MeGro

Flexible rolling process to form variable material thicknesses into stringer

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Abstract

Stringer profiles are profiles for longitudinal stiffening in aircraft and have variable material thicknesses along their length in order to reduce weight. The current method of achieving these tailored thicknesses is chemical milling, which is critical both ecologically and economically. In order to incorporate the change in thickness into the T-profiles in a more environmentally friendly way in the future, a new process for the flexible rolling of T-profiles made of AL7075 O was developed at the PtU as part of the MeGro project. The feasibility of the new process was tested on the basis of numerical investigations and a special stand for flexible rolling was subsequently developed and put into operation.

Project description

AT-profiles are a common choice for stringers. Currently, they are immersed in a chemical milling bath to introduce the change in thickness, with the variable thickness achieved through different dwell times. Due to the high cost and use of chemicals, this process is classified as economically and ecologically critical and is therefore to be replaced by an alternative, purely mechanical processing method. Flexible rolling has proven to be a particularly advantageous and resource-saving process for the production of tailor rolled blanks. However, flexible rolling is limited to flat sheets. Therefore, a new flexible rolling process is required for branched profiles such as T-profiles, which was developed as part of the MeGro project at the PtU.

A new roll configuration is required to ensure that the web and flange of the extruded T-profile are rolled simultaneously with the same roll gap height in order to avoid bowing due to different longitudinal strains in web and flange. This consists of a cylindrical roll and two skew rolls arranged at an angle of 45°, as illustrated in Figure 1. In addition to rotational movement, the rolls also require translational degrees of freedom in the radial direction for roll gap adjustment. By specifying control curves, the thickness curves can be introduced in a targeted manner.

As part of the research project, the functionality of the technological concept was first analysed and its feasibility was numerically verified. The feasible product portfolio and process control, including the boundary conditions and requirements for the roll stand and the specification of the control curves, were investigated. The flexible rolling process was then implemented in real operation. The final step of the project was the experimental investigation and validation of the technology on a prototype system in the research environment. The research project therefore consisted of three work packages:

1. Numerical analysis on the flexible rolling of thickness variation in extruded T-profiles
2. Concept development, design and manufacture of a flexible rolling stand
3. Commissioning of the rolling stand and realisation of experimental investigations

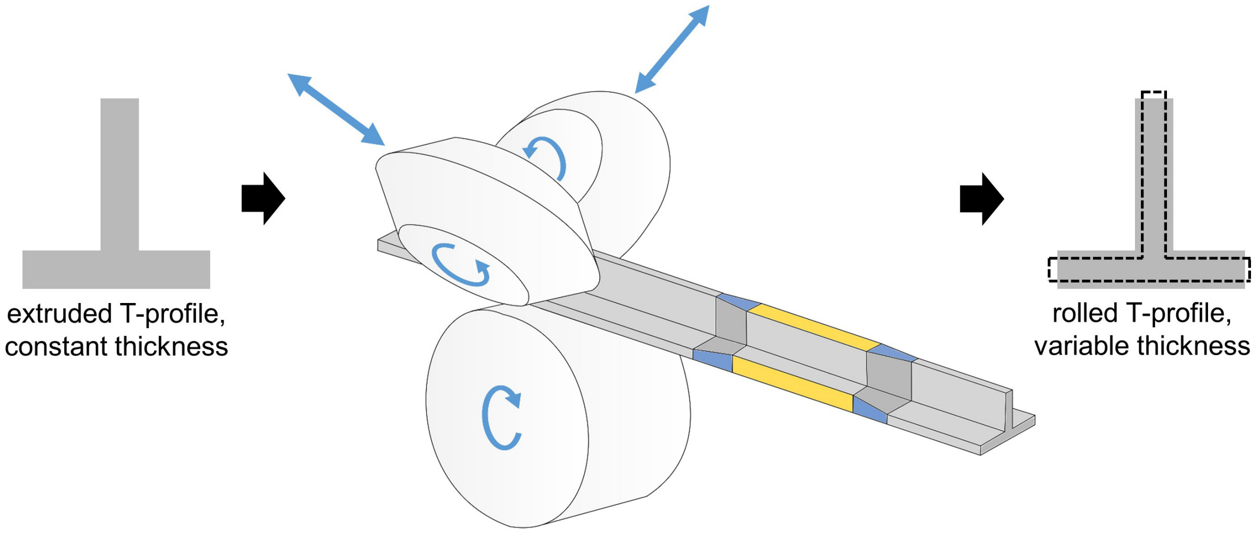

Figure 1: Flexible T-profile rolling

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Results

A roll stand was designed, constructed, manufactured and assembled based on the numerical findings. The result can be seen in Figure 2. In order to reduce the number of drives required, only the skew rolls are fed translationally and inline via screw jacks. An infeed angle of 63.43° is necessary to achieve the same elongation in the web and flange. The rotary drive for the profile feed is provided by cardan shafts.

Numerical preliminary investigations show that the material is displaced significantly in the longitudinal direction and that spreading of the material is prevented due to friction. Consequently, the design of the roll movement curves can be based on the principle of volume constancy.

However, the varying roll radii of the skew rolls lead to longitudinal strain differences across the web height and flange width. The asymmetry of the T-profile results in vertical longitudinal bowing. The profile bowing is dependent on a number of factors, including the amount of thickness reduction, the web height, the flange width, the initial profile thickness and the friction. Initial numerical investigations have shown that the bowing introduced can be straightened by selecting suitable process parameters.

A difference in the angular speeds of the rolls or different thickness reductions in the web and flange were identified as possible measures for straightening the profiles. This homogenises the longitudinal strains and straightens the profiles. To simplify the process design, an analytical model was developed to calculate the required infeed difference of the rollers, as detailed bay Aign et al. [3]. This optimised the process design to obtain dimensionally stable profiles.

The rolling stand was then put into operation and the first experiments with AL7075 O were carried out. The rolled out T-profile could be straightened by varying the angular speed of the cylindrical roll, thereby demonstrating the feasibility of the process.

Project-related publications

[1] Aign, F.; Groche, P.; Wang, T. (2021): Flexibles Auswalzen von T-Profilen zur Anwendung im Flugzeugbau.
In: Blechnet 4, 54-55, Vogel Business-Media, ISSN 1864-1016.
[2] Aign, F.; Groche, P. (2023): T-Profile-Rolling of Stringers with Tailored Thicknesses – Challenges and Approaches.
In: Production at the Leading Edge of Technology, 569-578, Springer.
[3] Aign, F. S.; Kilz, J.; Groche, P. (2024): Process design for flexible T-profile-rolling of tailored thickness stringers with different cross sections.
In: IOP Conf. Ser.: Mater. Sci. Eng. 1307 012051, DOI: 10.1088/1757-899X/1307/1/012051

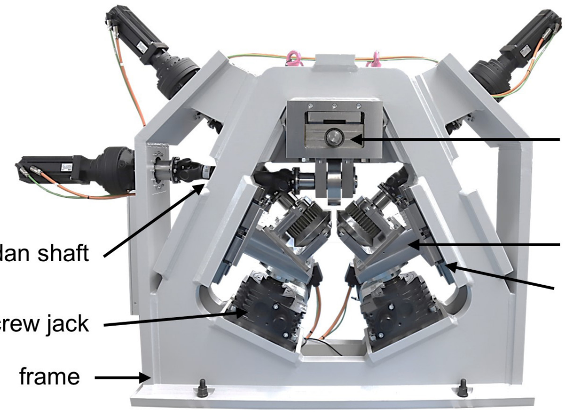

Figure 2: Developed rolling stand

Acknowledgement

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