Hardness, Tensile and Compression Test on various specimens

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Lab Report

Rockwell Hardness Test

AIM: - Hardness Test of Steel

OBJECTIVE: - To determine hardness of the given specimen using Rockwell hardness test.

APPARATUS: - 1) Rockwell hardness testing machine

2) Specimen of hard steel

3) Diamond cone indenter

THEORY: - Hardness is defined as the resistance of a metal to plastic deformation against Indentation, scratching, abrasion of cutting. The hardness of a material by this Rockwell hardness test method is measured by the depth of Penetration of the indenter. The depth of Penetration is inversely proportional to the hardness. Both ball or diamond cone types of indenters are used in this test.

First minor load is applied to overcome the film thickness on the metal surface. Minor load also eliminates errors in the depth of measurements due to spring of the machine frame or setting down of the specimen and table attachments.

The Rockwell hardness is derived from the measurement of the depth of the impression

EP = Depth of penetration due to Minor load of 98.07 N.

Ea. = Increase in depth of penetration due to Major load.

E = Permanent increase of depth of indentation under minor load at 98.07 N even after removal of Major load.

This method of test is suitable for finished or machined parts of simple shapes.

Measurement of indentation is made after removing the additional load. Indenter used is cone having an angle of 120 degrees made of black diamond.

Specification of Hardness Testing M/C and Indenters: - Rockwell Hardness tester gives the direct reading of a hardness number on a dial provided with the machine.

1) Ability to determine the hardness up to 100 RHN.
2) Maximum application of load 150kg.
3) Minimum application of load 10kg.
4) Method of load application, lever type.
5) Least measuring hardness number 1RHN.

Fig:- Rockwell Hardness Tester

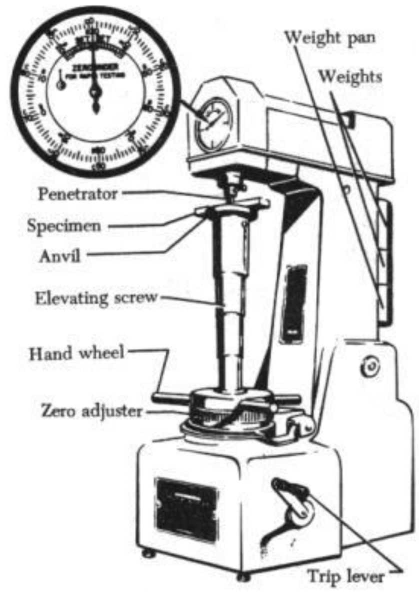


FIGURE 6–69. Rockwell hardness tester.

Technical Data:-

Maximum test height: - 295mm

Depth of throat: - 150 mm

Maximum depth of screw below base:-280mm

Dimensions of machine:-210X470mm

Height: - 850mm

Net weight:-125kg

Procedure: - For carrying out tests, the following procedure has to be followed carefully, any negligence may lead to damage to the indenter.

1) From the specimen given mark 2.5 in and cut it out using the spark testing. Then polish the surface to make the surface even without any irregularity.
2) Adjust the weight on plunger of dash-post according to the Rockwell scale.
3) Keep the lever at position A.
4) Place specimen securely on the testing table. Turn the handle wheel clockwise, so that specimen will push the indenter and show a reading on dial gauge as small pointer at 3(red spot) and long pointer close to ‘0’of outer scale.
5) Turn the lever from position A to B slowly so that, the total load is brought into action without any jerks.

Fig: - Turn the lever to start loading.

Fig: - Rotate the wheel to ensure that the diamond

cone indenter comes in proper contact with the specimen.

6) The long pointer dial gauge reaches a steady position when indentation is complete. Then take back the lever to ‘A’ position slowly. The weights are thereby lifted off, only the initial load remaining active.
7) Read the figure against the long pointer that is the direct reading of the Rockwell hardness of specimen. Use Black scale to measure Rockwell C Hardness of specimen.
8) Turn back the hand wheel and remove the specimen piece. Carry on the same procedure for further tests.
9) The first hardness value so obtained may not be correct. All standards recommend neglecting the first two reading to ensure that specimen, the indenter and the anvil are seating correctly. Further readings will be correct.

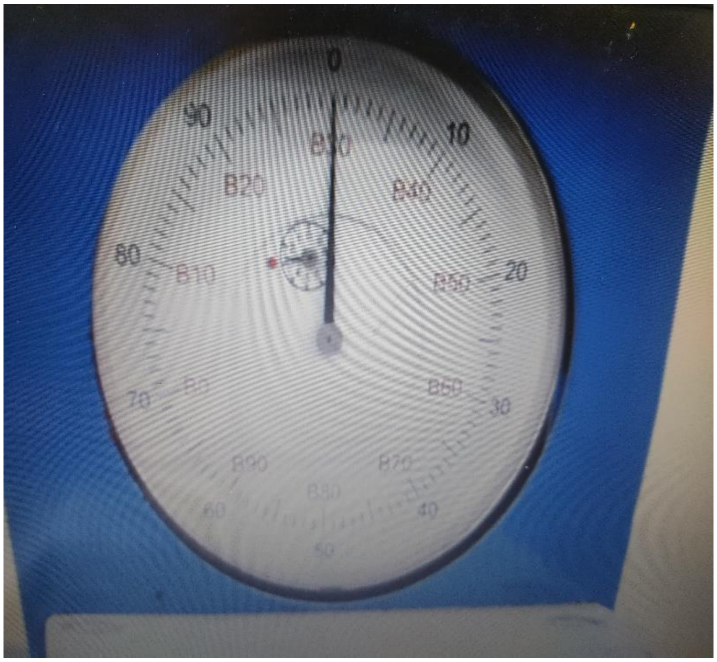


Fig: - The small dial pointer should correspond to 3 and larger pointer should correspond to 0.

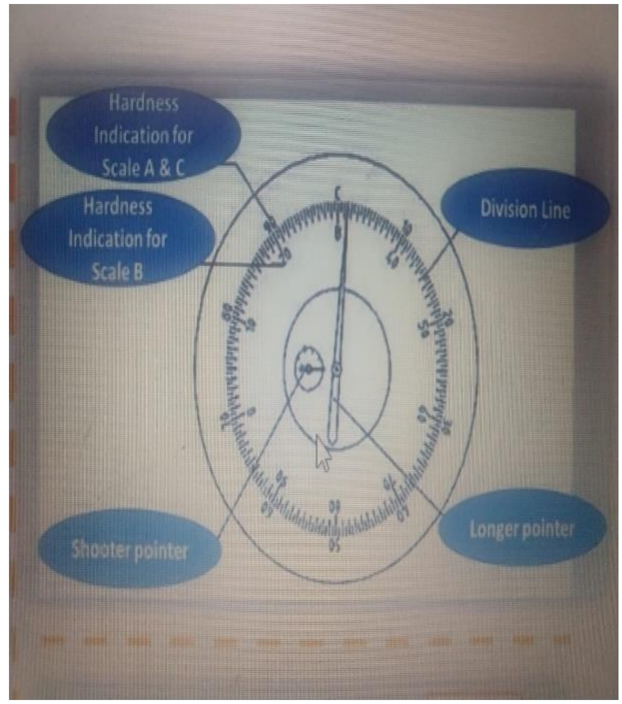


Fig: - The dial illustration for measurement of hardness

Precautions:-

1) Thickness of the specimen should not be less than 8 times the depth of the indentation to avoid the deformation to be extended to the opposite face of a specimen.
2) Indentation should not be made nearer to the edge of a specimen to avoid unnecessary concentration of stresses. In such case distance from the edge to the center of the indentation should be greater than 2.5 times diameter of indentation.
3) Rapid rate of applying load should be avoided. Load applied on the ball may rise a little because of its sudden action. Also rapidly applied load will restrict plastic flow of a material, which produces effect on size of indentation.
4) After applying Major load, wait for some time to allow the needle to come to rest. The waiting time vary from 2 to 8 seconds.
5) The surface of the test piece should be smooth and even and free from oxide scale and foreign matter.
6) For thin metal prices place another sufficiently thick metal piece between the test specimen and the platform to avoid any damage which may likely occur to the platform.

Tabular Column:-

SL No.	Specimen Material	Type of Indenter	Radius of indenter(mm)	Load applied(kgf)	Rockwell reading (HRC)
1	Steel	Diamond cone with an angle of 120 degrees	0.2	Major load:- 150 Minor load:- 10	18
2	Steel	Diamond cone with an angle of 120 degrees	0.2	Major load:- 150 Minor load:- 10	20
3	Steel	Diamond cone with an angle of 120 degrees	0.2	Major load:- 150 Minor load:- 10	23
4	Steel	Diamond cone with an angle of 120 degrees	0.2	Major load:- 150 Minor load:- 10	25
5	Steel	Diamond cone with an angle of 120 degrees	0.2	Major load:- 150 Minor load:- 10	21
6	Steel	Diamond cone with an angle of 120 degrees	0.2	Major load:- 150 Minor load:- 10	24

Average of the Rockwell reading (HRC) = (20+23+25+21+24)/5= 22.6 HRC

Chart: - Chart for most commonly used for Rockwell hardness test.

Total test force preliminary test force(10kgf)	60kgf	100kgf	150kgf
Indicator	Diamond Cone 120 degree	Ball 1/16th diameter	Diameter cone 120 degree
Scale	A	B	C
Pointer position on dial at	Set	Set	Set
Dial to be read	Black	Red	Black
Typical application	Thin steel and shallow case hardened steel	Soft steel,malleable,copper and aluminum alloys	Steel, hard cast steel, deep case hardened steel, other metals

Observation:-

1) Take average of the indentation of the given specimen. Obtain the hardness number from the dial of the machine.
2) For hard materials, diamond cone indenter with C scale (black graduation) is used applying major load up to 150kg.
3) For soft materials, ball (1/16th diameter) indenter with B scale (red graduation) is used applying major load up to 100kg.
4) The given specimen of steel being hard materials, its hardness was measured by using Rockwell C scale and diamond cone indenter.

Result: - Rockwell Hardness Number of the given specimen, HRC = 22.6 HRC

Pictures:-

Fig:- Indentation marks on the specimen

Fig:- Indentation marks on the specimen

Fig:- Specimen before testing

Tension Test

AIM: - To determine tensile test on the cast iron specimen.

Objective: - To conduct the tensile test on a specimen and determine the following

I) Limit of proportionality

II) Elastic Limit

III) Yield strength

IV) Ultimate strength

V) Young's modulus of elasticity

VI) Percentage of elongation

VII) Percentage reduction in area

Apparatus:-

1) UTM
2) Vernier Caliper
3) Cast iron Specimen

Theory: - The tensile test is most applied one, of all mechanical test. In this test ends of test piece are fixed into the grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original form as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve which is recoverable immediately after unloading is termed. As elastic and rest of the curve which represents the manner in which solid undergoes plastic deformation is called plastic. The stress below which the deformation essentially entirely elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. This stage the ultimate strength which is defined as the ratio of the load on the specimen to original cross section area, reaches a maximum value. Further loading, will cause neck formation and rupture.

Specifications: - Tensile Clearance at fully descended working piston (mm) = 50 to 700

Jaws for round bar (mm) = 10 to 25 & 25 to 40

Jaws for sheets metal (mm) = 0 to 15 and 15 to 30

Width (mm) = 65

The sample dimensions ratio of test length to test diameter should be 1:2 like test length =25 mmm and test diameter = 50 mm.

Description: - Select the proper jaw inserts and complete the upper and lower chuck assemblies as described. Apply some graphite grease to the tapered surface of the grip for the smooth motion then operate the upper cross head grip operation handle and grip fully the upper part of the test piece. The left valve is kept in fully closed position and the right valve normal open position. Open the right valve and close at after the lower table is slightly lifted. Now adjust the load to zero to Tare push button. Operate the lower grip operation handle left the lower head up and grip fully the lower part of the specimen. The lock the jaws in this position by operating the jaw locking handle. Then turn the right control valve slowly to open the position, (anti clock wise) until you get a desired loading rate. After this you will find that the specimen is under load and looser unclamp the locking handle. Now the jaws will not slide down due to their own weight then go on increasing the load. When the test piece is broken, close the right control valve and take out the broken test pieces. Then open the test control valve to take the position down.

Fig: - Universal Testing Machine

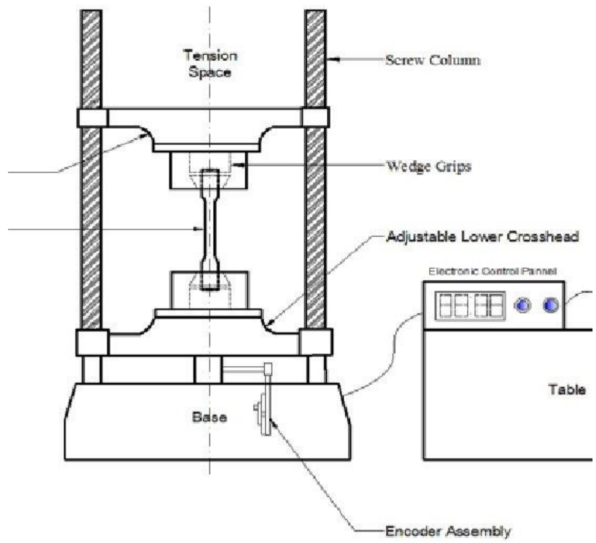
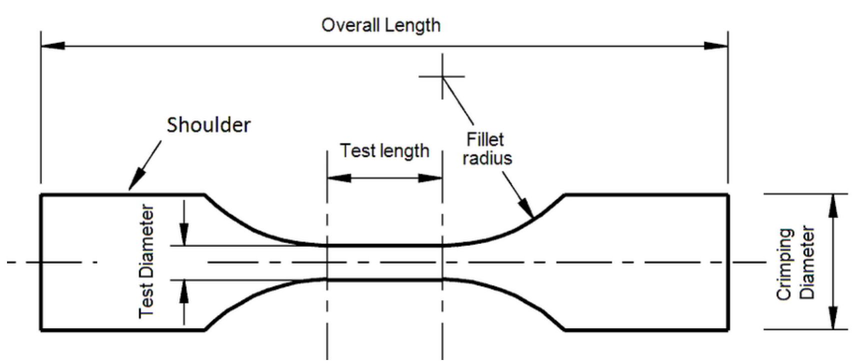


Fig: - Dogbone Specimen



Procedure:-

1) The sample of the material will be cut or injection moulded into dogbone shape according to the ASTM standard of ratio of test length to test diameter being 1:2 with the help of Vernier caliper.
2) Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
3) Insert the specimen into grips of the test machine and attach strain-measuring device to it.

4) Begin the load application and record load versus elongation data.
5) Take readings more frequently as yield point is approached.
6) Continue the test till Fracture occurs.
7) By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

Observation table:-

Dimensions before fracture:-

Test length (mm) = 3.22

Test diameter (mm) = 5

Dimensions after fracture:-

Test length (mm) = 4.7

Test diameter (mm) = 8.9

Chart 7

	A	B	C	D	E
1	Strain	Stress	0.2% offset	0.2% offset stress	
2	0	0	0.002	0	
3	0.1932	23.3769	0.1952	18.9961968	
4	0.4337	46.9601	0.4357	42.6431188	
5	0.9821	103.2789	0.9841	96.5640004	
6	1.2915	134.2206	1.2935	126.985446	
7	1.6792	168.5832	1.6812	165.1056608	
8	2.1109	206.5805	2.1129	207.5521316	
9	2.9254	288.9095	2.9274	287.6370296	
10	4.0554	412.0092	4.0574	398.7431496	
11	4.991	488.8513	4.993	490.735084	
12	5.5494	523.5175	5.5514	545.6392056	
13	6.1992	553.4813	6.2012	609.5301408	
14	6.8865	575.3517	6.8885	677.108226	
15	7.7571	596.406	7.7591	762.7091004	
16	8.3171	608.173	8.3191	817.7705404	
17	10.0515	638.6314	10.0535	988.303686	
18	11.3326	655.9451	11.3346	1114.266562	
19	12.1098	664.5007	12.1118	1190.683975	
20	13.8398	678.8143	13.8418	1360.784495	
21	15.0137	685.3009	15.0157	1476.207039	
22	20.2438	689.1169	20.2458	1990.451391	
23	20.3332	688.8303	20.3352	1999.241557	

A	B	C	D	E
10.0515	638.6314	10.0535	988.303686	
11.3326	655.9451	11.3346	1114.266562	
12.1098	664.5007	12.1118	1190.683975	
13.8398	678.8143	13.8418	1360.784495	
15.0137	685.3009	15.0157	1476.207039	
20.2438	689.1169	20.2458	1990.451391	
20.3332	688.8303	20.3352	1999.241557	
21.1948	684.4639	21.1968	2083.957515	
21.6421	678.8896	21.6441	2127.93784	
21.8099	672.8515	21.8119	2144.436608	
21.9221	662.0479	21.9241	2155.46856	
21.9443	655.9637	21.9463	2157.651353	
21.9554	648.2588	21.9574	2158.74275	
21.9665	638.8815	21.9685	2159.834146	
21.9738	-123.859	21.9758	2160.551911	
21.9738	-123.818	21.9758	2160.551911	

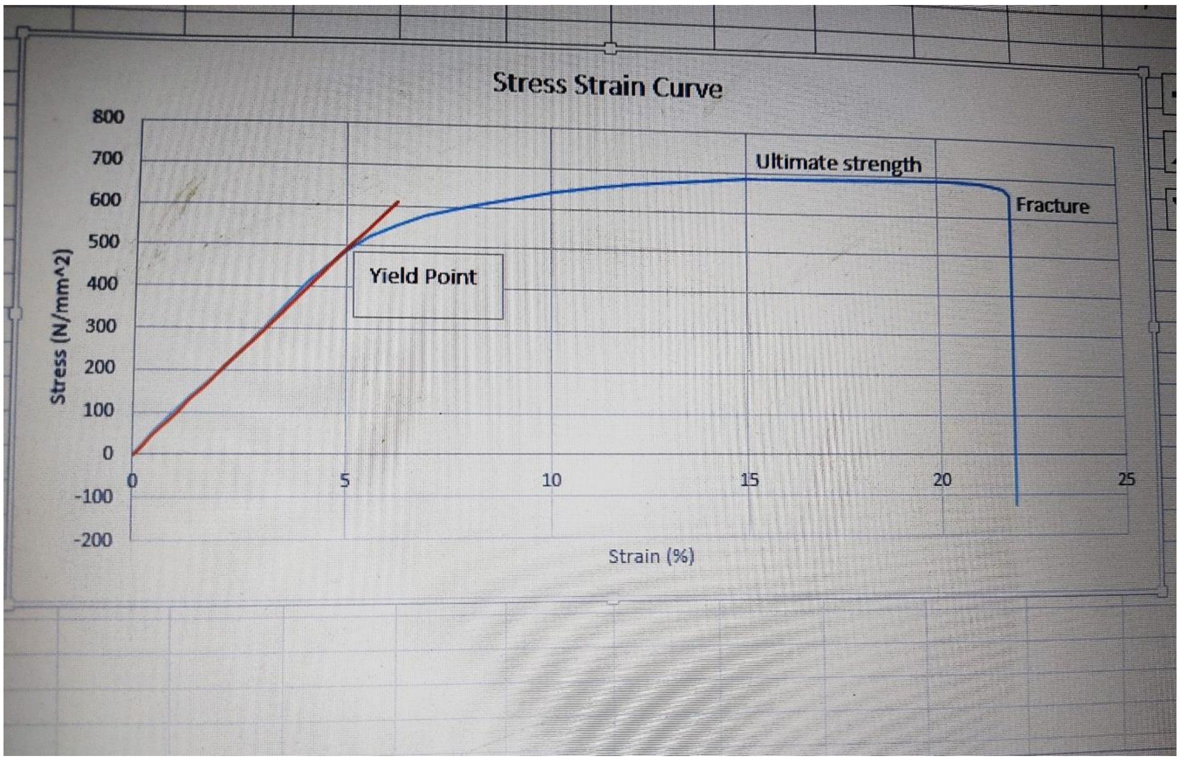
Fig: - Observational data points for stress strain curve plot for specimen given

Precautions:-

1) Maintain distance from while the experiment is processing.
2) The specimen should be prepared in proper dimensions.
3) The specimen should be properly to get between the jaws.
4) After breaking specimen stop to m/c.
5) If the specimen breaks due to any reason, other than the tensile test, the test procedure should be discarded and a new test must be performed on a fresh specimen.
6) The grips used in the UTM must be properly serrated so that there is no chance of slippage of specimen.
7) The thickness of the specimen should be according to the standard requirement.

Results: - Stress strain curve plotted for the given specimen. The Young's modulus value calculated from the graph is 98.324 (N/mm^2).

Graph:-



Picture:-

Fig: - Dogbone specimen undergone fracture after tensile testing

Compression Test

AIM: - To perform compressive test on the given brass specimen

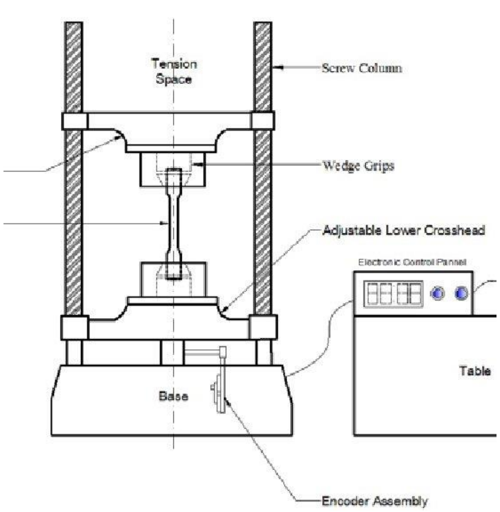
Objective: - To conduct compressive test of given specimen to determine the compressive strength.

Apparatus:-

1) UTM
2) Compressive pads
3) Given Specimen (Brass)

Theory: - Several m/c and structure components such as columns and struts are subjected to compressive load in applications. These components are made of high compressive strength materials. Not all the materials are strong in compression. Several materials, which are good in tension, are poor in compression. Contrary to this, many materials poor in tension but very strong in compression. Cast iron is one such example. That is why determine of ultimate compressive strength is essential before using a material. This strength is determined by conduct of a compression test.

Compression test is just opposite in nature to tensile test. Nature of deformation and fracture is quite different from that in tensile test. Compressive load tends to squeeze the specimen. Brittle materials are generally weak in tension but strong in compression. Hence this test is normally performed on cast iron, cement concrete etc. But ductile materials like aluminum and mild steel which are strong in tension, are also tested in compression.



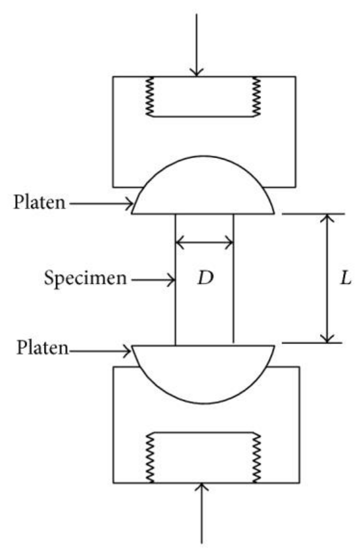


Fig: - Universal Testing Machine Fig: - How specimen is placed between the compressive pads

Description: - Fix upper and lower pressure plates on the lower cross – head and lower table respectively. Place the specimen on lower compression plate. The specimen must be aligned exactly according to the marking on the compression plate order to give the complete cross-section the specimen a change to participate equally in the acceptance of load. Then adjusted to by lifting the lower table and perform the test in the same way as the tension test.

Specification and Specimen Details: - A compression test can be performed on UTM by keeping the test-piece on base block and moving down the central grip to apply load. It can also be performed on a compression testing machine. A compression testing machine shown in fig. it has two compression plates/heads. The upper head moveable while the lower head is stationary. One of the two heads is equipped with a hemispherical bearing to obtain. Uniform distribution of load over the test-piece ends. A load gauge is fitted for recording the applied load.

Specimen: - In cylindrical specimen, it is essential to make the specimen according to the ASTM which requires us to prepare the specimen according to the ratio of length to width should be less than or equal to 2:1. This is done to avoid lateral instability due to bucking action and maintain axial load application.

Procedure:-

1) From the given brass specimen using spark testing cut a cylindrical shaped specimen with a dimension of length to diameter 2:1 which was measured using Vernier Caliper.
2) Place the specimen in position between the compression pads
3) Switch on the UTM
4) Bring the drag indicator in contact with the main indicator.
5) Select the suitable range of loads and space the corresponding weight in the pendulum and balance it if necessary with the help of small balancing weights.
6) Operate the button for driving the motor to drive the pump.
7) Gradually move the head control ever in left hand direction till the specimen fails.
8) Note down the load at which the specimen shears.
9) Stop the machine and remove the specimen.
10) Repeat the experiment with other specimens.

Observation:-

Specimen dimensions before fracture

Cylinder height: - 20.1 mm

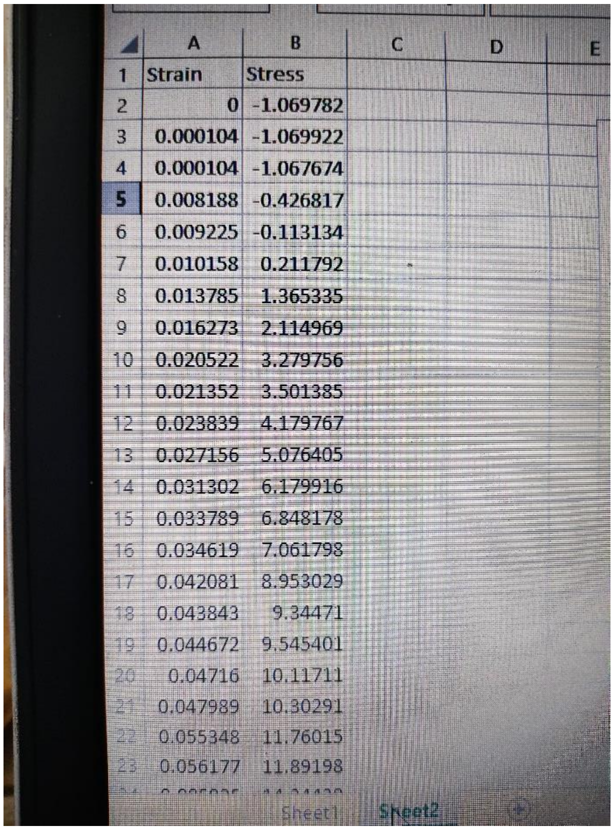
Cylinder diameter: - 12 mm

Speed: - 1mm/min

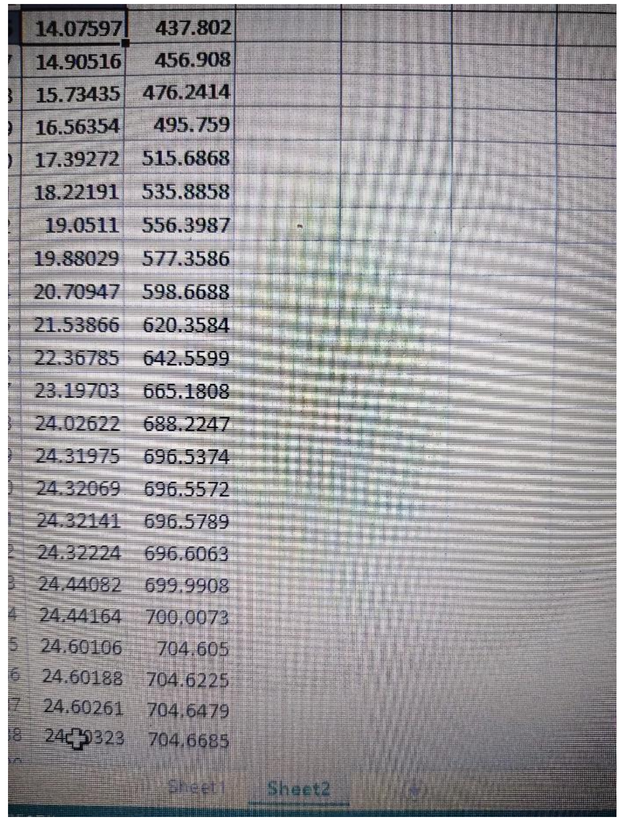
Specimen dimensions after fracture

Cylinder height: - 1.62 mm

Cylinder diameter: - 13.5 mm



	A	B	C	D	E
1	Strain	Stress			
2	0	-1.069782			
3	0.000104	-1.069922			
4	0.000104	-1.067674			
5	0.008188	-0.426817			
6	0.009225	-0.113134			
7	0.010158	0.211792			
8	0.013785	1.365335			
9	0.016273	2.114969			
10	0.020522	3.279756			
11	0.021352	3.501385			
12	0.023839	4.179767			
13	0.027156	5.076405			
14	0.031302	6.179916			
15	0.033789	6.848178			
16	0.034619	7.061798			
17	0.042081	8.953029			
18	0.043843	9.34471			
19	0.044672	9.545401			
20	0.04716	10.11711			
21	0.047989	10.30291			
22	0.055348	11.76015			
23	0.056177	11.89198			



14.07597	437.802
14.90516	456.908
15.73435	476.2414
16.56354	495.759
17.39272	515.6868
18.22191	535.8858
19.0511	556.3987
19.88029	577.3586
20.70947	598.6688
21.53866	620.3584
22.36785	642.5599
23.19703	665.1808
24.02622	688.2247
24.31975	696.5374
24.32069	696.5572
24.32141	696.5789
24.32224	696.6063
24.44082	699.9908
24.44164	700.0073
24.60106	704.605
24.60188	704.6225
24.60261	704.6479
24[illegible]0323	704.6685

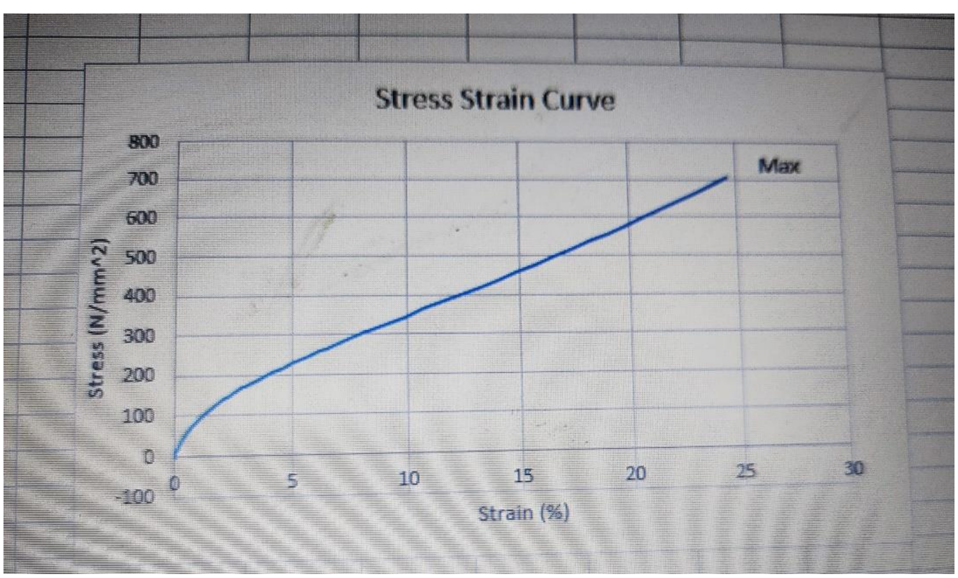
Fig: - Observational data point used to plot stress strain curve for compressive testing for the given specimen

Precautions:-

1) Place the specimen at center of compression pads.
2) The specimen should be prepared in proper dimensions.
3) Stop the UTM as soon as the specimen fails.
4) Cross sectional area of specimen for compression test should be kept large as compared to the specimen for tension test: to obtain the proper degree of stability.
5) Take reading carefully.
6) The loading is to be increased gradually.
7) Check the values entered are proper or not at the beginning of the compression test.

Results: - The stress strain curve for stress strain curve was plotted successfully.

Graph:-



Pictures: -

Fig: - Brass specimen after compressive test with bulging and reduced height