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OPTIMIZATION OF MANUFACTURING PROCESS PARAMETERS OF CYLINDRICAL CUPS USING NICKEL ALLOYS BY DEEP DRAWING PROCESS

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ABSTRACT

Sheet metal forming is a significant manufacturing process for producing large variety of automotive parts and aerospace parts as well as consumer products. In sheet metal forming a thin sheet is subjected to a plastic deformation using forming tools to get the designed shape. A flat blank sheet is formed into a cup by forcing a punch against the center portion of a blank that rests on the die.During this process if the process parameters are not selected properly the blank sheet develops some defects. Therefore, it is very important to optimize the process parameters to reduce the defects in the parts and to minimize the production cost.

The materials employed in this study are NICKEL201, MONEL400, and INCONEL600. In jet engines, super alloys are a group of nickel, iron–nickel, and cobalt alloys. These metals have outstanding heat resistance qualities, retaining stiffness, strength, toughness, and dimensional stability at far higher temperatures than other aerospace structural materials. When utilized at high temperatures in jet engines, super alloys also offer good corrosion and oxidation resistance. The most important type of super alloy is the nickel-based material that contains a high concentration of chromium, iron, titanium, cobalt and other alloying elements.

The control parameter levels were chosen to be within the operational range of the materials while employing the deep drawing method. Punch velocity, coefficient of friction, strain rate, and displacement per step were chosen as control parameters for the cold deep drawing process. Punch velocity, coefficient of friction, temperature, and blank thickness are the control parameters chosen for the warm deep drawing process. The orthogonal array (OA) L9 was chosen for this study.

DEFORM 3D software was used for finite element modeling and analysis. The circular sheet blank was modeled with the required diameter and thickness. The cylindrical top punch and

cylindrical bottom hollow die were modeled with relevant inner and outer radius and corner radius. Blank and punch, die and blank holder were coupled as a contact pair, and the sheet blank was meshed with tetrahedral elements. The interaction between the contact surfaces was assumed to be mechanical frictional contact. According to the design of experiments, the finite element analysis was performed using D-FORM 3D software.

The finite element results obtained are optimized using ANOVA (Analysis Of Variance) and the influences of process parameters are obtained. The farming limit diagrams (FLD) with damage in the cups for different thickness 0.8mm, 1mm, 1.2mm are drawn for the strains obtained and the quality of the cups analyzed by considering the necking and fracture zones.

The major process parameters which could the influence the deep drawing capability of nickel 201 cylindrical cups, were punch velocity and strain rate. The effective stress was increased with an increase in the punch velocity. The equivalent stress was increased from 10–100 s^{-1} while at quasi-static strain conditions below strain rate of 10 $s^{-1}$the total elongation is smaller and the material rupture at lower equivalent strains. The major process parameter which could influence the quality of the cup of INCONEL 600 was the punch velocity. The equivalent stress, surface expansion ratio, cup height and damage in the cups would increase with an increase in the punch velocity. The major process parameters which could influence the quality of the cup of MONEL 400 were punch velocity and displacement per step. Effective stress, surface expansion ratio and damage of the cup increases with increase in punch velocity and coefficient of friction. Surface expansion ratio decreases with increase in displacement per step.

The major parameters which influenced damage of NICKEL 201 warm cup were Temperature and thickness. The damage of the cup was least when punch velocity is 3.5mm/s, coefficient of friction is 0.4, Temperature is 700°C and thickness is1mm. The major parameters which influenced damage of MONEL 200 warm cup were temperature and thickness of the blank. Surface expansion ratio, damage of cup, effective strain and cup height increases with punch velocity and coefficient of friction. Height of the cup decreases with increase in temperature. Damage of the cup decreases with increase in thickness. The major process parameters which could the influence the warm deep drawing capability of Inconel-600 cylindrical cups, were punch velocity and temperature. The damage of the cups was found to be less with the sheet thickness of 1.2mm. Effective stress continuously decreased with increase in temperature.

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