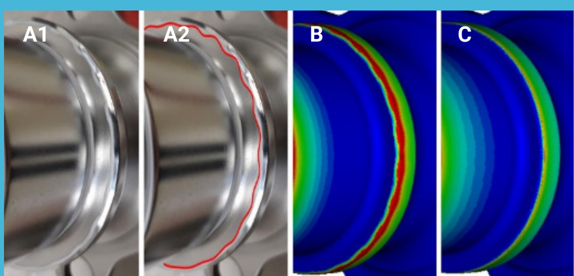
Evaluation of Purpose-built Tooling Concept for

Electroplating of Hard Chrome on Aerospace Components

Industrial hard chrome plating is a rather complex, lengthy and labour-intensive process: typically, the low cathodic current efficiency of Cr plating baths results in limited deposition rates, taking an hour to deposit a thickness of 25 μm on any size of the part. In the majority of cases, the hard Cr plating process requires the use of tooling structures, making the process strongly operator-dependent and therefore, highly prone to errors. According to the Fokker Landing Gear BV team, operator-independence as well as process simplification are expected to be achieved by developing a purpose-built tooling concept, evaluated by the electroplating simulation approach.

The development team of Fokker Landing Gear BV is moving to computer modeling for their hard chrome electroplating processes. Assistance of this smart manufacturing technology aids in assessing design issues of the tooling structures developed by typical trial & error wet trials and mitigate them towards better tooling performance. Elsyca's in-house developed simulation technology, Elsyca PlatingManager, has been used for this purpose: www.elsycaplatingmanager.com.

Fokker Landing Gear BV uses the simulation tool to address the hard chrome plating process on a landing gear shaft part, where a complex tooling concept has to be employed. The first dry run study has been performed for the tooling concept developed by experience, via several trial & error onsite iterative changes to the operating tooling structures. The initial simulation model considered the lastly evaluated tooling concept, which onsite performance resulted in the occurrence of a "wavy" Cr deposit formation over critical diameters of the shaft part (Figure 1: A1 & A2). The PlatingManager simulation model was set to the same process and tooling configurations, and the obtained simulation result indicated similar observation: a "wavy" Cr deposit formation around the critical diameters of the part could be seen (Figure 1: B). The Cr layer thickness distribution is presented by a color map, where different colors stand for different thickness values. In the present project, the red color indicates overplated surface areas, whereas the blue color highlights underplated surface areas. This conventional assessment gives a straightforward indication of the surface quality issues that require further mitigation. Several timely mitigative trials have been run onsite in order to explain and eliminate the formation of patterned Cr deposit. Predictive modeling was also used to address the same quality issues and sort out a mitigation strategy that was best suited for solving the observed problem. It appeared that while it took several trial & error onsite tests to recognize and mitigate around the "wavy" Cr deposit formation, only a few quick simulations were necessary to arrive to the same conclusion: the "wavy" Cr deposit formation was caused by certain openings present in the tooling components facing the critical diameters of the shaft part. Once the openings were closed and tooling components facing the diameters were solid in form, a uniform Cr deposit distribution could be achieved (Figure 1: C).

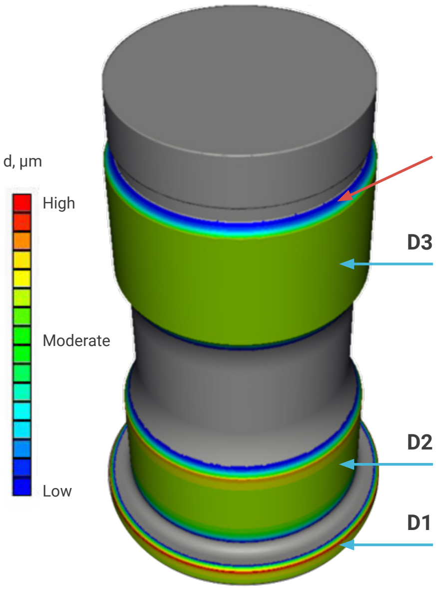


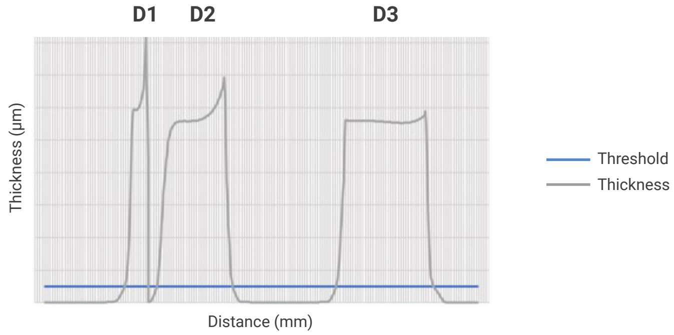
Hard Cr deposit over one of the critical shaft's diameters

A1 & A2: as-deposited onsite - red line indicates the "wavy" formation of the Cr layer;

B: as-simulated per same process and tooling settings as A - different colors stand for different Cr thicknesses, where red indicates overplating and blue stands for underplating;

C: as-simulated per improved process and tooling setting.





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Fokker's development team states that predictive modeling approaches and in particular, Elsyca PlatingManager simulation technology, can significantly improve the process of tooling design: only a few iterations are necessary to propose the most appropriate tooling concept, which greatly reduces the number of wet trials performed onsite to address and eliminate the quality issues of deposited chromium layer.

It is also noted that despite some minor process and / or tooling changes that might be still necessary, relying on the predictive modeling prior to setting up the actual plating process gives a much better starting point for further process and tooling adjustments. Moreover, the time needed for tooling design, as well as the costs associated with the tooling design and fabrication are both reduced, considerably influencing the capital expenditures (CAPEX) and operating expenses (OPEX).

With the first successful evaluation, the predictive modeling was then used to improve the remaining tooling component designs, impacting Cr deposit distribution over other critical diameters of the shaft part. As presented in the figure above, the following changes in the Cr layer distribution were expected: the bottom diameter (D1) was now characterized by an improved deposit length towards upper diameter (D2), and almost no overshooting was observed. Runouts of both diameters were rather good. The top diameter (D3) ended up at the right length and the Cr layer was deposited up to the edge (pointed out by red arrow). With this satisfying simulation result, the applied mitigation strategy has been moved into the physical process environment, where the wet runs were performed in accordance with the designs created in the virtual mock-up of the plating line. Once the onsite tests were executed, the results obtained based on the tooling concept developed by computer modeling were compared to the results obtained by typical trial & error onsite iterative developments. The images below show a few differences in the Cr layer distribution observed directly on the physical parts: it is noted that Cr layer built was poorer in the case of the tooling concept developed by typical onsite trial & error approach (images on the left) – the Cr layer was either over-built what decreased the plating gap between the two diameters, or under-built what resulted in lacking deposit on the surface areas still to be plated. As per tooling concept developed by predictive modeling approaches (images on the right), an improved size of the plating gap was achieved, as well as the Cr layer built towards the edge point was of a better length. Nevertheless, some minor iterations on the tooling performance shall be still performed as the edge point has not been completely approached.

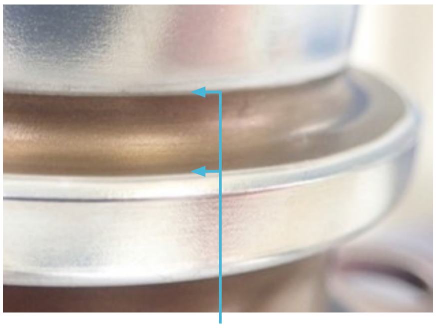
Result of a tooling design done by onsite trial & error

Cr layer built towards edge level - too low

Too small plating gap between two diameters

Result of a tooling design done by predictive modeling approach

Cr layer built towards edge level - low, but improved



Improved plating gap between two diameters