Techniques for Measuring Adhesion and Abrasion Durability of Coatings & Inks

By Scott R. Sabreen, The Sabreen Group, Inc.

This is the second of a 2-part series on Techniques for Measuring Adhesion and Abrasion Durability of Coatings & Inks. This issue examines Abrasion Durability including new equipment and measurement techniques.

As discussed in Part 1 Adhesion -- *Plastics Decorating* 'Technology Feature' January/February 2005, adhesion and abrasion durability of cured coatings and inks are two critical performance properties. These properties can be interdependent but often are mutually exclusive. That is, cured coatings and inks can demonstrate good adhesion and poor abrasion, or poor adhesion and good abrasion. Proper testing and understanding of adhesion and abrasion ensures conformance to specifications and is invaluable in solving coating and printing problems. The identification of the failure mechanism, adhesion (cohesion), abrasion or both, will determine the engineering process solution. This article addresses several different test methods and instruments. Among these is a new linear abraser made by Taber Industries that is designed to evaluate actual product shapes involving contoured surfaces as well as flat specimens. Advanced measurement techniques such as the ones cited in this article are helping manufacturers achieve superior product performance and six-sigma process excellence.

Abrasion Test Methods

Numerous abrasion test methods exist and, similar to adhesion testing, each company must decide which method(s) best evaluates their specific product. Many industries cite specific ASTM requirements based upon the product market application. The Norman Tool Abrader is the original manufacturer of the well known "RCA" Abrasion Wear Tester. Since 1964 Norman Tool Inc. has manufactured, distributed, and exported Abrasion Wear Testers used to test painted or plated organic finishes, foil, and inked key pad lettering for resistance to abrasion and wear. It is commonly used in automotive, appliance, cellular phones, and plastics coating industries. Over the years the system has been continuously upgraded for accuracy and ease-of-use.

This instrument is a point contact abrasion tester and capable of testing flat and concave (actual) products. Weights are 55 grams, 175 grams and 275 grams. The principle operation and purpose of the test is to wear through an applied finish on any substrate via weight (load). At a point of blemish or wear through of the top coat to expose a second surface or coating of a contrasting color or shade will be the point of wear through. The method of operation is a specimen with a coating to be abraded is placed upon a holding device attached to the Tester's base plate so as not to move during abrading. The abrading material, paper, is then threaded through the machine and secured to the windup shaft assembly. After the setup instructions are completed, the counter is turned to zero and the motors are turned on to commence the testing cycle. At a predetermined cycle count, the machine is stopped, and the vertical shaft is raised for evaluation of the tested spot area. The machine also can be cycled continuously. Each specimen plate sent to customers world-wide is pre-verified for accuracy and reproducibility based upon Norman Tool's "Master RCA Abrasion Wear Tester".

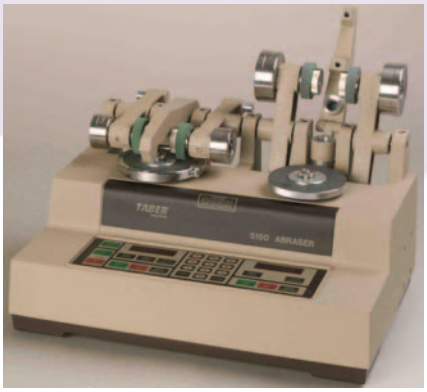
Some technicians strongly recommend that the paper should not be bought for more than six months use. Old paper is less abrasive due to having absorbed moisture. Store the paper in a cool, dry environment. Paper size 11 /16" wide x 8" O.D. on 2" core, un-oiled paper produces approximately 1,800 cycles. Paper tape 1/4" Wide Polyester Tape Reel produces approximately 3,400 cycles. Paper can only be procured from Norman Tool. The Norman Tool Abrader conforms to ASTM F 2357 Standard Test Methods for Determining the Abrasion Resistance of Inks and Coatings on Membrane Switches Using the Norman Tool "RCA" Abrader. Norman Tool has a new pneumatic finger tester apparatus.

Taber Industries has been manufacturing abrasion and wear instruments since 1941. The original Taber Rotary Abraser (shown below) is designed to test flat specimens at constant speed including those that have been painted, coated or printed. Products with contoured geometries cannot be tested directly with this apparatus. Mounted to a rotating turntable, specimens are subjected to rub-wear action of weighted abrasive wheels. Driven by the test sample, the wheels produce abrasion marks that form a pattern of crossed arcs over a circular ring. Abrasion resistance can be calculated by loss in weight at a specified number of abrasion cycles, as a number of cycles required to remove a unit amount of coating thickness, or visually by the amount of coating removed compared to predetermined standards. For accurate results the coatings or inks on the test specimens must be completely cured. Additionally, procedures are described for proper surfacing of the wheels prior to each trial. The Taber

continued on next page

 continued from page 15

Rotary Abraser is referenced in numerous standards including ASTM D 4060 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser, ASTM D 6037 Standard Test Methods for Dry Abrasion Mar Resistance of High Gloss Coatings, ASTM F 1478 Standard Test Method for Determination of Abrasion Resistance of Images Produced from Copiers and Printers (Taber Method), SAE J365 Method of Testing Resistance To Scuffing of Trim Materials and Ford Motor Company Test Method BN108-02 Resistance to Abrasion – Taber Abraser.



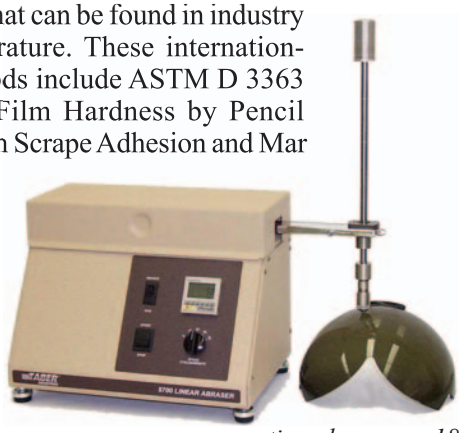
The latest generation of abrasion test machines is the Taber Linear Abraser Model 5700 (shown above). This new linear abraser was developed to permit testing of actual products. Utilizing a reciprocating linear motion, interchangeable attachments are mounted to the end of a free-floating, spline shaft. As the arm cycles, the shaft raises or lowers such that the attachment follows the contours of the product shape - convex, concave or flat.

Taber Industries has recently introduced a new version of its linear abraser, Model 5750. Many new and advanced features have been added including a) digital display, b) laser guide alignment, c) minimum load of 60 grams, d) variable stroke speed from 2-75 with six preset buttons, and e) new attachments for testing versatility.

Using industry standard Taber wheel materials, wear resistance of materials including plastics are tested using linear motion. As with the Taber Rotary Abraser the Wearaser™, the material must be refaced prior to use. Machine models 5700/5750 have an- automatic programmable Reface mode. The stroke length, speed, and load can be customized for any test. The programmable controls enable testing to a preset number of stroke cycles or continuous until coating/printing removal. The universal attachment head allows the user to select ASTM certified abrasive media or the user can employ their own abradant material that may be unique to a specific industry. The Linear Abraser Models 5700/5750 also can be configured for scratch, rub, coin (Dime, Nickel, etc.) and crockmeter testing. As with many abrasion testers results can be determined by weight loss or visual standards when the surface coating has been worn down to the substrate material or a portion thereof (breakthrough). Crock (color transfer) entails evaluating the crocking cloth to determine how much color has transferred onto the cloth and is incorporated in ASTM D 6279 Standard Test Method for Rub Abrasion Resistance of High Gloss Coatings and ASTM F 1319 Standard Test Method for Determination of Abrasion and Smudge Resistance of Images Produced from Business Copy Products. Taber is presently pursuing additional ASTM certifications for the Linear Abraser Models 5700/5750.

With the diversity of products that can be tested on the linear abraser, there is not a universal standard to fixture a product into position for testing. The end-user determines a suitable clamp or fixture device appropriate for the product. In some cases, a standard vise is used. For other products more elaborate fixture devices may be required. The important aspect is for the product to remain in a rigid position during the testing.

In addition to the Norman RCA Abrasion Wear Tester and the Taber Rotary and Linear Abrasers discussed in this article, there are countless numbers of adhesion and abrasion test apparatus that can be found in industry catalogues and literature. These internationally accepted methods include ASTM D 3363 Standard Test for Film Hardness by Pencil Test; Balanced Beam Scrape Adhesion and Mar Tester for ASTM D 2197 Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion and D5178-98(2002)



continued on page 18

 continued from page 16

Standard Test Method for Mar Resistance of Organic Coatings; and ABREX® abrasion testing on printed/coated surfaces under influence of different fluids (sweat, lotion, oils) via simulated finger/hand contact motion according to DIN EN 60068-2-70. ABREX® is a new instrument in which limited information was available at the time this paper was written. In addition to these tests, many companies develop in-house procedures using sophisticated digital test systems such as Com-Ten and Instron equipment incorporating many ASTM procedure methods. Based upon a product's intended use, performance testing also can include chemical and solvent resistant testing, water immersion followed by tape testing, dishwasher and washing machine testing, etc. Companies frequently use multiple test methods during product development and manufacturing.

Test Standards and Process Excellence

Many companies use some of the test methods discussed in this article out of necessity, i.e., to acquire business by demonstrating their manufacturing processes conform to specific industry standards. Unfortunately, manufacturers can often be unaware of field failure problems until their customers return nonconforming products. By default, "poor adhesion" is to blame. Through proper understanding of the many possible causes for adhesion versus abrasion failures, engineers can adroitly identify the critical root causes and implement corrective actions. Testing should not be reserved only for product development and troubleshooting. Continuous in-line testing of products using the methods and techniques presented and Six Sigma techniques will ensure robust manufacturing. ■

Acknowledgements

- American Society of Testing and Materials International
- BYK Gardner
- Gardner Company
- Norman Tool, Inc.
- Taber Industries

Scott R. Sabreen is Founder & President of The Sabreen Group, Inc. (TSG). TSG is a global engineering company specializing in secondary plastics manufacturing processes – surface pretreatments, bonding, decorating & finishing, laser marking and product security. For more information call toll-free (888)-SABREEN or visit www.sabreen.com and www.plasticslasermarking.com