Designing a turbine wheel mounting mechanism to prevent manufacturing defects and improve ergonomics in a cost-effective manner

Daan Theoden, Industrial Design Engineering, University of Twente, the Netherlands

Background Information

The assignment offering organization is Aeronamic B.V. in Almelo. Aeronamic develops, produces and maintains aircraft components and sub-systems for top players in the aerospace industry. They mainly focus on rotating parts such as scroll compressors and turbine wheels. The company has 135 employees in their headquarters in Almelo and 55 in their second manufacturing facility in Sibiu, Romania.

The goal of this assignment was to design a device that allows its operator to mount different types of turbine wheels on steel Erowa® pallets. These pallets are the carriers of parts that are processed in milling machines. The device had to be placed on the current workbench in the factory. Since some employees have back and shoulder problems, the device had to improve the ergonomics of the process. Besides, the manufacturing costs of the device had to be optimized. Hence, the research question was formulated as follows*: 'Can a turbine wheel mounting mechanism be designed that prevents handling defects and improves ergonomics whilst optimizing cost price?'*

The result of the project is a high-fidelity prototype that is tested against predetermined requirements. The findings during the testing phase will result in a final design and recommendations to further improve the prototype. Aeronamic's wish is that (parts of) the prototype can be reused in the final mounting mechanism.

Approach & Results

By thorough analysis of the current process, applying the occupational repetitive actions (OCRA) checklist (Colombini et al, 2002) and studying the effects of lifting on the back, a set of product requirements is formulated. Based on these requirements, 2 concepts are developed. These are translated and refined into 1 final prototype design. This prototype is built and tested against 11 of the product requirements. A failure mode and effects analysis (FMEA) is performed to investigate how potential failure modes can be prevented. The OCRA checklist is partially performed again to compare the existing process with the new process. Furthermore, an online operator satisfaction survey is conducted to collect additional feedback.

During the research was found that it is possible to design a mounting mechanism that prevents handling defects and improves ergonomics in a cost-effective manner (figure 1). Handling defects are prevented by designing the device such that the turbine wheels do not touch any object while being moved and rotated. Ergonomics are improved by designing the device such that the steel Erowa pallets can be slid. This prevents operators from having to do heavy lifting. Cost price is optimized by using off-the-shelf components and polypropylene (blue in figure 1) for custom parts where possible. The FMEA analysis indicates that no urgent actions need to be taken to prevent failure of the device. The prototype has been tested on 11 out of 13 product requirements. The device passed these 11 tests. The OCRA score of the new process that involves the device is significantly lower than the old process. This indicates that ergonomics are improved. The operators' satisfaction survey indicates that operators are satisfied with the device and how it influences the production process.

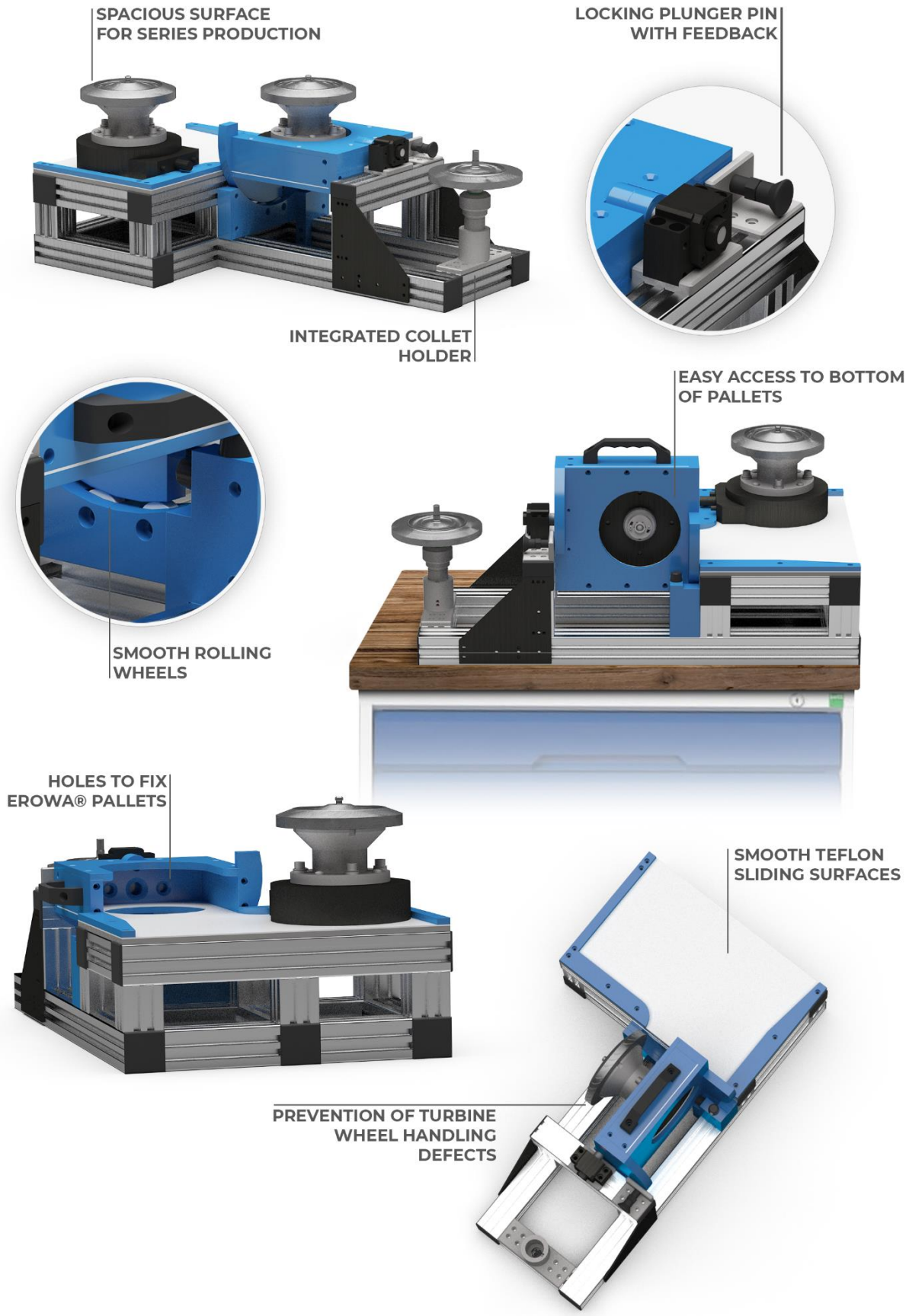

Figure 1: Final Renders of the Mounting Mechanism

Conclusions & Recommendations

Concluding, the research question is answered. By designing a mounting mechanism that prevents turbine wheels from touching any object while being rotated, handling defects can be prevented. By designing the device such that operators can slide pallets instead of lifting them, the chance on incidences of low back pain is reduced. By making use of off-the-shelf components and plastics for custom parts were possible, the cost price of the mounting mechanism is optimized. Based on the prototype, no urgent actions are required to prevent failure.

During the FMEA, tests and operator's satisfaction survey, a lot of feedback on the design of the device has been obtained. These recommendations are being implemented at the time of writing. A major new insight is that the device could be placed on a mobile workbench or trolley. Studying the feasibility and application of this idea is suggested for further research. Lastly, it is recommended to test the 2 product requirements that are not tested during this research.

References

Colombini, D., Occhipinti, E., & Grieco, A. (2002). *Risk assessment and management of repetitive movements and exertions of upper limbs job analysis, Ocra risk indices, prevention strategies, and design principles*. Elsevier.