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Title	A study of sheet metal stamping processes of lightweight parts

(800 words)

Due to soaring of fuel price and stringent environmental regulations, forming of lightweight parts is strongly demanded. Particularly, the reduction in weight of automobile parts has great influence on fuel consumption of vehicles. In this study, a multi-stage stamping process of lightweight steel wheel disks was developed. In addition, a stamping process of tailor square blanks having local thickening was presented to control the thickness distribution of a square cup for the reduction in weight. A cold stamping process was also developed to form magnesium alloy cups having small bottom corner radiuses.

Since the fatigue strength of the wheel disk largely decreases even by a small decrease in wall thickness at the inner corner, blanks having large thickness have been employed in the multi-stage stamping process, whereas the increase in weight of the disk results. A multi-stage stamping process with conical punches for increasing the wall thickness at the inner corner of a wheel disk was designed from finite element simulation. For the increase, the punch angle and the stroke were optimized in the simulation to take account of the drawn volume in the 2nd stage. The wheel disk having a 9% increase in thickness at the inner corner was successfully formed.

A two-stage forming process of tailor circular blanks having local thickening was developed by finite element simulation. In this process, the wall thickness of the tailor blank was locally increased by compressing a drawn portion in the 1st stage ring with flat tools in the 2nd stage. The effectiveness of the tailor blanks having local thickening was shown from an application of the tailor blanks to automobile wheel disks. A 12% increase in wall thickness at the inner corner of the wheel disk formed from the tailor blank was successfully obtained.

Deformation behaviors in the multi-stage stamping process of high strength steel wheel disks by means of the conical punches was performed by finite element simulation for the reduction in weight. The degree of increase in thickness at the inner corner became small due to the decrease in blank thickness. A high strength steel tailor circular blank was employed to improve the increase in thickness at the inner corner of the disk. The optimum forming conditions in the stamping process of the tailor blank were presented. A lightweight high strength steel wheel disk having a 15.7% increase in thickness at the inner corner was successfully formed.

Since the automobile parts for example door panels, fuel tanks, etc. have the features similar like a square cup, the thickness distribution of a mild steel square cup was controlled for the reduction in weight. Since the wall thickness at the bottom corners of a square cup tends to decrease in a drawing process, the blank thickness was increased to satisfy the high requisite strength at the corners, whereas the increase in weight of cup results. A stamping process of tailor square blanks having local thickening at the portion equivalent to bottom corners of the square cup was developed by finite element simulation. The target of local thickening having two vertical and two horizontal portions is equivalent to the bottom edges of the square cup. An 18 % increase in thickness at the vertical portions of the tailor blank was obtained from the simulation after the 1st thickening operation for the side wall angle of 55°. The blank was rotated 90° for the 2nd thickening operation at the horizontal portion for the same side wall angle. The crosses between the 1st and the 2nd thickened portions of the tailor square blank having two times of local thickening or 33% increase in thickness are equivalent to the bottom corners of the square cup. Although the square cup formed from the flat blank has 17% decrease in wall thickness at the bottom corners, the one formed from the tailor square blank has 10% increase in thickness

Magnesium alloy square cups are conventionally formed by hot stamping process in industries. Due to high cost and complexity of heating apparatuses, cold forming of the cup is strongly demanded. Cold drawing of the cup by punch having small corner radius tends to generate crack at the bottom corner due to stress concentration. Although the drawing ratios of the round and the square magnesium alloy cup in room temperature have been increased to 1.73 and 1.44 by annealing, the cups having large bottom corner radius were formed. Since the casing of laptops is similar like a square cup having small bottom corner radius, cold forming process of the cup is strongly demanded. In this study, a two-stage cold forming process of the round and the square magnesium alloy cups having small bottom corner radius was developed. The bottom corner radius of the round cup was successfully reduced from 5mm to 1.1mm. The employment of the conical punch in the 1st stage further reduced the bottom corner radius of the round cup to 0.6mm. An ironing die was designed in the 1st stage, and the round cup having 8.3% increases in height of the side wall was formed. The bottom corner radius of a square cup was successfully reduced from 3.7mm to 0.6mm.