ABSTRACT

The solid-state metal forming technique known as "Friction Stir Incremental Forming" (FSIF) uses mechanical deformation and frictional heat to gradually create complicated structures. This procedure involves inserting a rotating tool into a workpiece and slowly moving it along the material's length, which causes the material to deform gradually. The FSIF technique is frequently utilized in the manufacturing of numerous elements, including consumer goods, aerospace structures, and automotive components.

The FSIF process has a number of advantages over more traditional metal forming techniques. There is no melting or recrystallization of the material because it is a solid-state process, which enhances the material's qualities like strength and fatigue resistance. Due to its ability to produce precise, high-quality components with improved material properties, it is a popular choice across a wide range of industry sectors.

The main objective of this work is to design and development of different coated tools for improving surface quality. In this work, a novel attempt was made to use three different tool coatings to increase the desired surface quality while minimizing tool wear. Process variables such spindle speed, step size, and table feed were taken into account, along with the two response parameters constituting force and surface roughness, in order to determine the ideal values. A full factorial design was used to conduct a total of 27 experiments.

The parameters for this TOPSIS optimization are chosen based on which FSIF portions should have the lowest forming force and surface roughness. Based on the findings, the tool's titanium nitride coating improved the surface roughness and boosted maximum formability. This study offers the ideal parameter setting for the AA8011 and explains the friction stir effect during incremental formation.

In comparison to the other two tool materials, the TiN coated tool generated greater formability and reduced surface roughness. The optimal output response parameters were discovered to be the forming force of 702N and surface roughness of 0.361µm, which are created by the FSIF process at a Step size of 0.5mm, Spindle speed of 800rpm, and Table feed of 1400mm/min. After that, it was discovered that a lower step size produces better formability and greater localised deformation.

The numerical evaluation is used to confirm the quantifiable difference in friction. Additionally, executing process optimization has been greatly aided in confirming the high level of surface quality. The fundamental knowledge of the frictional stir effect in the incremental forming process is provided by this work. Furthermore, this work demonstrates the phenomenon of FSIF parameter selection based on the TOPSIS technique.

To forecast the stress created throughout the process and formability, FEM analyses were carried out. As a result, the forming height and surface quality were positively impacted by tool coating. To examine the various stresses placed on the sheets throughout the forming process, FEM analysis was done.

On AA 8011 alloy sheets, scanning electron microscopy (SEM) analysis has been done to look into the impacts of tool-workpiece interaction, surface roughness, and surface flaws. It was discovered that created sheets were in superior shape.