EXPERIMENT NO. 1 (a)
DISC COMPRESSION TEST

- **Aim of the Experiment:** To demonstrate the effect of friction and height-to-diameter ratio in the axi-symmetric compression of a cylinder.

- **Apparatus Required:**
  - A compression testing machine (here Hydraulic type)
  - Cylindrical shaped specimen of Aluminium
  - Vernier Caliper

- **Theory:**

A compression test is used to determine the behaviour of a material under compressive load. The specimen is compressed and deformations at various loads are recorded. Compressive stress and strain are recorded and plotted as a stress-strain diagram, which is used to determine elastic limit, proportional limit, yield point, yield strength, and for some materials, compressive strength.

The following materials are typically subjected to a compression test :-

- Concrete
- Metals
- Plastics
- Ceramics
- Composites
- Corrugated Cardboard

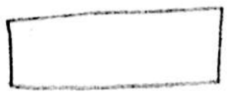
Modes of Deformation in Compression Testing:

Buckling
(L/D > 5)

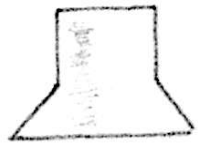
Shearing
(L/D > 2.5)

Double Barrelling
(L/D ≥ 2.0)

Barrelling
(L/D < 2.0)



Homogenous Compression
(L/D < 2.0, no friction)

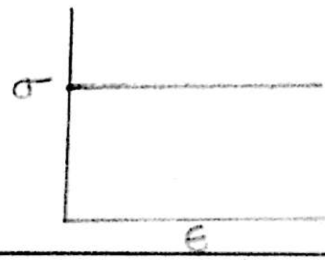


Compressive Instability
(Work-softening Material)

Various Idealisations of Materials:

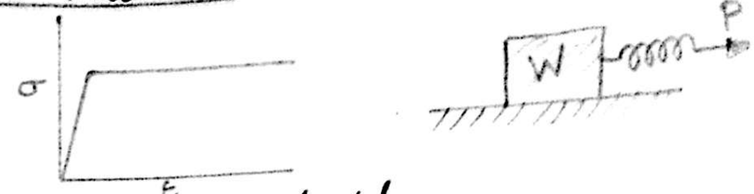
The stress-strain relation is often idealized by a simple mechanical motion of spring-loaded block.

(a) A rigid, perfectly plastic material
eg. wood



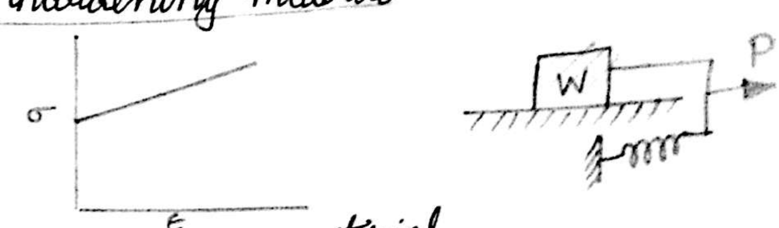
(b) An elastic, perfectly plastic material.

eg. Alloy steel plate



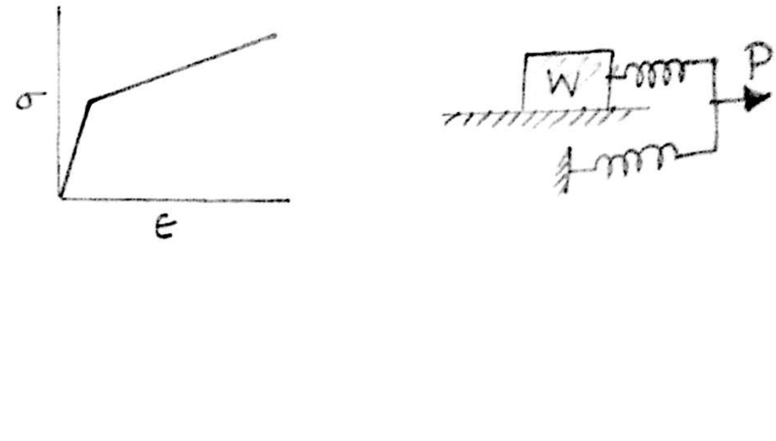
(c) A rigid, linearly strain-hardening material

eg. Aluminium



(d) An elastic, linear strain-hardening material.

eg. Low Carbon Steel.



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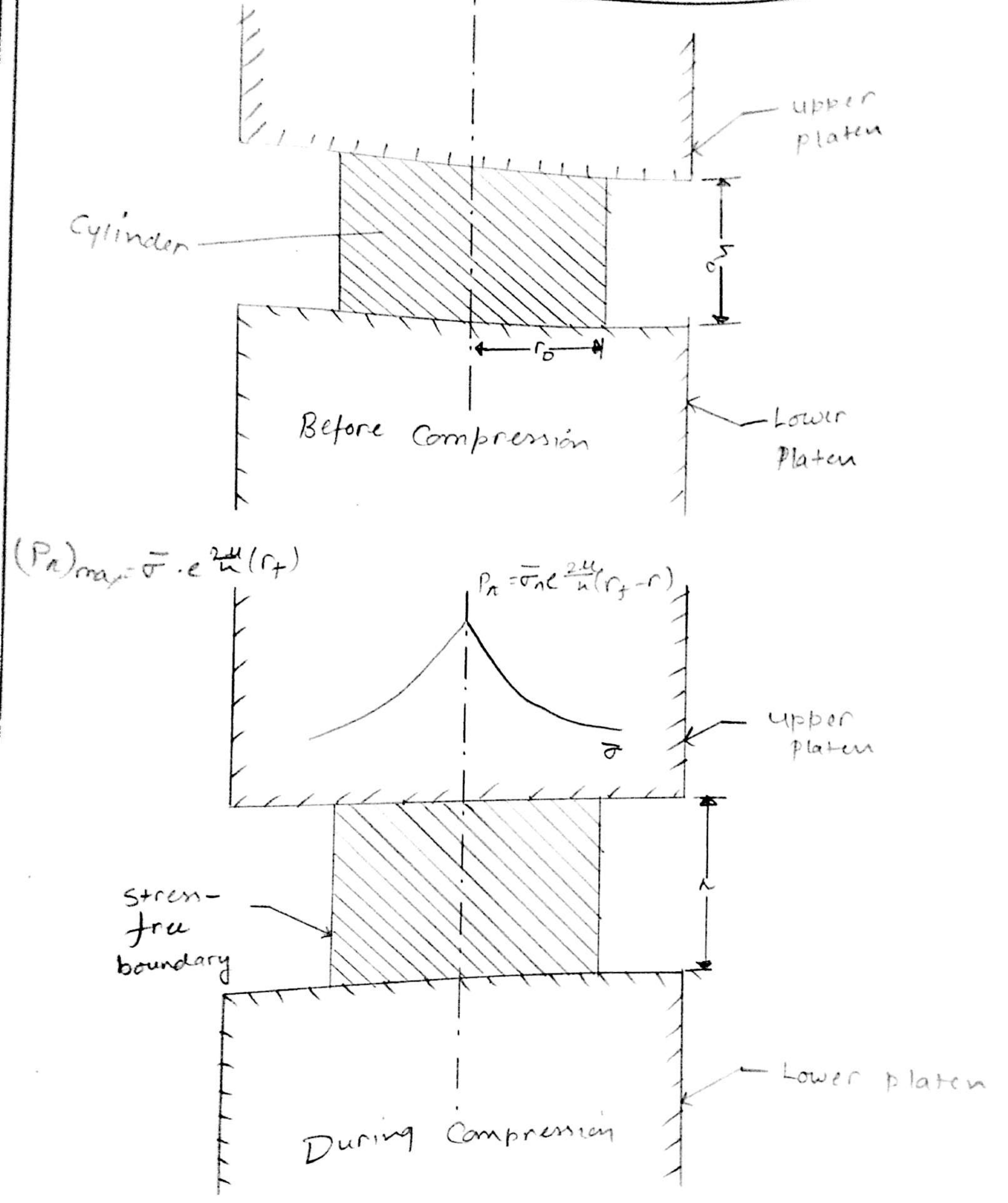


Fig :- Distribution of normal stress with rough platens

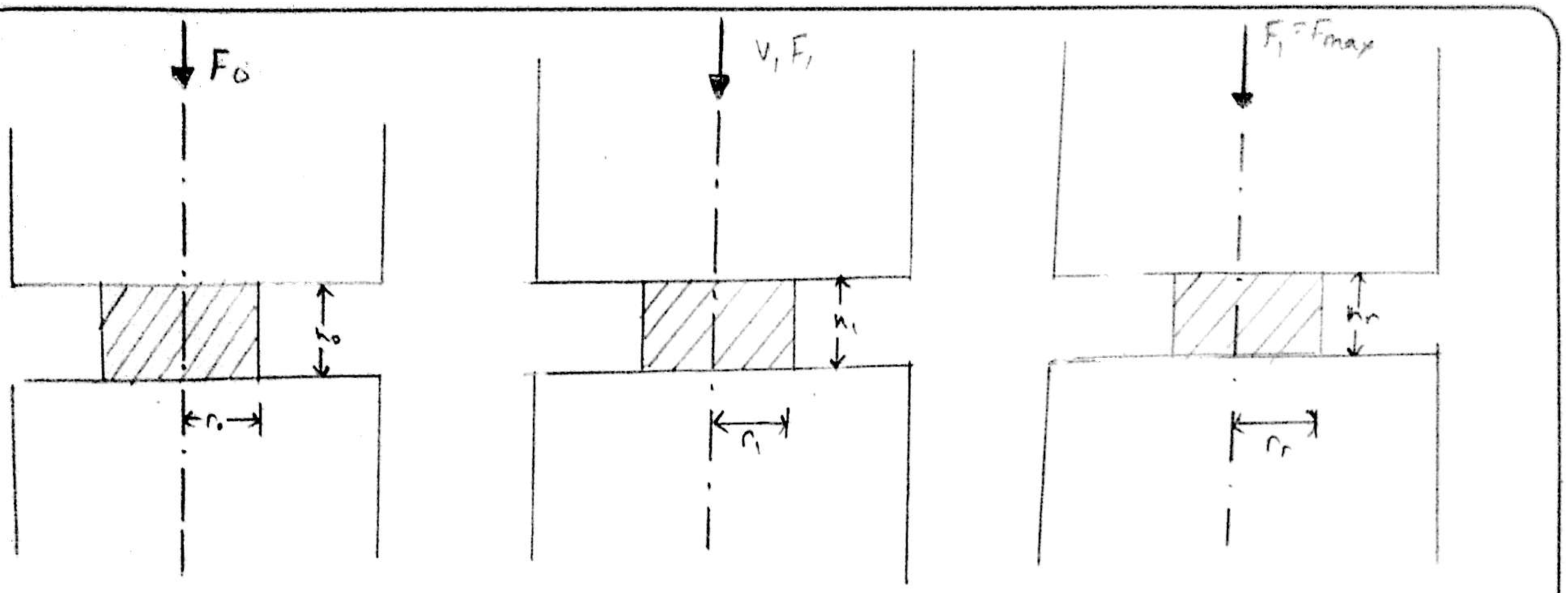


Fig:- HOMOGENEOUS UPSETTING OF CYLINDRICAL BILLET

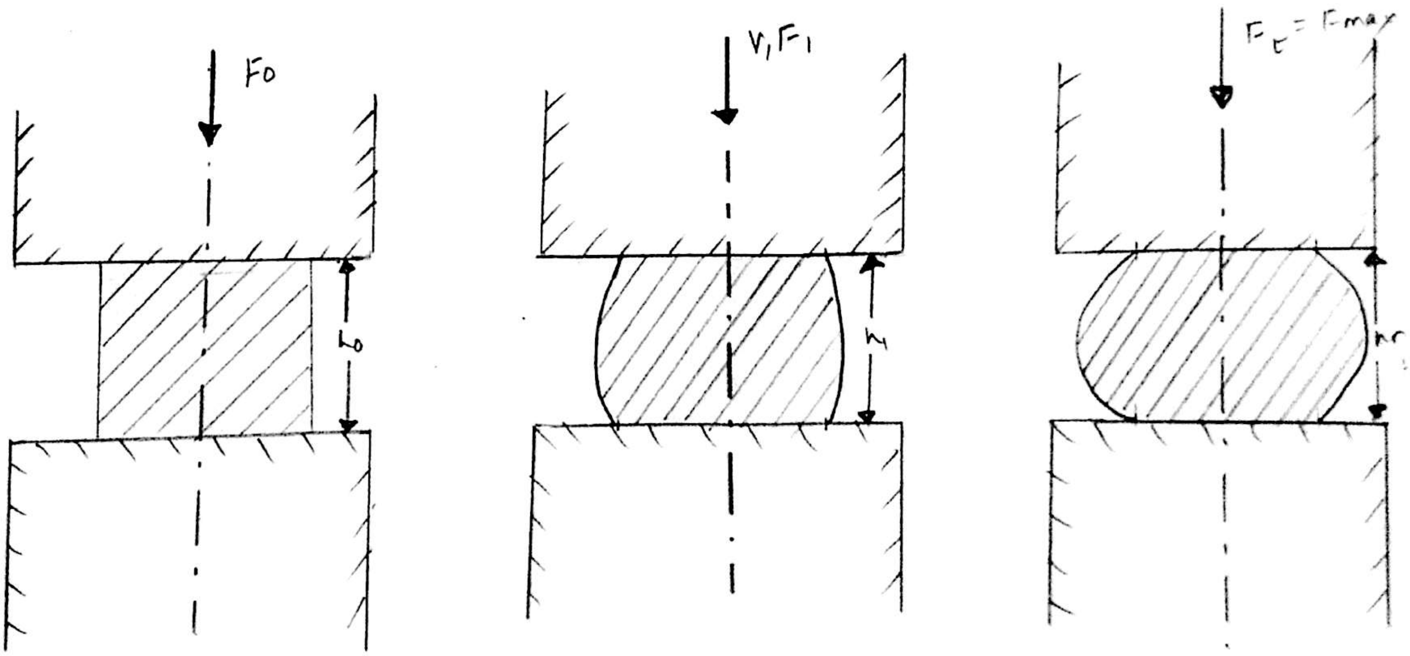


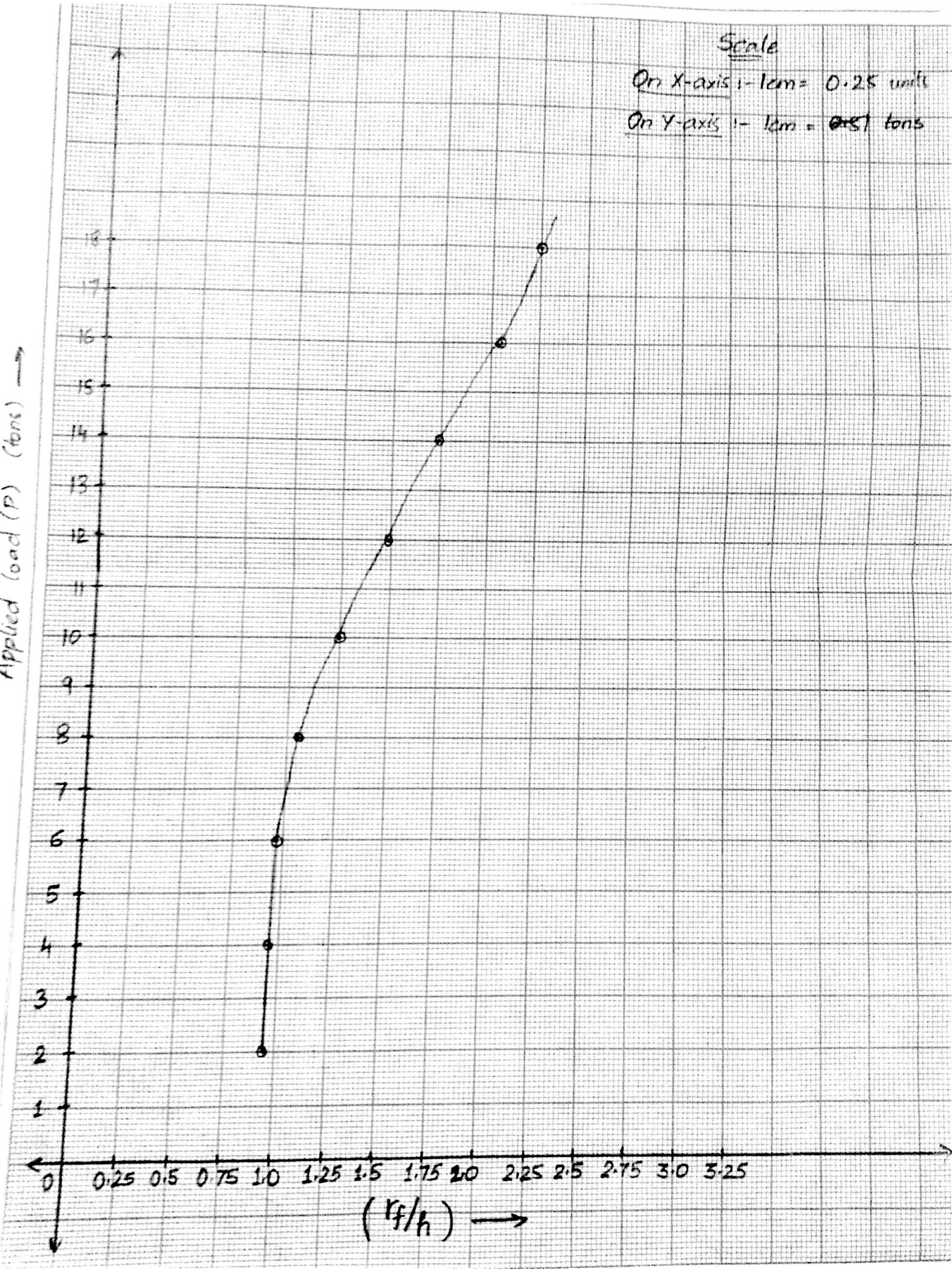
FIG:- PRACTICAL UPSETTING OF A CYLINDERICAL BILLET.

Observation Table:-

Initial Height : 10.1 mm

Diameter = 19.10 mm

Serial No.	Applied load (P) in tons	Diameter ($2r_f$) in mm	Height (h) in mm	$\frac{r_f}{h}$
1	2	19.10	10.10	0.946
2	4	19.10	10.10	0.95
3	6	19.15	10.00	0.958
4	8	19.85	9.40	1.06
5	10	21.05	8.40	1.25
6	12	22.30	7.50	1.49
7	14	23.55	6.75	1.74
8	16	24.8	6.05	2.05
9	18	25.7	5.70	2.25


Scale
On X-axis :- 1cm = 0.25 units
On Y-axis :- 1cm = 1 tons
Applied load (P) (tons)
0
0.25
0.5
0.75
1.0
1.25
1.5
1.75
2.0
2.25
2.5
2.75
3.0
3.25
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
(r_f/h)

Questions for discussion :-

1) How do ductile and brittle materials behave in compressive test ?

→ When the compressive force is applied to the specimens in the compressive test, we see the variation in the diameter of the specimen along its height. When ~~du~~ this test is done on ductile material, this variation in the diameter is large and specimen do not break. But when brittle material is used, as the compressive load increases above the certain limit, the specimen breaks into pieces.

2) Compressive test are generally performed on brittle materiel. Why ?

→ Brittle materials are generally weak in tension but they are strong in compression. ~~So~~ Compression load tends to squeeze the specimen. So, brittle materials are used at the places where compressive strength is very important and tensile strength is not used.

Before their use they are needed to be tested. So the compressive test is generally performed on brittle material.

3) Is it possible to plot true stress-strain curve by compression test for a given material? Explain.

→ Yes, it is possible to plot true stress-strain curve if we measure the instantaneous height and area of the specimen for each loading condition.

4) What is the limitation of tensile-stress?

→ As discussed above, brittle material show strong compressive strength and weak tensile strength. So, the result which we get in the compressive test cannot be applied to the tension of the brittle material. In order to determine it, separate test must be performed.

5) what is the difference between strain hardening and
re-crystallization? Is there any correlation between
them?

→ As the deformation of material occurs in the plastic
region, the dislocations in the material are increased
The dislocation interactions are repulsive. As the dislo-
cation density increases, the further deformation of
the material ~~is~~ becomes difficult. This is called as
strain hardening. While strain hardening, the strain
energy ~~hardening~~ of the material is increased. Temperature
is not considered while strain hardening.

In recrystallisation, small grains are formed and
size increases gradually to occupy all the material,
Recrystalisation occurs at 0.4 to 0.6Tm where
Tm is the melting temperature. In recrystalisation,
the driving force is the difference in the strain
energy. Final grains which are formed are
strain energy free.

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EXPERIMENT NO 1(b)
RING COMPRESSION TEST

Aim of Experiment :

To determine the coefficient of interfacial friction during plastic deformation of metals by means of compression of a ring between two compression plates.

Appartus required :

1) A compression testing machine (Hydraulic type)
2) Hollow cylindrical shaped specimen of Aluminium.
3) Vernier calliper

Theory :

The friction at the interface of die/workpiece plays an important role in the overall integrity of metal forming process. Friction affects deformation load, surface quality, internal structure of product.

Coloumb's Law of friction : $\tau = \mu P$

τ = frictional shear stress , P = normal stress

μ = coefficient of friction.

The ring compression test is used to determine frictional condition at the interfaces.

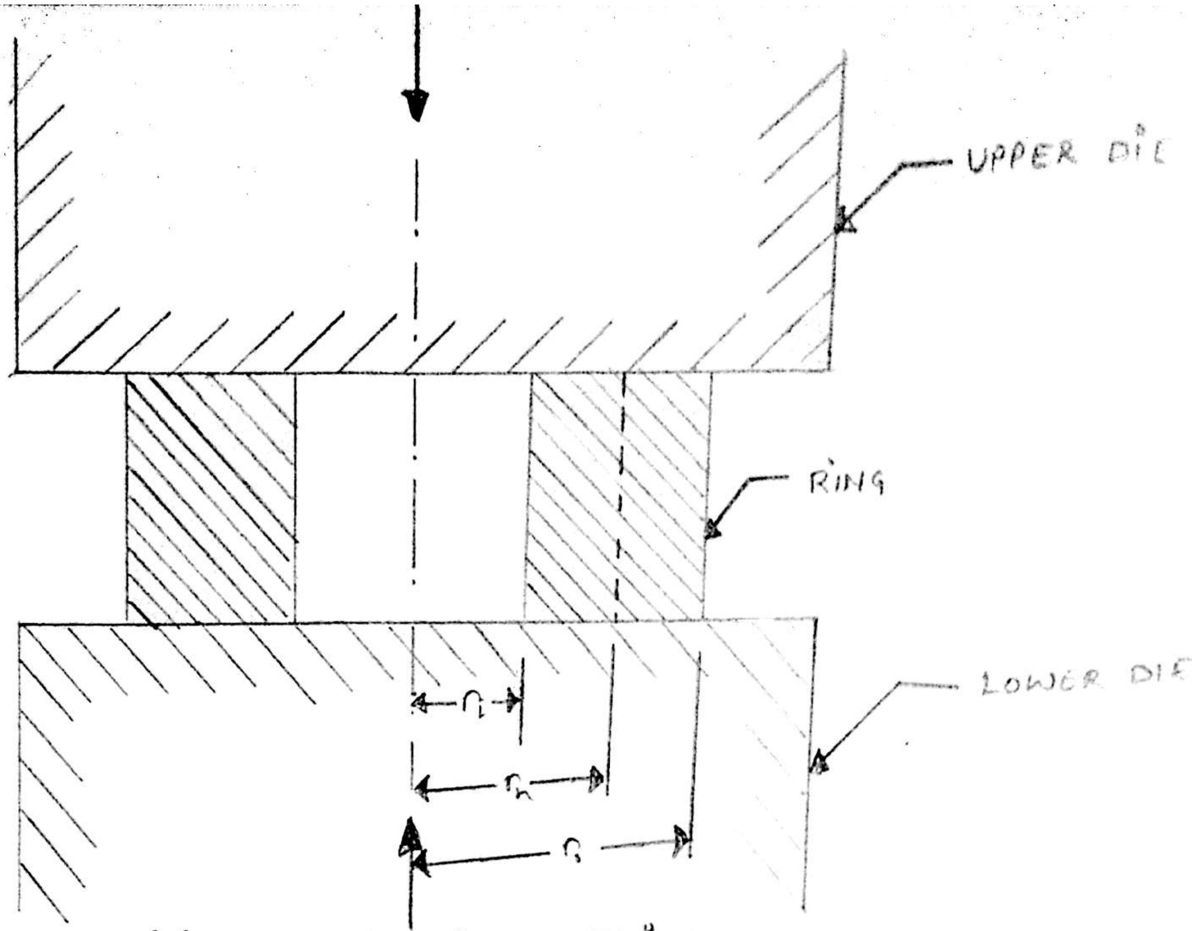
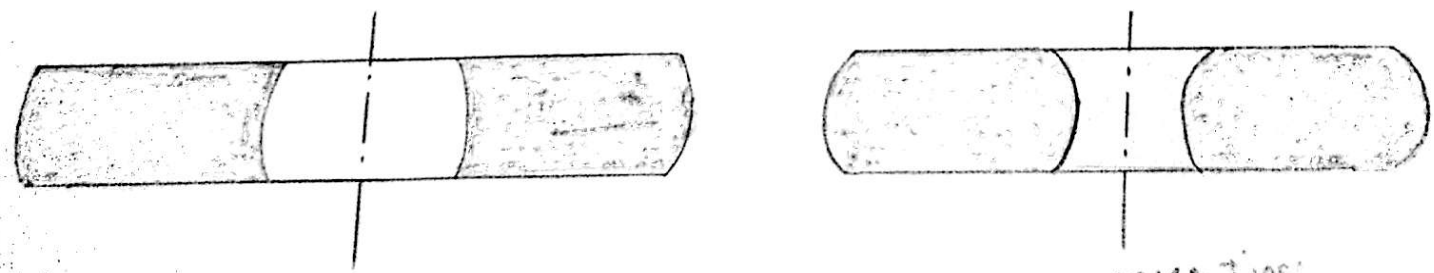


FIG :- RING COMPRESSION

When a flat ring specimen is plastically compressed between two flat plates, increasing friction results in a inward flow of material, while decreasing friction results in an outward flow of material. If there were no friction between the dies and workpiece, both the inner and outer diameters of ring would expand. However for large friction at material / die interference, the internal diameter of ring is reduced with increasing deformation.

For a given percentage of height reduction during compression test, the corresponding measurement of internal diameter of test specimen provides a qualitative knowledge of magnitude of coefficient of friction at die/material interface. For lower friction specimen's internal diameter increases during deformation but for higher friction internal diameter decreases during deformation. Using this relationship, specific curves called fruction calibration curves, were generated by Male and Cockroft, relating reduction in internal diameter to reduction in height of test specimen. for varying degrees of coefficient of friction.



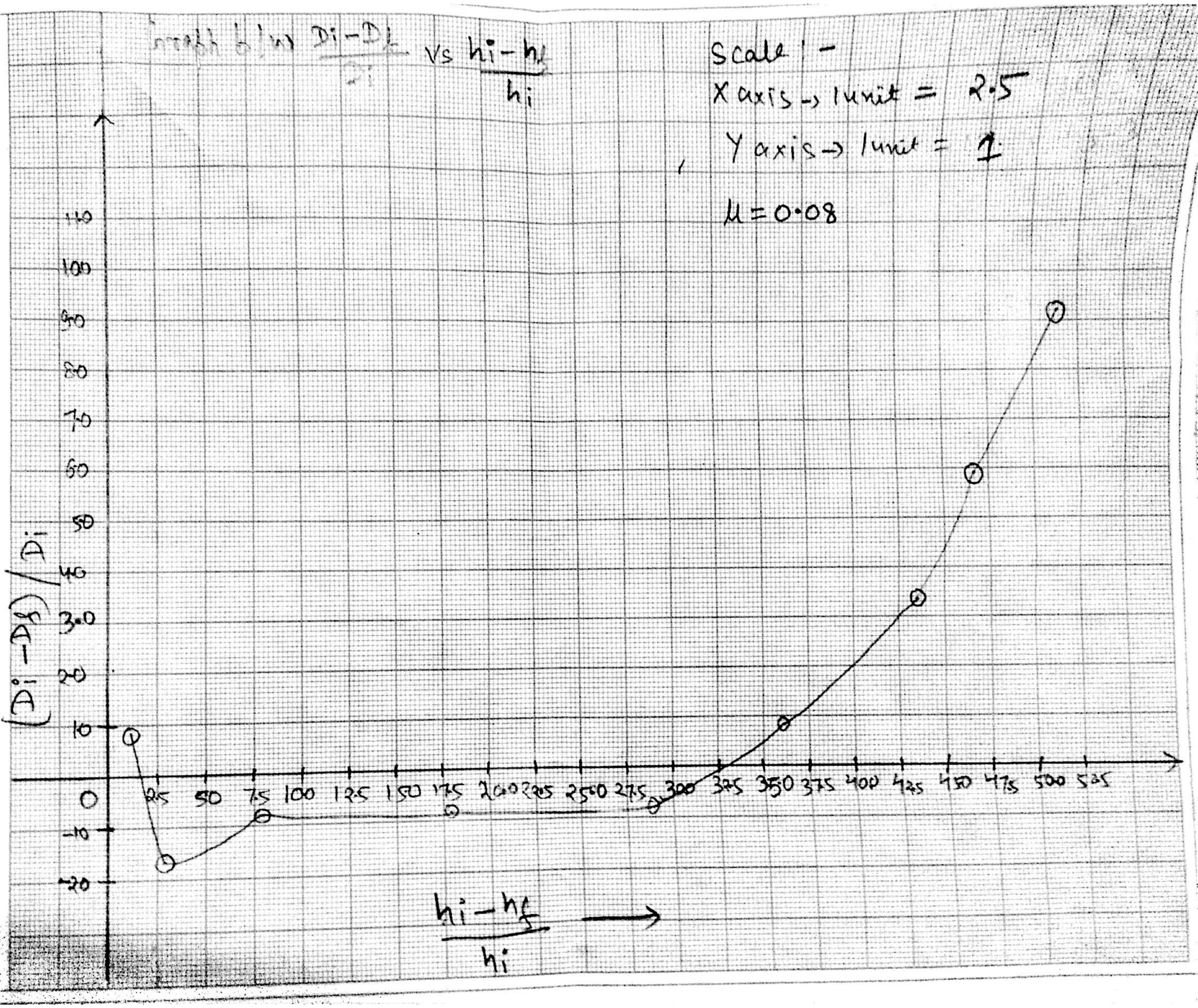
(a) GOOD LUBRICATION (b) POOR LUBRICATION

Observation Table:-

Initial diameter (internal) = 5.95 mm

Height = 8.85 mm

Serial No.	Applied load (P) in tonnes	Diameter ($2r_f$) in mm	Height (h) in mm	$\frac{r_f}{h}$
1	2	5.90	8.75	0.34
2	4	6.05	8.60	0.35
3	6	6.00	8.15	0.37
4	8	6.00	7.30	0.41
5	10	6.00	6.30	0.48
6	12	5.90	5.65	0.52
7	14	5.75	5.00	0.58
8	16	5.60	4.70	0.60
9	18	5.40	4.30	0.63


Graph b/w Di−Df/Di vs hi−hf/hi
Scale :-
X axis → 1unit = 2.5
Y axis → 1unit = 1
μ = 0.08
(Di−Df)/Di
hi−hf/hi
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
500
525

Questions for discussion:-

1) what is the limitation of ring compression test?

→ Ring compression test is finally used to determine the coefficient of friction between the dice and specimen. Here the shape of the specimen used is circular. Diameter is a very important parameter of the specimen which is used to find the coefficient of friction. But when the specimen of irregular shape is used, it is very difficult to find the effective diameter. so, in such cases, we cannot find the coefficient of friction. This is the limitation of ring compressive test.