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WORKING PAPER

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# Tolerance Stack-up Analysis of Toggle Mechanism for Clamping Unit of an Injection Moulding Machine

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**Title:** Tolerance Stack-up Analysis of Toggle Mechanism for Clamping Unit of an Injection Moulding Machine

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**Abstract (150 words, Font 12):** The toggle-type injection moulding machine is studied in this project to analyze the effect of tolerance stack-up of the toggle mechanism on the clamping unit of the injection moulding machine. The toggle mechanism comprises kinematic linkages with pin joints to transfer force and movements from the hydraulic cylinder to the platen for the closing and opening of the die. The dimensions of these links play a crucial role in the clamping force generation to hold the moulds in place. By determining the tolerance sensitivity of the components, critical component dimensions which affect the mechanism's straightness and product quality can be identified. In this study, analytical equations are derived from the geometrical analysis of the mechanism for calculating the middle pin deviation, and also CAD methods are implemented to verify the results. In the CAD method, a 2D line diagram of the mechanism is made in SolidWorks with proper constraints. The analysis is divided into two cases- in the first case, the pin deviation is calculated when the machine is under no tonnage condition (crosshead position fixed). The second case calculates the pin deviation under the tonnage condition (moving platen position fixed). Pin deviation is calculated by giving tolerance to all the link dimensions one at a time. Tolerance stack-up is carried out by identifying the worst case from the tolerance sensitivity analysis of individual components and links. By carrying out the analysis, it can be concluded that under no tonnage condition, short link (101.803 mm), tertiary link (65 mm), crosshead distance (170 mm), and rear platen distance (350 mm) have a significant effect on the pin deviation in comparison to the other link dimensions. While for tonnage conditions, the tertiary link (270 mm) and binary link (419.143 mm) significantly affect the pin deviation compared to the tolerance of other links.

**Purpose:** To analyze the effect of tolerance stack-up of the toggle mechanism on the clamping unit of the injection moulding machine.

**Design/Methodology/ Approach:** Analytical and CAD

**Findings:** Under no tonnage condition, short link, tertiary link, crosshead distance, and rear platen distance have a significant effect on the pin deviation in comparison to the other link dimensions.

**Research Limitations/ implications:** The research applicability is to toggle mechanism's tolerance stack-up in an injection moulding machine

**Originality/ Value:** To find out the deviation in the straightness of the links that affect the machine's tonnage output and self-locking. Critical dimensions are identified by doing the tolerance sensitivity analysis of the components, which affect the middle pin deviation value.

**Keywords:** Toggle Mechanism, Injection Moulding, Tolerance Sensitivity, Tolerance Stack-up

**Description:** The paper has been presented in Scopus-indexed 4<sup>th</sup> International Conference on Recent Advances in Mechanical Infrastructure jointly organised by IITRAM Ahmedabad and IIT Bhilai on December 17, 2022.