# Experiment No. 03 : Extrusion

## Aim of the experiment :

- To extrude a cylindrical cup by backward extrusion.
- To determine the load variation with the thickness of the bottom of the cup.

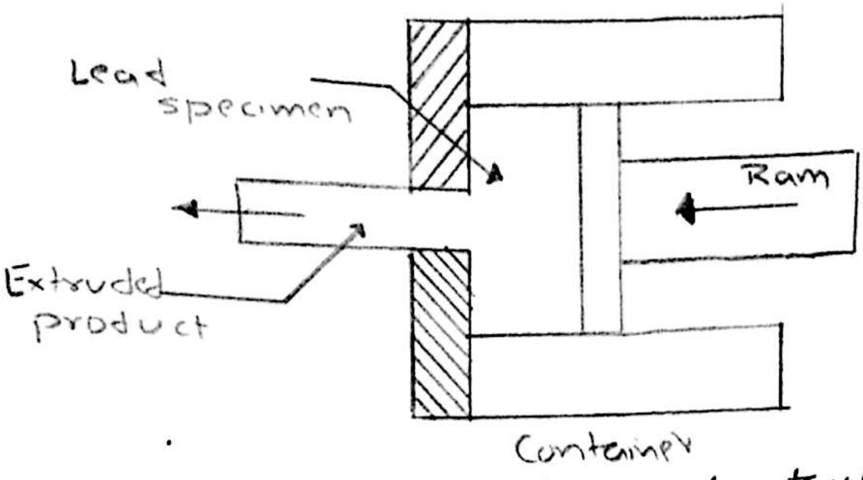
## Equipment and Specimen Required:

- Extruding punch and dies
- Compression testing machine
- LVDT
- Load Cell
- Vernier Caliper
- Lead specimen

## Theory:

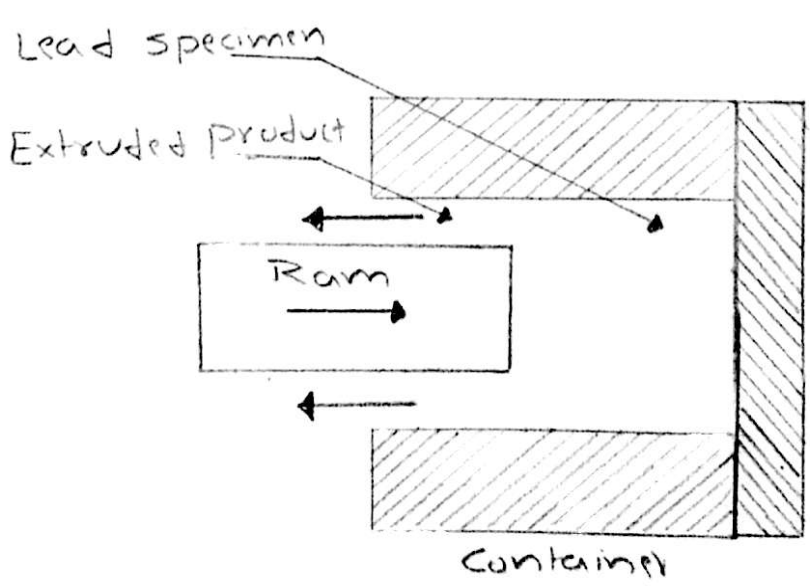
Extrusion is a plastic deformation process in which a block of metal (billet) is forced to flow by compressing through the die opening of a smaller cross-sectional area than that of the original billet. The different types of extrusion processes are:

In direct or forward extrusion, metal flows in the same direction as that of the ram. Because of the relative motion between the heated billet and the chamber walls, friction is severe and is reduced by using lubricant. (See Figure below)




Direct Extrusion

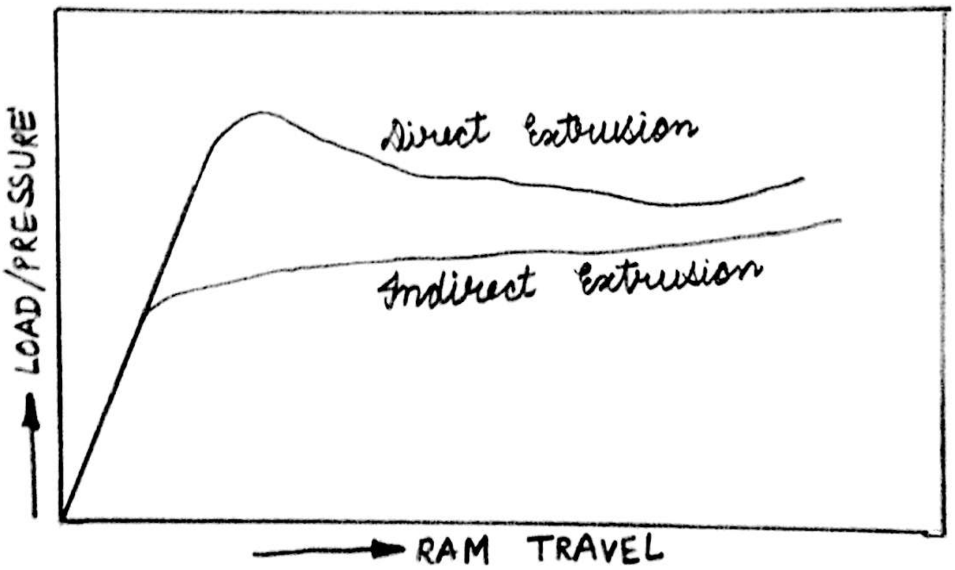
In indirect or backward extrusion, metal flows in the opposite direction as that of the ram. It is more efficient since it reduces friction losses considerably.. The process, however, is not used extensively because it restricts the length of the extruded component (See Figure below).




Indirect Extrusion

Extrusion may be hot extrusion or cold extrusion depending on the recrystallization temperature of the material to be extruded. If the extrusion is carried out above the recrystallization temperature of the material, it is called <u>hot extrusion</u>; and if it is carried out below the recrystallization temperature of the material, it is called <u>cold extrusion</u>.

The force required for extrusion can be calculated approximately by equating specific internal strain energy to the external work per unit volume of the material extruded under the assumption of no losses.




<u>Variation of force with ram displacement</u>

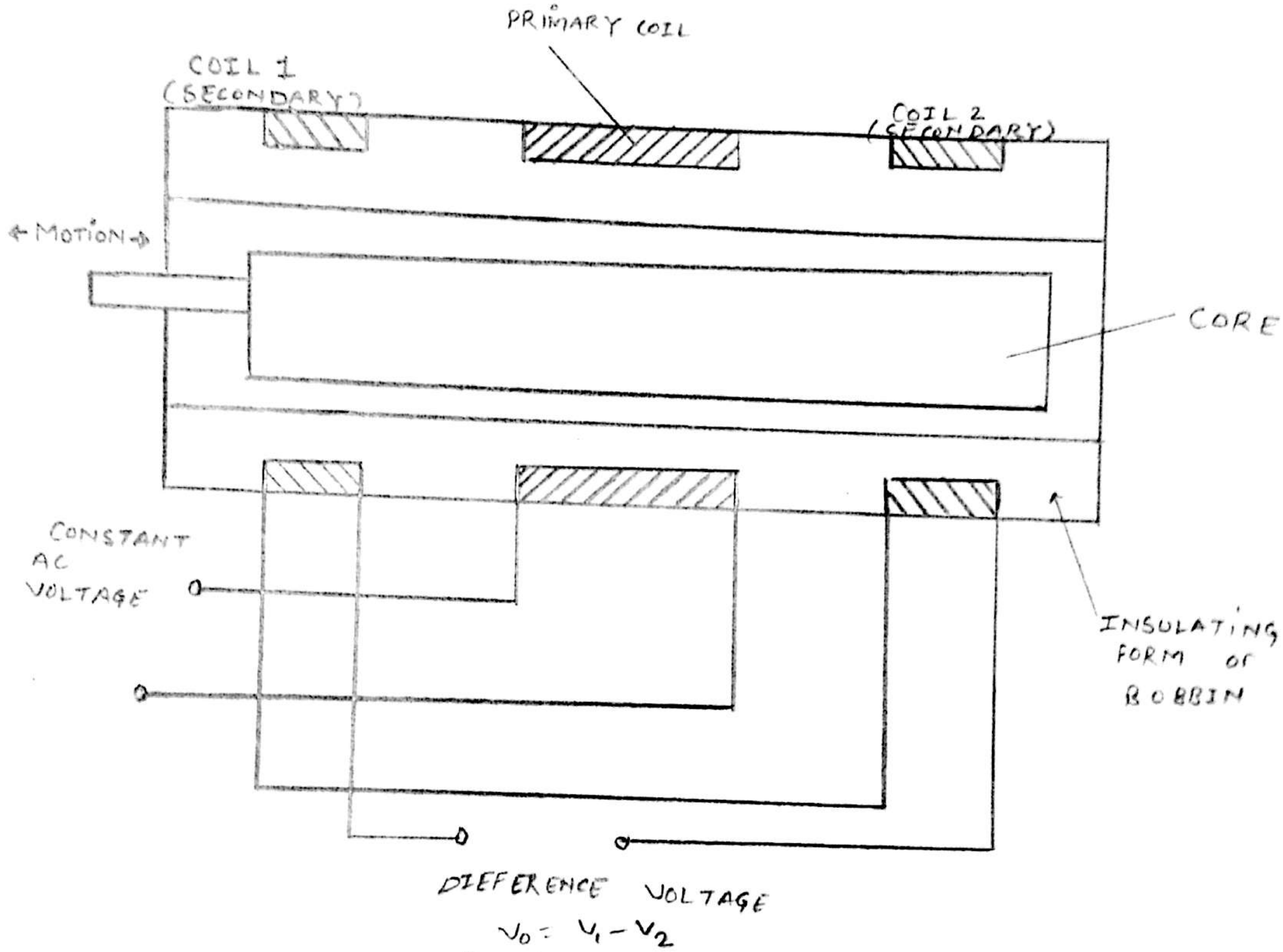
## ● <u>Compression Testing Machine:</u>

The extrusion operation is carried out on Compression testing machine. The machine is divided into two sub assemblies. One assembly consists of hydraulic oil container, few valves to operate the machine, a motor which sucks oil from oil container and deliver it with high pressure to high pressure oil chamber (at another assembly) and circular scale which gives load readings. Another assembly consists of upper and lower crosshead, high pressure oil chamber, oil pipe lines and base. The upper crosshead can be moved by electric motor, just operating valves (at first assembly); whereas the lower crosshead is moved by high pressurised oil. With this assembly there is an attachment to attach LVDT.

## Linear Variable Differential Transformer (LVDT) :-

LVDT is a type of electrical transformer used for measuring linear displacement. It consists of a cylindrical former where it is surrounded by one primary winding in the center of the former and the two secondary windings at the sides. An alternating current drives the primary and causes a voltage to be induced in each secondary proportional to the length of the core linking to the secondary.

When the core is equidistant from the two secondary coils, equal voltages are induced in the two secondary windings and the output voltage is zero. As the core moves, the primary's linkage to the two secondary windings changes and causes the induced voltages to change. The phase of the output voltage determines the direction of the displacement ( up or down ) and amplitude indicates the amount of displacement.



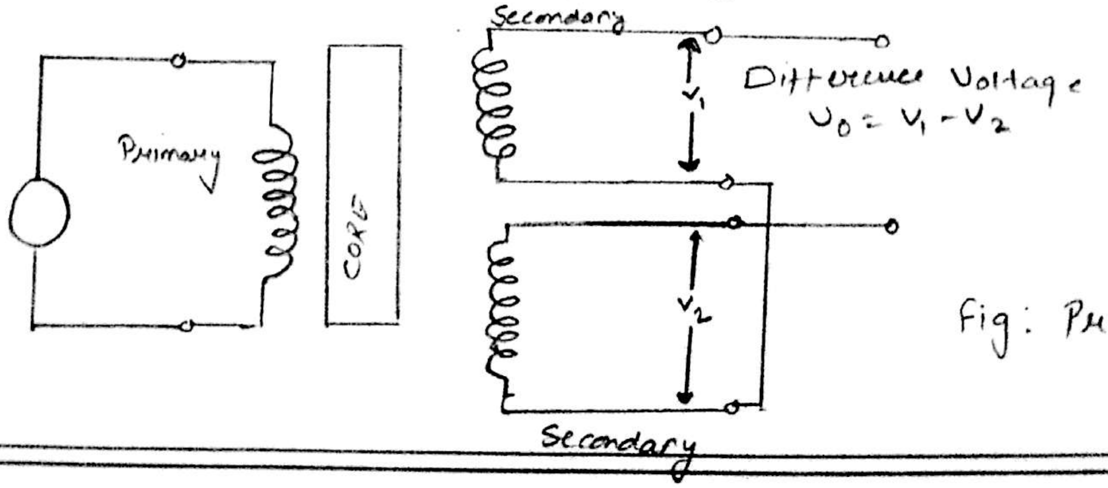




Fig: Principal of LVDT

Load cell :-

A load cell is a transducer that is used to convert a force into electrical signal. Here we are using strain gauge load cell.

A strain gauge load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Through a mechanical arrangement, the force being sensed deforms strain gauge and strain gauge measures the deformation (strain) as an electrical signal, because the strain changes the effective electrical resistance of the wire.

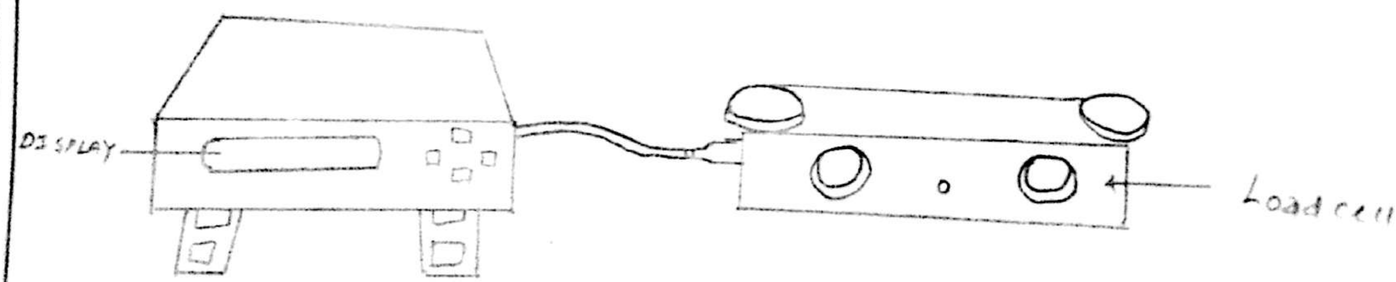



Fig. Load cell

## Observation Table :-

Initial diameter = 35.2 mm

Initial height = 24.5 mm

Final height = 76.8 mm

Final diameter =

(i) Internal = 34 mm

(ii) External = 38.4 mm

| Sl.no. | Punch displacement (mm) | Load (kgf) |
|---|---|---|
| 1. | 0 | 2460 |
| 2. | 0.2 | 2680 |
| 3. | 0.4 | 2866 |
| 4. | 0.6 | 3024 |
| 5. | 0.8 | 3138 |
| 6. | 1.0 | 3254 |
| 7. | 1.2 | 3342 |
| 8. | 1.4 | 3532 |
| 9. | 1.6 | 3770 |
| 10. | 1.8 | 4116 |
| 11. | 2.0 | 4420 |
| 12. | 2.2 | 4880 |
| 13. | 2.4 | 7395 |
| 14. | 2.6 | 9652 |

| | | |
|---|---|---|
| 15. | 2.8 | 10986 |
| 16. | 3.0 | 11796 |
| 17. | 3.2 | 12510 |
| 18. | 3.4 | 12966 |
| 19. | 3.6 | 13302 |
| 20. | 3.8 | 13498 |
| 21. | 4.0 | 13824 |
| 22. | 4.2 | 13958 |
| 23. | 4.4 | 14096 |
| 24. | 4.6 | 14190 |
| 25. | 4.8 | 14206 |
| 26. | 5.0 | 14342 |
| 27. | 5.2 | 14404 |
| 28. | 5.4 | 14456 |
| 29. | 5.6 | 14524 |
| 30. | 5.8 | 14540 |
| 31. | 6.0 | 14534 |
| 32. | 6.2 | 14528 |
| 33. | 6.4 | 14526 |

| | | |
|---|---|---|
| 34. | 6.6 | 14500 |
| 35. | 6.8 | 14462 |
| 36. | 7.0 | 14426 |
| 37. | 7.2 | 14364 |
| 38. | 7.4 | 14310 |
| 39. | 7.6 | 14258 |
| 40. | 7.8 | 14216 |
| 41. | 8.0 | 14160 |
| 42. | 8.2 | 14110 |
| 43. | 8.4 | 14050 |
| 44. | 8.6 | 13996 |
| 45. | 8.8 | 13938 |
| 46. | 9.0 | 13874 |
| 47. | 9.2 | 13832 |
| 48. | 9.4 | 13778 |
| 49. | 9.6 | 13732 |
| 50. | 9.8 | 13698 |
| 51. | 10.0 | 13672 |
| 52. | 10.2 | 13654 |

| | | |
|---|---|---|
| 53. | 10.4 | 13630 |
| 54. | 10.6 | 13620 |
| 55. | 10.8 | 13604 |
| 56. | 11.0 | 13582 |
| 57. | 11.2 | 13556 |
| 58. | 11.4 | 13530 |
| 59. | 11.6 | 13494 |
| 60. | 11.8 | 13460 |
| 61. | 12.0 | 13424 |
| 62. | 12.2 | 13396 |
| 63. | 12.4 | 13358 |
| 64. | 12.6 | 13322 |
| 65. | 12.8 | 13258 |
| 66. | 13.0 | 13252 |
| 67. | 13.2 | 13244 |
| 68. | 13.4 | 13216 |
| 69. | 13.6 | 13196 |
| 70. | 13.8 | 13166 |
| 71. | 14.0 | 13128 |
| 72. | 14.2 | 13082 |

| | | |
|---|---|---|
| 73. | 14.4 | 13048 |
| 74. | 14.6 | 12984 |
| 75. | 14.8 | 12968 |
| 76. | 15.0 | 12946 |
| 77. | 15.2 | 12968 |
| 78. | 15.4 | 12972 |
| 79. | 15.6 | 12976 |
| 80. | 15.8 | 12956 |
| 81. | 16.0 | 12938 |
| 82. | 16.2 | 12930 |
| 83. | 16.4 | 12850 |
| 84. | 16.6 | 12922 |
| 85. | 16.8 | 13010 |

- Conclusion:

  - Trends of the graph plotted:

Initially, with the small increase in the thickness of the cup, load increased rapidly. After certain thickness of the cup, load attained a maximum value. Then after a little decrease in the load, it remained constant for a considerable range of thickness of the cup. Finally, load started increasing exponentially with the thickness of the cup.

  - Quality of the extruded cup:

Quality of the cup formed was considerably good. But there were some defects seen in the final product. Thickness of the curved surface was not uniform. As a result, eventually, cracks were developed in the cup. This happened probably because, initial raw material was not placed exactly at the centre. As it was not alligned properly, thickness of the curved surface was non uniform.

● Questions:

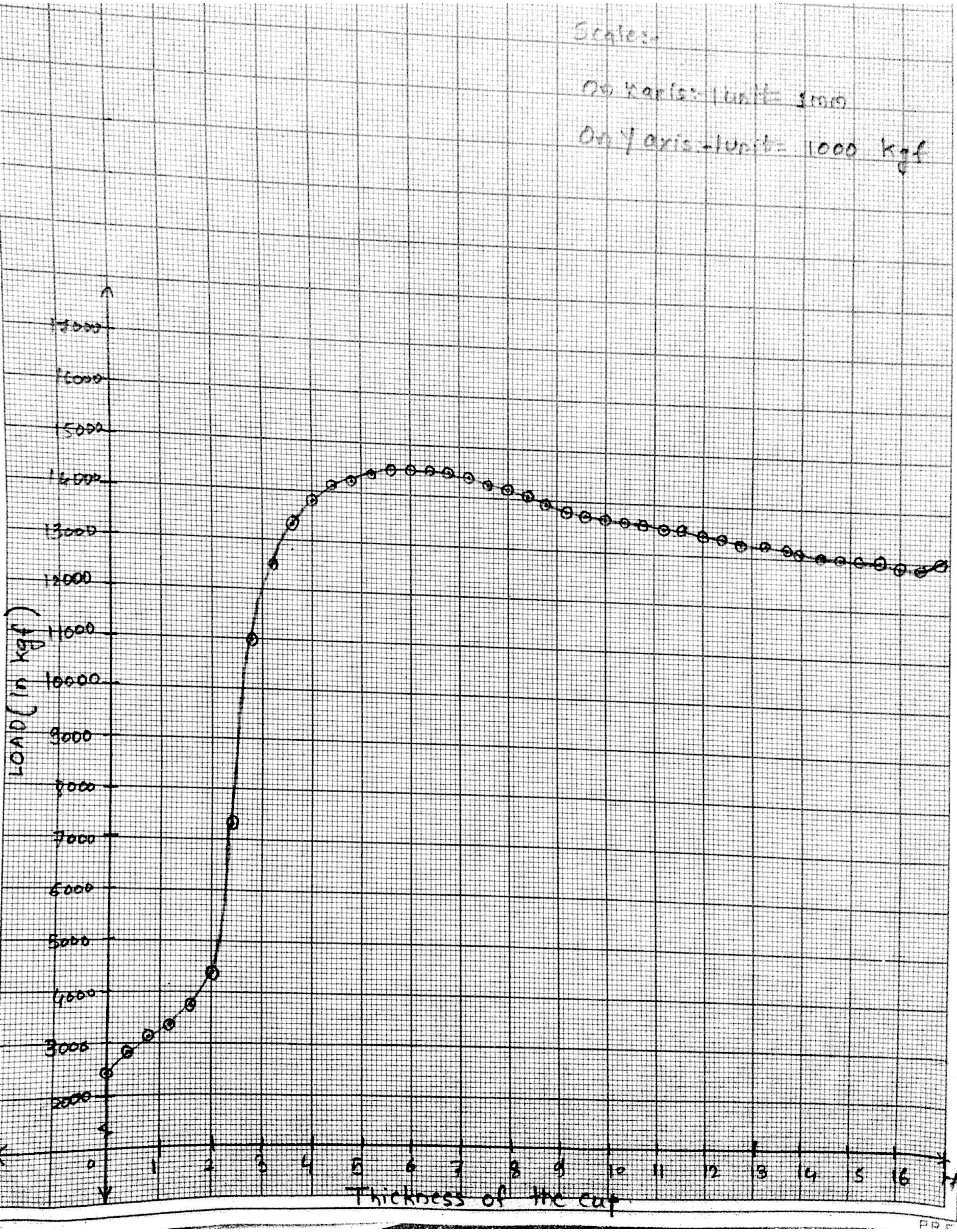
① What material properties control extrusion?

Material should possess following properties for extrusion.

(i) Recrystallisation temperature of the material
(ii) Ductility
(iii) Compressive strength of material
(iv) Shear strength
(v)

② Differentiate between hot working and cold working.

| Hot working | Cold Working |
| --- | --- |
| (i) Working temperature is greater than recrystallisation temperature | (i) Working temperature is less than recrystallisation temperature |
| (ii) Ductility is more | (ii) Ductility is less. |
| (iii) Oxide formation takes place | (iii) Oxide formation does not take place. |
| (iv) Surface finish is poor | (iv) Good surface finish. |
| (v) softening of dies and punch take place. | (v) Softening of dies and punch does not take place. |



Scale:-
On X axis:- 1 unit = 1mm
On Y axis:- 1 unit = 1000 kgf
LOAD (in kgf)
Thickness of the cup