THE MEASUREMENT OF ADHESIVE TACK

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INTRODUCTION

Tack is the property of adhesives that allows the immediate formation of a bond on contact with another surface - in other words it is a definition of the 'stickiness' of the adhesive. Control of tack is essential in many bonding processes. Too great a tack may cause nearly as many problems (in removing and refitting) as too low a tack (leading to bond failure) during bonding assembly. Thus, measurement of tack is important for adhesive and process selection as well as in quality control.

Tack is a complex property depending on the adhesive, the surfaces and the assembly/testing process. The human thumb is a sensitive instrument for investigating tackiness but, unfortunately, is neither quantitative, capable of calibration nor reproducibly sensitive. Tack measurement methods are therefore required. Tack is defined and measured in many - usually incomparable - ways in different industries. Thus measured values are often not transferable between applications leading to re-testing. Better understanding of tack measurements is one of the aims of the DTI Materials Metrology programme on the Performance of Adhesive Joints. NPL, SATRA and Pira International have collaborated in research into better tack measurement. This paper summarises some of the findings of this research.

TACK IN THE FOOTWEAR INDUSTRY

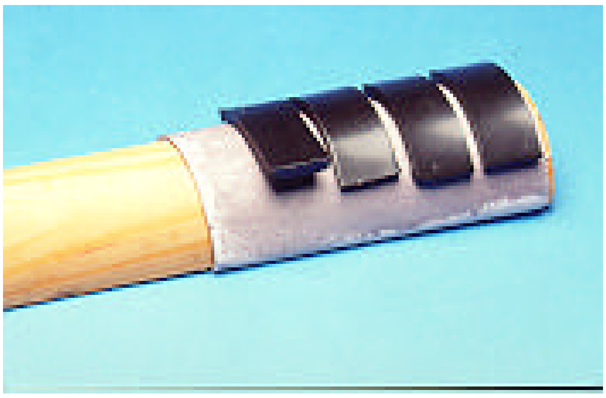

Figure 1: Shoe Tack Test

Adhesive tack is of particular concern in the manufacture of footwear. The heat activated adhesive is required to hold sole and upper together during manufacture. The industry standard method for assessing tack was to nail the leather upper to a semi-circular wooden mandrel and bond, under light manual pressure, a standardised rubber sole sample (Figure 1). The tack was determined qualitatively from the extent of spontaneous peel of the sole from the mandrel occurring within a set time. This technique was recognised to be flawed, particularly in the difficulty of reproducing the press-on force with different operators.

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SATRA and NPL jointly developed an instrumented testing device to improve the measurement of footwear tack (1). This instrument is shown in Figure 2. The test stand and load cell allow control of the loading rate and compressive force in forming the bond. The tensile force required to rupture the bond is then measured. Test fixtures can include shaped mandrels and flat surfaces. Using the latter arrangement, a comprehensive study of the influence of the variables associated with shoe adhesive preparation and testing was performed by SATRA. The results of this study indicate that the measured tack force is very sensitive to the compliance of the test substrate, the thermal and loading history of the adhesive and the coating weight. Typical results are shown in Figures 3 and 4. These results show the important test conditions to control for quantitative, comparative studies and also point towards process conditions for better bonding.

Figure 2: SATRA/NPL Shoe Tack Tester

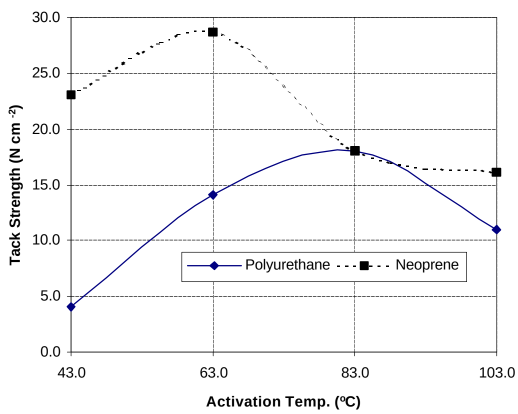


Figure 3. Tack Strength of Two Solvent Based Adhesives at a Range of Temperatures

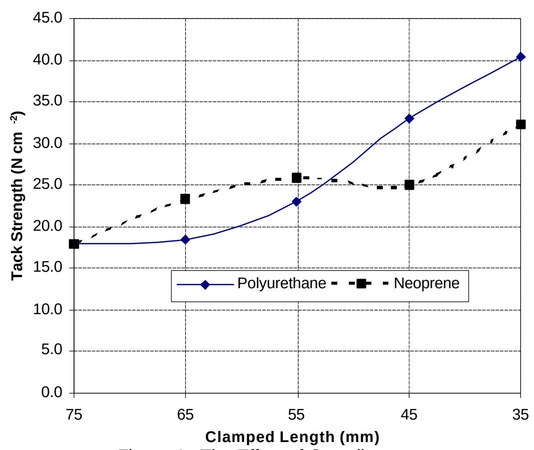


Figure 4: The Effect of Compliance on Measured Tack Strength

LOOP TACK TESTING

Loop tack testing is widely used in the adhesive tape and pressure sensitive adhesive industries, primarily as a quality control tool. A survey of test methods (2) showed that the two British Standards on loop tack testing are not widely used. The most popular method is the FINAT Test Method No 9 (3). The steps involved in the test are shown in Figure 5. Typical apparatus used is shown in Figure 6. The forces applied on compressing the loop (not required for the FINAT method) and on pulling the tape off the float glass plate are measured using a load cell attached to the loop.

A comparative round-robin exercise organised by Pira involved 13 companies measuring three tapes (designated high, medium and low tack; corresponding to tapes 1,2 and 3 respectively in Table I) using this method (4). The results of this study showed that whereas repeatability within a laboratory was reasonable, reproducibility between laboratories was poor. The results showed that 9 out of the 13 laboratories ranked the tapes according to their nominal tack ranking whilst the rest did not. The tape with the highest nominal tack (tape 1) also had the least rigid backing material. Many of the laboratories reported difficulties handling this tape and forming satisfactory loops. Where the ranking order reported differed from the nominal order, the loop tack forces measured for this tape were extremely low compared with the other laboratories. The measurements for the other tapes with stiffer backings were normally comparable. Thus the variations in the ranking may be ascribed to difficulties in handling low stiffness tapes.

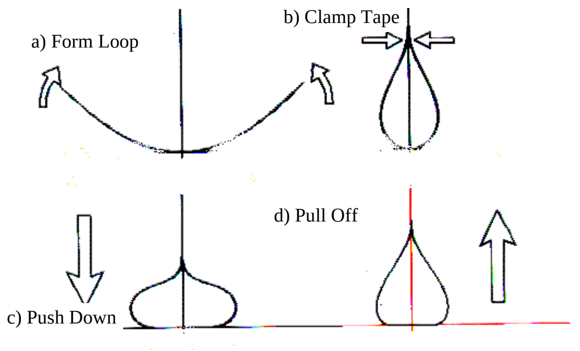


Figure 5: Cycles in the Loop Tack Test

Figure 6: Loop Tack Test

COMPARISON OF TEST MEASUREMENTS

The most commonly used methods for measuring tack are the loop tack test (e.g. the FINAT No 9), probe tack test and rolling ball test. A study was undertaken by NPL to compare these test methods for measuring the tack of a number of tapes (5).

Figure 7: Probe Tack Head

The probe tack test (6), Figure 7, is performed by bringing the probe into contact with the adhesive tape, stuck over an annular weight (giving the contact pressure), maintaining contact for a pre-determined dwell time and then pulling off at the set separation speed. The tack is defined as the maximum force measured while separating the surfaces. Tack tended to increase with contact pressure and dwell time which is expected as both of these will improve spreading of the adhesive.

The rolling ball test (7), Figure 8, relies on measuring the distance required to stop a ball rolling over the adhesive surface of the tape. The shorter the distance to stop, the larger the tack. However, the kinetic energy of the ball will also be absorbed by thick coatings or soft backing materials even when the 'tack' is low.

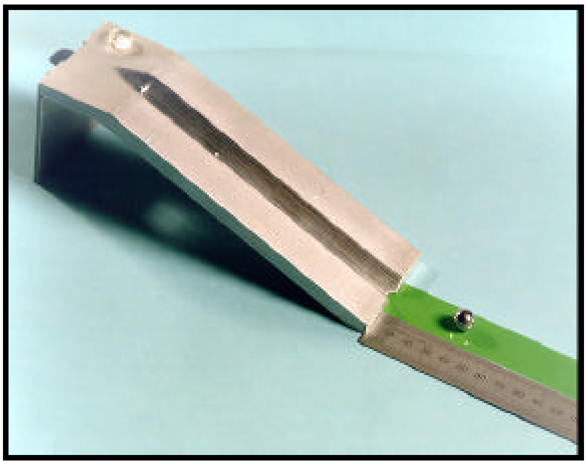


Figure 8: Rolling Ball Test

A series of tests performed on 8 different tapes using the loop tack and the probe tack tests gave the data shown in Table I. Single sided tapes are indicated (S) and double sided tapes (D). The ranking position for the tape in the series (1 being the most tacky) is given in brackets. Double sided tapes have the highest tack by these test methods. Rolling ball tests were performed on the first three tapes (corresponding to the tapes used in the round robin). In general, the loop and probe tests rank the adhesives in a similar order - each is able to distinguish between 'high' and 'low' tack tapes (although the rank order may change slightly for tapes with similar tack). The variability in the loop and probe tack test results is similar. However, the rolling ball test results conflict with the others. The loop and probe tack tests clearly indicate that tape 1 has the highest tack out of the first three tapes. However, the rolling ball test suggests that this has a significantly lower tack than the other tapes.

Table I: Tack Measurements on Adhesive Tapes

	loop tack		probe tack		rolling ball	
Tape	Force (N)	± 1 sd	Force (N)	± 1 sd	distance (mm)	± 1 sd
1 (S)	23.01 (4)	2.83	5.33 (4)	1.52	652 (3)	88
2 (S)	14.80 (6)	0.65	2.13 (7)	0.35	21 (1)	6.7
3 (S)	9.25 (7)	0.87	3.21 (6)	0.32	190 (2)	18
4 (S)	7.87 (8)	1.61	1.26 (8)	0.23		
5 (D)	35.70 (2)	5.48	10.61 (1)	1.70		
6 (D)	35.12 (3)	4.64	9.37 (2)	1.52		
7 (D)	43.64 (1)	3.38	9.04 (3)	1.29		
8 (S)	28.46 (5)	2.27	3.96 (5)	0.63		

Tapes 2 and 3 are ranked differently by the loop and probe tack methods. Tack is sensitive to test conditions such as contact pressure, dwell time and separation speeds.

These differ between the two test methods as outlined in Table II. As Figure 9 shows, the probe tack of tapes 1-3 increases with increasing dwell time. However, tape 2 is more sensitive to dwell time than tape 3. The ranking of the tapes reverses between 1 s and 10 s dwell time. The longer dwell time is characteristic of the loop tack test and the ranking of the tapes at longer times (tape 2 > tape 3) now agrees with the loop tack test results.

Table II. The practical differences between the loop tack and probe tack methods

	Loop	Probe
Adherend surface	Glass	Stainless steel 304
Adherend roughness	Smooth	280 grit abrasive finish
Contact area	625 square mm	20 square mm (approx.)
Contact pressure	About 0.2 - 5.0 g/ sq. cm	100 g/ sq. cm
Dwell time	Variable, 20 - 30 s	Fixed, 1 s
Speed of separation	5 mm/sec	10 mm/sec

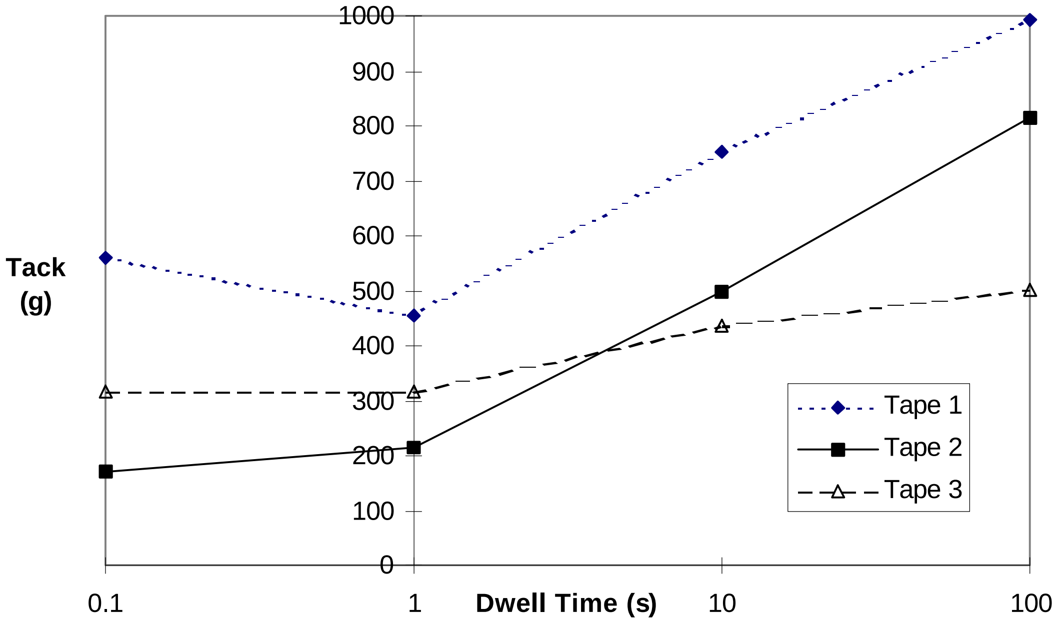
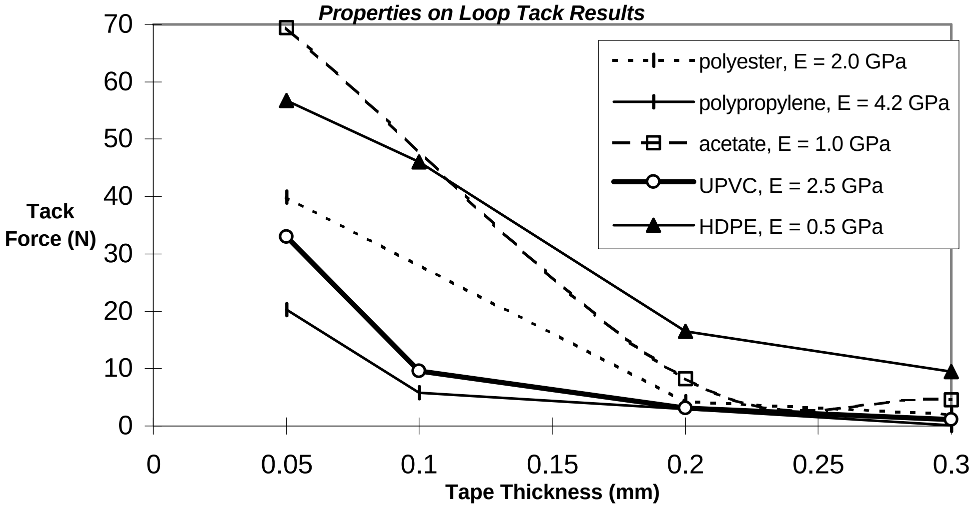


Figure 9: Probe tack as a function of dwell time

MODELLING TACK

It is often difficult to separate influences of the test system from the adhesive in the results since measured tack depends to some degree on the stiffness of the test system. To improve the understanding of how changing the stiffness of the test system effects results a Finite Element model of the loop tack was written at NPL using ABAQUS (8). User elements have been developed to also allow the inclusion of adhesion properties in the model. The effect of changing the material and thickness of the backing tape can be predicted. Some predictions made using the model are shown in Figure 10. The model predicts that decreasing the stiffness and thickness of the backing tape should increase the measured tack force.

Figure 10: FE Predictions of Influence of Backing Tape Properties on Loop Tack Results



CONCLUSIONS

Tack measurement can be strongly influenced by the measurement method and test conditions selected. The effect of temperature, adherend compliance and dwell time are demonstrated. It is important to choose the testing conditions to suit the application of the adhesive. Alternatively, the testing can be used to optimise processing conditions for a given adhesive. Often results are not comparable between the loop, probe and rolling ball tack methods. However, some of these differences may be explained if the practical differences between the test methods are considered.

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