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Wear Intensity Behavior on Direct Cold Extrusion Die Profile for Aluminum Alloy

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The direct cold extrusion process of aluminum alloy is widely used on manufacturing industry for series production of metallic structures. The extrusion die geometry has reach a singular importance due to technologic advantages that offer to process; this profiles can be conical or curved, in the past, this last one were difficult to manufacturing, however the develop of Computer Numeric Control (CNC) tool-machines and electric-abrasion machining has made possible the manufacturing of die extrusion complex profile with high quality and good dimensional precision.

Considering the wide range of manufacturing methods, geometric configurations of the extrusion die profile have emerged as a solution for obtain a better behaviors of the flow stress in the work piece material, reduce the extrusion force, decrease the die tensile stress and improve the surface finish.

In recent years, simulation by the Finite Element Method (FEM) has become a powerful tool for scientific research and industrial practice, as well as for the analysis and optimization of the extrusion process. There are several investigations that analyze the behavior of the geometric parameters variation of the extrusion die on the wear phenomenon using numerical techniques and experimental procedures The Archard's wear model is used to relate the main physical parameters involved in sliding body wear. However, most of these studies focus on dies with conventional or conical extrusion profiles.

In this investigation is analyzed the wear intensity behavior for two extrusion die profiles: conic and sinusoidal. The process of cold direct extrusion of aluminum alloys 6061-O is simulates by the FEM, using the software DEFORMTM -2D. The Archard's wear model is used to determine the wear intensity in the Principal Incidence Zone (PIZ) of the forming tool. The factorial design 23 is used to investigate the performance parameters: extrusion velocity, friction coefficient and extrusion ratio.

The PIZ of the extrusion die is located between the position where the work piece reduction begins and the exit position, where the contact between the die and the work piece ends. In the PIZ 20 measurement points are established to determine the wear intensity on the both extrusion die in order to determine the average of the wear intensity in that area of crucial importance for the process. There is wear throughout all PIZ, the highest values are concentrated in the intermediate and final region of the PIZ in both dies, regardless of the profile.

In a comparative analysis of the wear intensity behavior at the PIZ points of the conic and sinusoidal dies profile is possible to affirm that although the average point wear intensity, throughout the process, in the conical profile extrusion die is greater than in the sinusoidal profile die, in this last one exists slightly higher wear values in the intermediate-final zone of the PIZ. The aforementioned is associated with the existence of higher levels of the sliding velocity of the work piece in the sinusoidal profile die, in that particular region, in comparison with conical profile die.

This particular behavior has only been registered in sinusoidal profile dies with high levels of extrusion ratio, however due to its location and the rapid decrease wear in the final area of the PIZ, it is possible to state that this behavior does not affect the final quality of the extruded part.

Due to the variance analysis for the conical profile extrusion die is possible to affirm that the main effect of the performance parameters and their combinations do not have a significant influence on tool wear. However, it is appreciated that the extrusion velocity constitutes a factor to be taken into account because its variability can end up compromising the wear intensity behavior.

Likewise, it is possible to affirm that the wear intensity in the sinusoidal profile extrusion die is not significantly influenced by the variations of the performance parameters and their combinations.

Low levels of extrusion velocity and extrusion ratio make possible that there are lower intensity wear values, since in this way the sliding velocity at the die-work piece interface decreases, which makes material loss difficult. Also, a combination with high values of extrusion velocity and extrusion ratio cause an increase in the wear intensity on the forming tool. The behavior described above is consistent for both configurations of profiles studied. All of which have an adequate correspondence with the Archard's wear model.

The extrusion velocity in the direct cold extrusion process for aluminum alloys must be kept at low levels, since the dies extrusion wear intensity with low levels of extrusion ratio and high extrusion velocity can be even superior to dies with large extrusion ratios and low velocity, regardless of the tool geometric profile.

The main reason for the occurrence of the wear phenomenon in the extrusion die is related to the normal pressure at the die-work piece interface, according to a several investigations. Although this approach is not wrong, it dismisses the extrusion velocity influence as a fundamental element of the Archard's wear model. Because a high velocity causes an energy full contact between material surface asperities and generates forming abrasive particles.

In general, the sinusoidal profile extrusion die has a better wear behavior than the conical profile extrusion die, but there are factors levels to be appropriate selected in order to minimized the wear phenomenon in both dies geometrics configuration.