This descaling arm is very easy to operate with its rotative arm to position the turret of the excavator like working arms. This arm can be fitted with a hydraulic hammer or water jetting.

Figure 7. The robot can be transported through an elevator, and it can be stored easily on account of the fold-up design. It is articulated, and the forward reach is adapted according to the reservoir's size and configuration.

8. Anchorage and Transportation

The descaling robots are designed according to operational requirements with few limitations in terms of weight and size, as well as of the method of positioning the robot on or in the reservoir, since the solution is customized, a design can be elaborated to meet most needs. A descaling robot for a conventional mud thickener could be bolted to the tank wall to perform descaling operations. For HRD, the robot arm is lowered inside of the reservoir where it stabilizes its position with three telescopic legs that push against the tank wall. To clean a horizontal digester, the robot is supported by a small mobile power unit and is not attached onto reservoir itself.

Another feature of Mecfor descaling robot arms is the ease of transportation and storage. According to the plant's operational requirements and facilities layout, Mecfor developed robots that may be disassembled or with a fold-up design. For plants in which storage space is very limited and where the descaling robot arm must be transported by means of an elevator, the fold-up design is privileged.

Figure 8. Easy to carry across.

9. Conclusion

Many improvements were added to the descaling robot arm design throughout the years, such as electro-proportional joysticks, operator control cabins and wireless remote-control systems. The safety issues were successfully addressed, and the workers operate the robot from a comfortable, ergonomic station. With a camera and monitoring system, they may view and easily control each step of the operations. The result is a high quality, consistent and thorough cleaning of accumulated scale eliminating safety issues for the operator. Completely automating the cleaning sequence is also an option.

All the remotely controlled descaling robot arms designed by Mecfor have had a high-performance level from startup, and the downtime required to perform descaling duties has been reduced by more than 50 % in all cases. It is also fair to say that safer and better working conditions have translated into increased productivity.

Finally, Mecfor extended competency and its array of descaling solution available make our team ahead of the game. Each Mecfor Descaling Robot Arm have been designed with a mindset of great adaptability using latest technologies offering as much as possible automated solution.