CHAPTER - 5

EXPERIMENTAL PROCEDURE

Theoretical calibration curves have been drawn as per the procedures explained in section 4.5. These calibration curves are used to evaluate the lubricants in metal forming processes. The lubricants selected for evaluation in this study are teflon, castor oil and soap. To evaluate these lubricants, a test rig was fabricated to conduct the DCE test.

5.1 DESCRIPTION OF DOUBLE CUP EXTRUSION TEST RIG

Double cup extrusion test is performed by means of the test-rig shown in Fig 5.1. The set up consists of an upper punch and a lower punch. The geometries of the upper punch and lower punch are similar. The upper punch is moving down inside an inner cylindrical container. The lower punch is stationary and is threaded firmly on a bottom plate/base. The inner container has press fit with the outer container that consists of locating holes. The locating holes align the upper and lower punch coaxially. The outer container is firmly placed over the base/bottom plate. The upper punch is threaded with the lower platen and is placed inside the container bore. The load required for the extrusion is transmitted through the platens to the upper punch. A hardened ball is provided in between the platens for self centering while loading. Any type of punches can be replaced for experiments in this set up. The required diameter of the bore can be achieved by replacing the inner container. The details of parts are given in Fig. 5.2 and Fig. 5.3.
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<th>Part No.</th>
<th>Description</th>
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<tr>
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<td>01</td>
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<td>02</td>
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<td>03</td>
<td>Lower Platern</td>
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<td>06</td>
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<td>09</td>
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<tr>
<td>10</td>
<td>Bottom Plate</td>
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Fig. 5.1 Double cup extrusion test-rig setup
Fig. 5.2 Part drawings of DCE test rig
(a) upper platen
(b) lower platen
(c) outer container
(d) inner container
(e) bottom plate

All dimensions are in mm
Fig. 5.3 Details of the selected punch geometry

(a) upper punch
(b) lower punch

All dimensions are in mm
5.1.1 Details of the punch heads

The punches for the DCE test are obtained from the optimized parameters discussed in sections 6.1 to 6.4. The details of the punch head geometries are given in Fig. 5.3. The punch heads were fabricated to the dimensions shown in Fig. 5.3. The punches were made of EN 27 steel and hardened and tempered to Rc 45. The punches were ground to the dimensions. The punches were polished with fine emery paper prior to every use.

5.1.2 Details of the container and other parts

The container consists of two parts namely inner and outer container. The inner container is made of EN 27 steel and reamed to 20mm diameter hole. The container is hardened and tempered to Rc 45 whereas the outer container is made up of mild steel. The other parts such as base plate, locating pins, platens etc. are given in part list and these are fabricated to dimensions.

5.2 PREPARATION OF SPECIMEN

In the earlier theoretical studies and experimental work, it was recommended to use the cylindrical specimen of 20mm diameter and 20mm height. In the present study, aluminium is selected as the work piece material. Commercial pure aluminium was obtained in the form of a rod of diameter 25 mm. The rod is cut to a length 150mm in a power hacksaw machine for heat treatment. These rods are annealed at a temperature of 400° C (673 K) for 1 hr.
From annealed aluminium rod the specimens for compression test to find out the flow properties were prepared. A cylindrical specimen of diameter 20mm and height 30mm was used for compression test.

Ring test specimens of outside diameter 18 mm, inside diameter 9mm and height 6mm were machined from the annealed specimen. For DCE test, cylindrical specimen of 20mm diameter and 20mm height were used.

5.3 EXPERIMENTAL PROCEDURE FOR DCE TESTS

i. The punches were cleaned and polished by emery paper before use.

ii. The work pieces were also polished by emery paper to free them from burrs before use.

iii. The punches and specimens were well lubricated with the selected lubricant.

iv. The specimen was compressed to a specified height reduction.

v. The specimen was taken out and the extruded cup heights were measured at four points. The average cup height was recorded. A depth micrometer was used to measure extruded cup heights.

vi. The cup height ratio was calculated from the measured heights.

5.4 EXPERIMENTAL PROCEDURE FOR THE RING TEST

i. The hardened lower and upper platens were cleaned and polished using emery paper before every use.

ii. The specimens were polished by emery paper to remove burrs.
iii. The platens and specimens were well lubricated by selected lubricant before the experiments.

iv. The rings were compressed to required height reduction.

v. The inside diameter of the compressed rings were measured at four points and the average values were recorded.

vi. The % change in internal diameter was calculated and used as a measure of frictional values. These values were compared with the theoretical calibration curves and the lubricants ‘m’ values were evaluated.

5.5 EXPERIMENTAL PROCEDURE TO FIND FLOW PROPERTIES

The flow properties of the material are needed as one of the input variables for the FEM simulation. To find out stress - strain values, compression tests were conducted. The experiments were conducted in the following manner.

i. Hardened flat platens were cleaned and polished with emery sheet before every test.

ii. The specimen was polished with emery sheet to free it from burrs.

iii. The specimens and the platens were well lubricated with teflon tapes.

iv. After every 5% reduction of the height, the specimens were taken out and lubricated with teflon. By this frequent lubrication the bulging effect is reduced and a uniform deformation can be obtained.
v. The height of specimen and load were recorded at specified intervals.

vi. From the recorded results, true stress and true strain values were determined.

The flow properties found out from the experiment are shown in Fig. 5.4.

5.6 EXPERIMENTAL PROCEDURE FOR THE VALIDATION

The dies required for forming the component hub forging were machined to dimensions. These dies were hardened and tempered.

The experiments were conducted as follows

i. The dies and specimen were well lubricated by selected lubricants.

ii. The specimen was compressed to the known height reduction. The changes in dimensions were measured at selected locations and recorded.

iii. The recorded values were compared with the theoretical results.
Fig. 5.4 Flow curve of annealed aluminium specimen