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Design and Fabrication of Peel Strength Measuring Machine

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Abstract: The project mainly focuses on measuring peel strength of adhesive tapes. Peel strength is average force required to separate two bonded materials from one another.

It is properly applicable to various industries such as aerospace, automotive, adhesives, packaging, biomaterials, microelectronics, etc. Peel test data is used to determine the quality of the adhesive joint. Peel tests are constant- speed tests in the tensile direction. In material testing, peel strength is calculated after measuring and averaging the load to peel the specimen and dividing the average load by unit width of the adhesive. Different adhesives are used for joining the different types of materials. The different types of peel tests available for investigating the adhesive strength are 90º, 135º, 180º and T-peel test. This project mainly focuses on 180º peel type test.

Focal point of this study is to get precise reading by 180-degree peel strength measurement machine. In peel strength measuring machine the motor used is of low rpm which drives power screw with help of coupler. Rotational motion of lead screw is converted into linear motion of table. Support rods supports table mounted on lead screw and strength of adhesive tested with help of measuring gauge.

I. INTRODUCTION

The project Peel Strength Measuring Machine is mainly focused on measuring the Peel strength of adhesive tapes. Peel strength is very important factor for any type of adhesive as it plays very important role for the selection of adhesive and as per the requirement parameter. Peel strength is generally used to measure the bond strength of a material, typically an adhesive. Peel strength is the average load per unit width of bond line required to separate bonded materials where the angle of separation is 180 degrees.

Peeling tests are the practice of testing adhesion properties of film bonded to substrate, usually by tensile. The peel strength determines the adhesive strength (also called the adhesive fracture toughness). Physical testing of packaging products by peeling can tell us a lot about its properties and manufacturing process such as sealing consistency, bonding strength, adherence ability, and cohesive properties of the interface, bond durability and other Parameters.

There are two primary reasons for performing a peeling test:

1. Assessing the uniformity of the adhesion of a given type of pressure sensitive
2. Distinguishing between acceptable and unacceptable criteria, by determining the adhesive strength range which is acceptable for consumer or for the purpose of the adhesive.

II. OBJECTIVE

1. To check and ensure quality of adhesive bond using 180 Degree Peel test.
2. To check effect on peel strength of different types of adhesive tapes at different temperatures.
3. To design and manufacture cost effective and modular peel strength testing machine with upgradable option using relatively low cost with simplicity in construction using readily available materials in workshops.
4. To Asses the uniformity of the adhesion of a given type of pressure sensitive adhesive interface, which indicates a bad adhesion and good adhesion between the adhesives and the adherents.

III. PROBLEM STATEMENT

Currently industries are using the peel strength measuring machine which works on the mechanism of '90° peel test type 'A' in which the complexity of the machine is very high which resulted in high cost of the machine. But as peeling angle increases the accuracy will also increases, so we are focusing on '180° peel test type B' as per ASTM standard D3330.

On the other side, the solution that we have proposed based on the 180° peel strength mechanism which has reduced the machine complexity and result economical peel strength measuring machine.

Figure 3.1. Existing Peel strength Tester

IV. METHODOLOGY

PSMM (Peel Strength Measurement Machine) consist of these main parts-

1. Driving motor
2. Body or Frame
3. Coupler
4. Power Screw
5. Table Mounting
6. Supporting plates
7. Toggle Switch
8. Limit switches
9. Supporting Bar
10. Bearing

V. DESIGN CALCULATION

By analyzing all related articles and research paper we finally conclude with required analytical calculations and decide the all specification of parts for doing optimum design of Peel Strength Testing Machine. For this by calculating power requirement for prime mover we select other parts of machine-like pitch of power screw, bearings, etc. After concluding with all the setup, we take many readings on different adhesive tapes for gathering final results.

Nominal diameter	Major Diameter		Minor diameter	Pitch	Depth of thread		Area of core(Ac) mm2
	Bolt	Nut			Bolt	Nut	
d1	d	D	dc	p	h	H	Ac
14	14	14.5	12	2	1	12.5	113
16	16	16.5	14				154
18	18	18.5	16				201
20	20	20.5	18				254

Table 5.1. IS:4694-1968 dimensions for Square thread

For our design, taking its compactness in size and working load of max. 20 kg inconsideration we had chosen 24 mm as Nominal dia. For square thread shaft. And as per IS: 4694-1968 dimensions (all are in mm) are-

Nominal dia. = 18
Major dia. = 18(for bolt), 18.5(for nut)
Minor dia. = 16
Pitch = 2
Depth of thread = 1(for bolt), 1.25(for nut)
Coefficient of friction (for mild steel bolt and Nut) (tanØ) = 0.09 ….. [As per ref. mentioned textbook]

As per ASTM D3330 Standards peeling should be done with max. Velocity of 300mm/min, so
V=300mm/min

So, this will be standard data, as we require low speed motor which carries max. 20 kg load, so we are estimating motor specifications as per follow-

W = 20kg = 20x9.81N = 196.13N

Motor Speed (N) = $\frac{\text{Velocit of nut}}{\text{Pitch of screw}} = \frac{120}{2}$ = 60 rpm

Angular speed (ω) =$2\pi \times \frac{60}{60}$ = 6.28rad/s

tanα = $\frac{\text{Pitch}}{\pi \times \text{Dia of Screw}}$ = 0.03539

So, force required at circumference of the screw (P)

$$P = W \tan(\alpha + \phi) = W \left[\frac{\tan\alpha + \tan\phi}{1 - \tan\alpha \cdot \tan\phi}\right]$$

P=24.6713N

Torque of motor (T) = P x radius of power screw= 24.6713 x 9

= 222.041 N-mm

= 22.634 Kg-mm

≈ 2.263 kg-cm

Power of Motor (P) = (ω) x (T) = 222.041 x 6.28 = 1394.423 W

=1.3945 kW≈ 1.5 kW

This parameter we had calculated for Electric Motor for our requirement and from these specifications available electric motor in market is,

Speed	60 rpm
No. of phase	Single Phase
Country of origin	India
Torque	7 Kgcm
Voltage	240 V
Current	125 mA

5.1.Parameters of Power Screw :-

By considering desired dynamic load, static load and motor rpm we design the power screw of following parameters.

1. Material used - Stainless Steel
2. Major Diameter - 18mm
3. Minor diameter - 16mm
4. Pitch - 2mm
5. Length - 500mm
6. Thread Type – Acme Thread angle-29

5.2.Parameters of Bearing :-

By considering desired dynamic and static load considerations and considering nominal diameter of power screw (15mm) we use bearing including following specifications [From Ref No.10]

1. Part no - UCP202 (Metric Series Two Bolt Pillow Block)
2. Bearing type - Extended inner race with set screws
3. Dynamic Load Rating (Cr) - 12.843N
4. Static Load Rating (Cor) – 6.668N
5. Shaft Dia. - 15.000mm
6. Weight (g) - 635.00grams
7. Material Used - Cast iron housing and Chrome steel bearing

5.3.Parameters of Universal Joint :-

By considering eccentricity between motor shaft and power screw and different diameters of both we prefer universal joint having flexibility up to 450 and including following parameters. [19]

1. Type-Single Joint Universal Coupling
2. Material-Stainless Steel
3. Min.Torque-5.5Nm

5.4. 3D Model Design in Catia

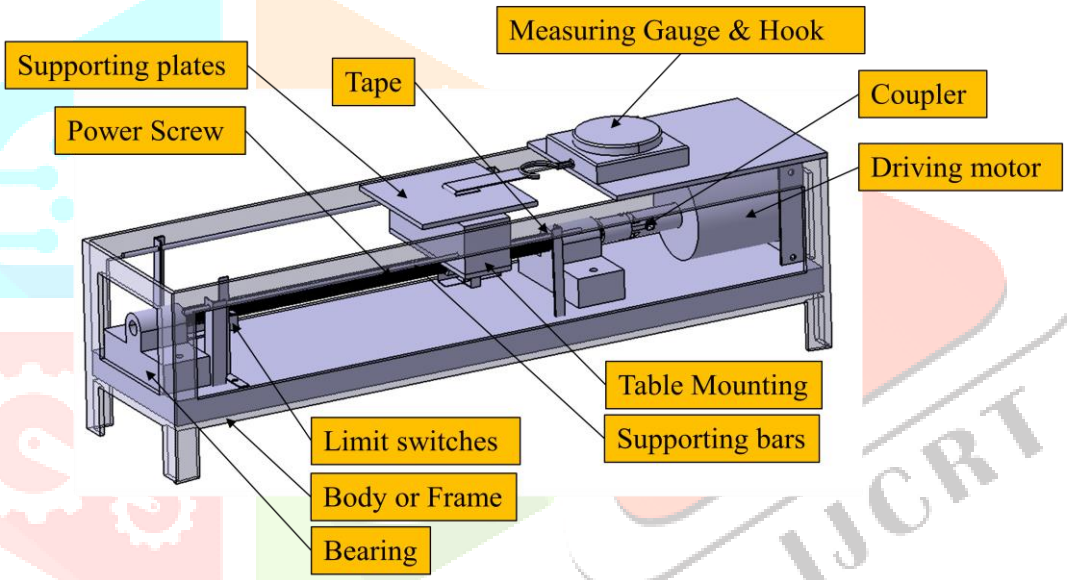


Fig.5.4.1. Catia Design Model Of peel Strength Testing Machine and Its components

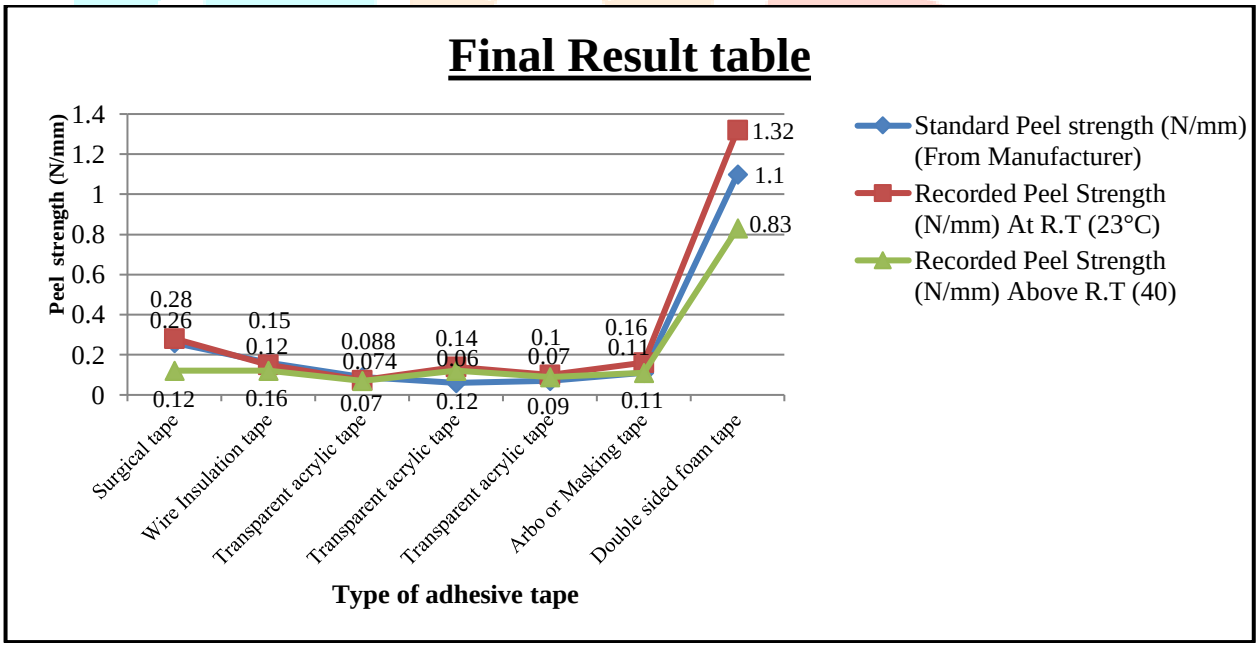
VI. TESTING AND RESULTS

6.1. Final Result table :-

After performing standard test on different adhesive tapes by peel testing machine we have concluded with following sample result,

Sr. No.	Type of adhesive tape	Standard Peel strength (N/mm) (From Manufacturer)	Recorded Peel Strength (N/mm)	
			At R.T (23°C)	Above R.T (40°C)
1.	Surgical tape (25 mm)	0.26	0.28	0.12
2.	Wire Insulation tape (18 mm)	0.16	0.15	0.12
4.	Transparent acrylic tape (10 mm)	0.088	0.074	0.07
5.	Transparent acrylic tape (1 inch)	0.06	0.14	0.12
6.	Transparent acrylic tape (2 Inch)	0.07	0.10	0.09
1.	Arbo or Masking tape (1 inch)	0.11	0.16	0.11
1.	Double sided foam tape (20 mm)	1.10	1.32	0.83

6.2. Graphical Representation :-



VII. CONCLUSION

1. By performing peel test at different temperature results obtained are:
   i) For 3M double sided acrylic tape, standard value is 1.10 N/mm, value at room temperature is 1.32 N/mm, and value above room temperature is 0.83 N/mm.
   ii) For wonder tape 1 inch standard value is 0.07 N/mm, Value at room temperature is 0.1 N/mm, and value above room temperature is 0.9 N/mm.

   Similarly, from other reading we can conclude that:
   - As temperature increases strength required for peeling adhesive is decreases.
   - Temperature is inversely proportional to peel strength.

2. By performing peel test at different surface finish i.e. on steel plate and aluminum sheet for Wonder tape 555 (1 inch),
   i) Using stainless steel panel value at room temperature is 0.1 N/mm, above room temperature 0.09 N/mm.
   ii) Using Aluminum composite panel value at room temperature 0.14 N/mm, value above room temperature 0.1 N/mm.
   iii) As surface roughness increases value strength required for peeling is also increases.
   iv) Surface roughness is directly proportional to peel strength.

After performing peel test on different adhesive tapes by peel strength measuring machine, we can conclude that highest peel strength required is for 3m double tape which is nearly 1.32 N/mm at room temperature.
Currently industries use 90-degree peel strength measuring machine for finding peel strength of different adhesives, which is quite expensive, we introduce totally new idea of 180-degree peel strength measuring machine with fabrication in affordable range and gives precise reading.

VIII. FUTURE SCOPE

- We are fabricating 180º peel strength measuring machine to obtain accuracy at low cost near about 15k, when the machines available in market cost near about 1.5 lac.
- If we use digital gauges, it will cost up to 45-50 k (depending upon precision of gauge) and hence in future we improve the accuracy of this, using digital measuring gauge.
- Using this machine, we can perform test on different types of materials, there is no requirement of specific material.
- This test can performed anywhere at any atmospheric condition and at any temperature.
- After some modification we can perform both 180º and 90º peel strength test on this machine

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