Integrated project Engineering Technology

2024-2025

Modification of the pressure vessel winding system: Replacement of the KUKA robot and process optimization.

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Bridging programme for Master of Electromechanical Engineering Technology

CHALLENGE

Cteso is collaborating with a manufacturer specialized in the production of pressure vessels made from a polymer tape. These pressure vessels are manufactured by winding the material around a mold with a specialized machine designed by the manufacturer. Currently, the movement of this mold is controlled by a KUKA robot. Since this robot is an expensive solution, the possibility of a more cost-effective alternative with sufficient degrees of freedom is being investigated. The goal of this investigation is to reduce production costs and improve scalability without compromising the precision required in the winding process. Additionally, optimizing the design of the winding frame offers opportunities to make the winding process more efficient and/or faster. One of the key challenges is maintaining the complex multi-axis motion required for even winding. During the process, the polymer is kept at +250 °C using heat lamps integrated into the winding frame to ensure proper adhesion while winding.

APPROACH

MOTION

To simplify the motion setup and reduce costs, four linear modules were arranged in a cross configuration, with two mounted on top of the other two. These were combined with an indexing table to create a compact and cost-effective solution offering three degrees of freedom—two translational and one rotational—all integrated into a single system, as seen in *Figure 1*. These components are mounted onto a robust steel frame that provides structural support and ensures stable and accurate motion during operation.

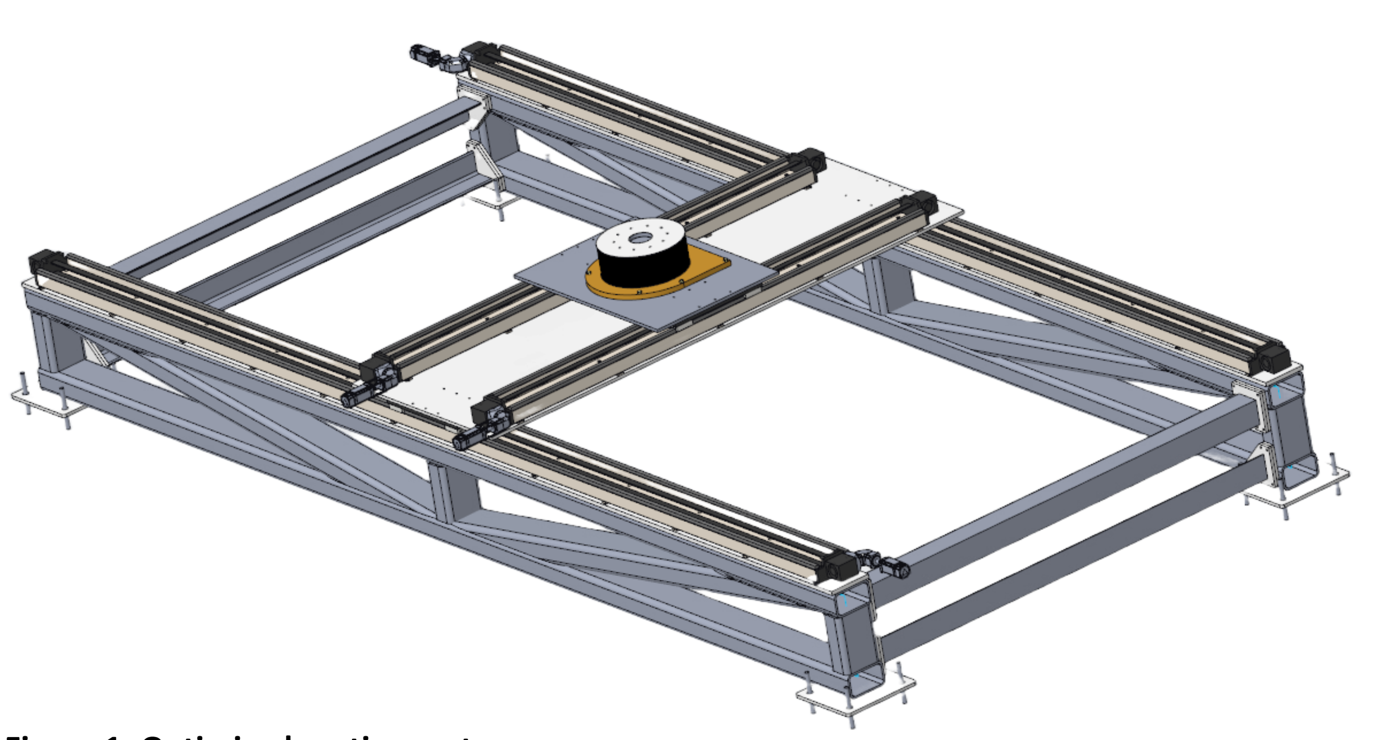

Figure 1: Optimized motion system

DESIGN OPTIMIZATION

The original winding frame only had one open side, which limited the setup to a single polymer dispenser and unidirectional winding. In the new version, two sides have been left open, as seen in *Figure 2*, allowing a polymer dispenser to be placed on both ends of the mold. This design enables simultaneous winding from both directions, effectively doubling the output speed. In addition to increasing productivity, this symmetrical layout also improves material distribution and can contribute to better balance and consistency in the final product. Furthermore, the temperature inside the new winding frame remains at +250°C, ensuring optimal conditions for the winding process.

Scan for a 3D-view

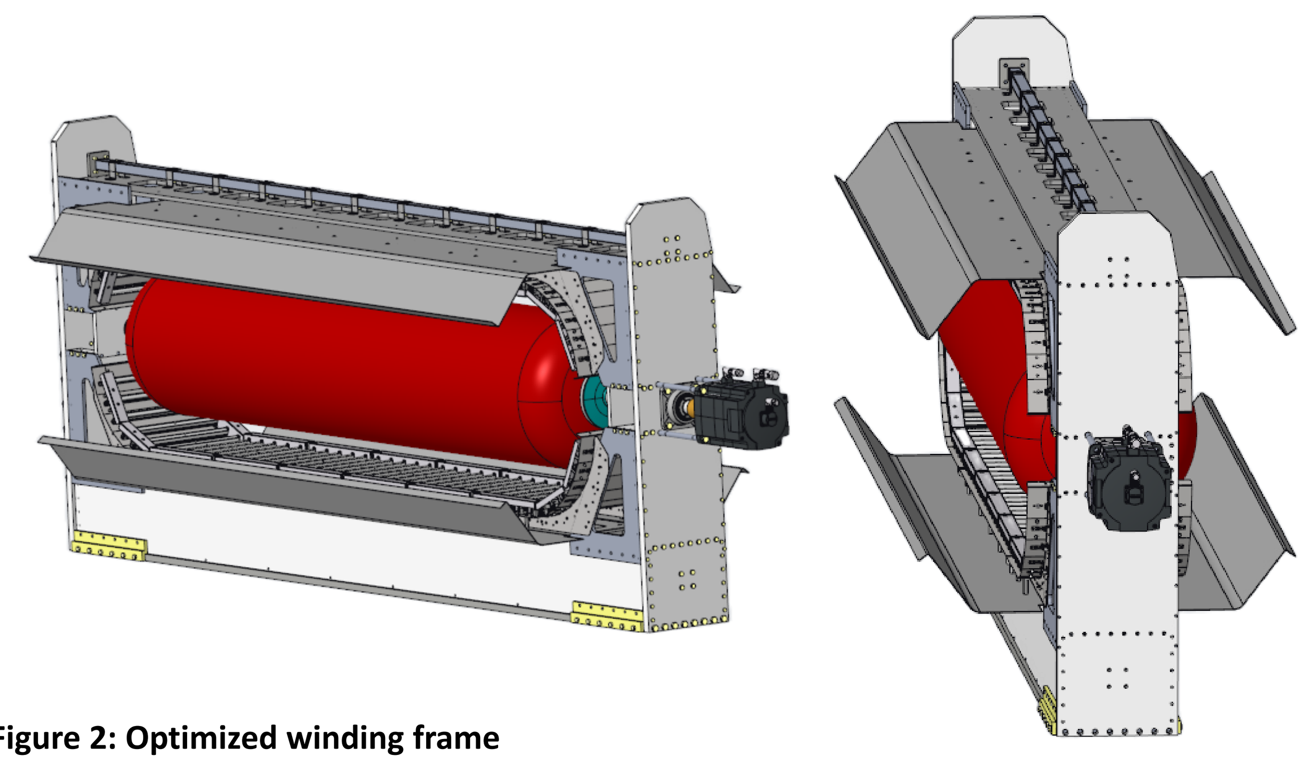

Figure 2: Optimized winding frame

RESULTS

BEFORE

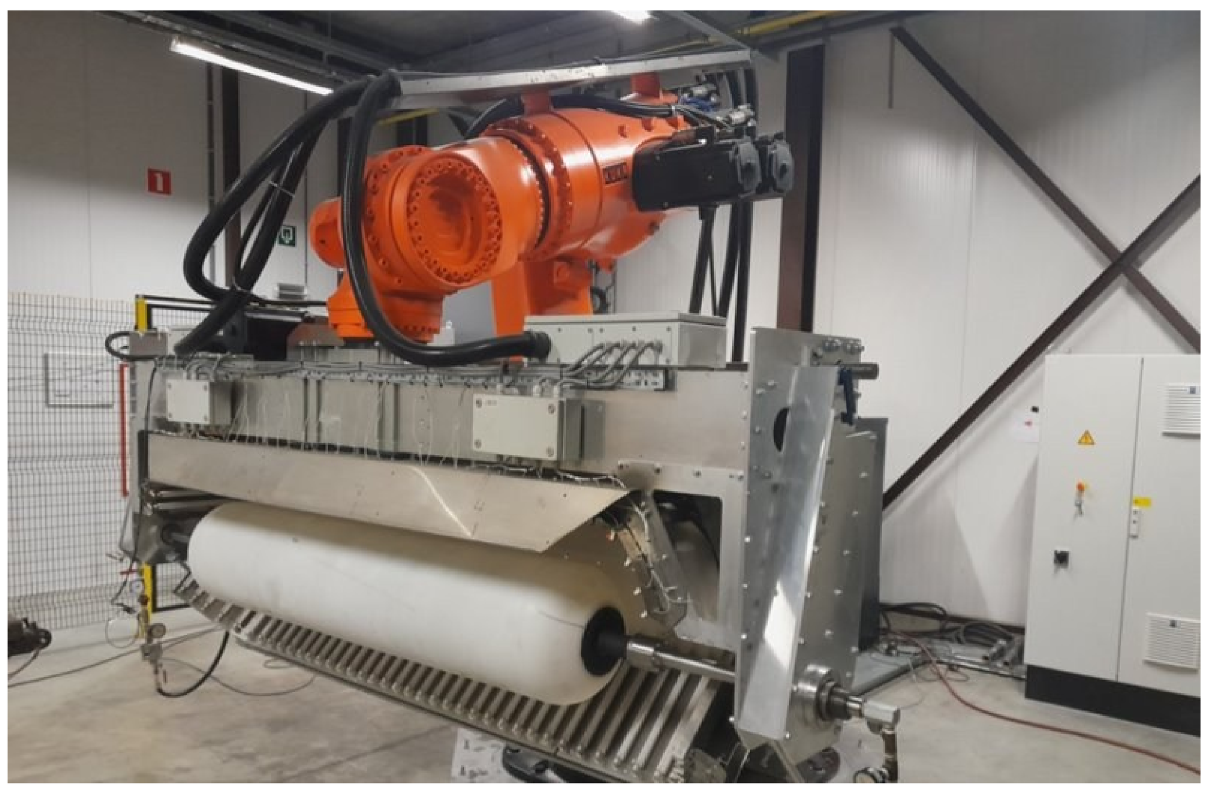

Figure 3: Original system

AFTER

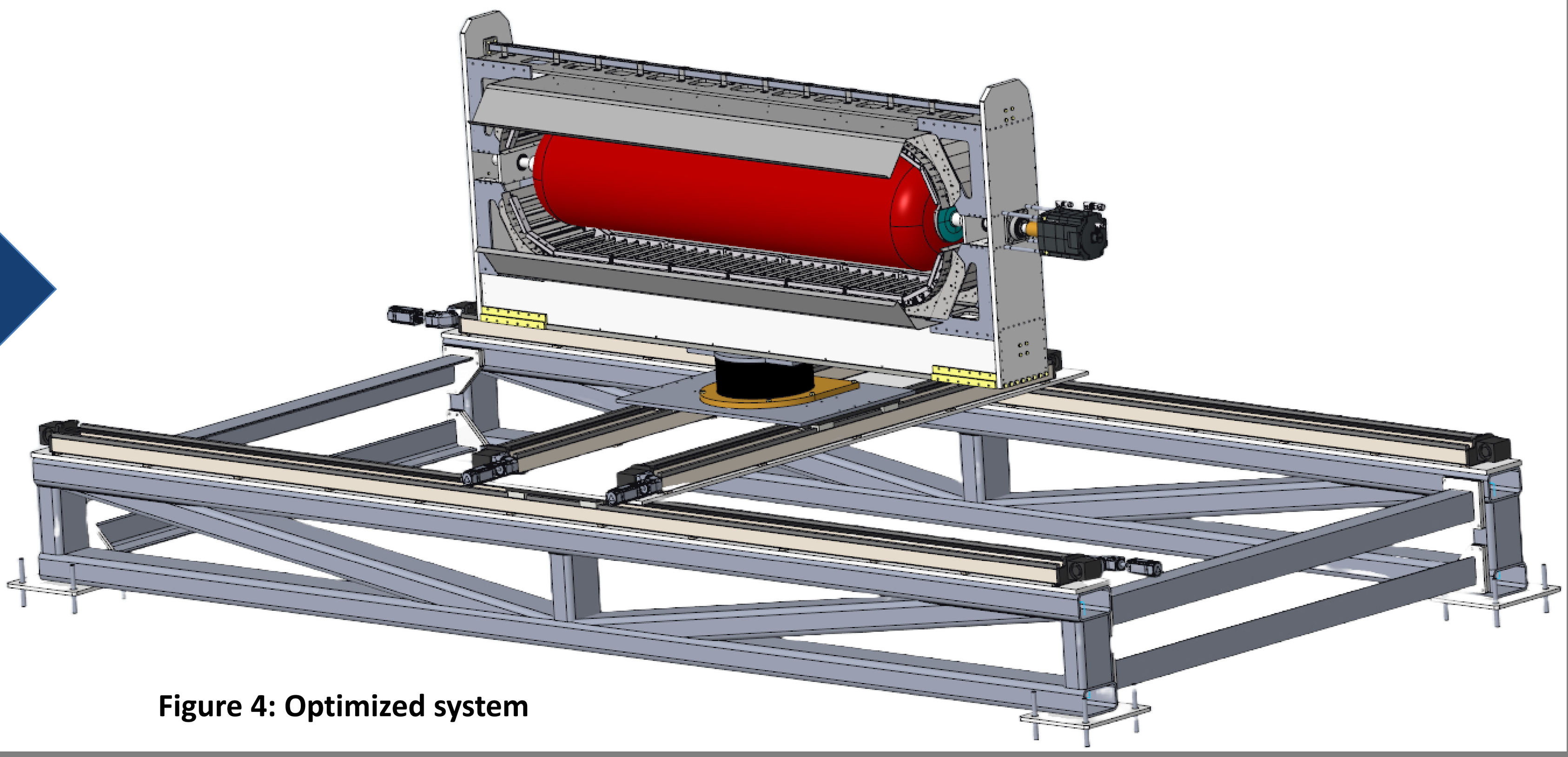

Figure 4: Optimized system

CONCLUSION

As seen in Figure 3 and Figure 4, the motion system and the winding frame have been successfully integrated, achieving the required degrees of freedom: linear motion in the X- and Y-directions, and rotation around the Z-axis. This compact and modular setup not only ensures precise control over the winding process but also enables the use of multiple winders simultaneously. To support this workflow, a larger frame was chosen, allowing the entire system to rotate 90° to the left and move linearly to the loading position, where a pressure vessel can be easily placed. Afterwards, it returns to the central position for winding. The system can then travel fully to the right and rotate 90° for unloading. This sequence facilitates seamless integration with automated loading and unloading systems, improves accessibility, and reduces manual handling. As a result, the overall process duration is significantly reduced, and the production setup becomes more cost-efficient, scalable, and suitable for high-throughput manufacturing.

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