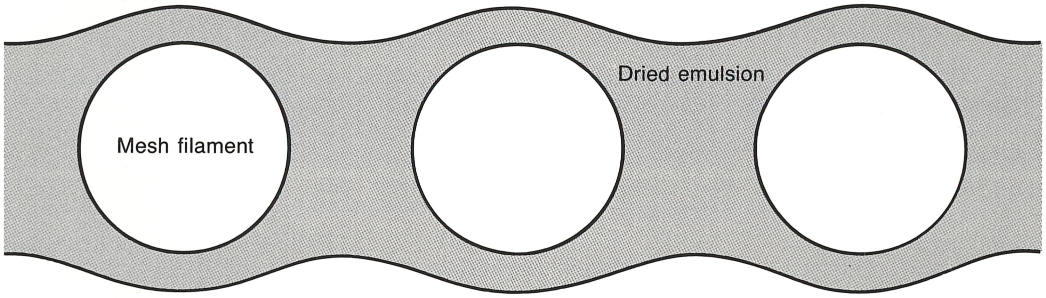
The R_z Value:

A New Concept in Screen-Quality Evaluation



● ***Figure 1*** *Emulsion shrinkage*

Wolfgang Pfirrmann
Kissel & Wolf GmbH

Evaluating the quality of a direct-emulsion stencil before it is on press is a difficult task. Pinholes and edge defects might be uncovered with illumination and magnification, but overall stencil quality and flatness are impossible to measure. After many months of research, a test has been established that can evaluate the relationship between the emulsion and the mesh. We call this relationship the R_z value, and it may provide the screen-printing industry with a concrete method of judging the quality of direct-emulsion stencils before printing.

Mesh equalization

The R_z value is a numerical reference to the mesh/emulsion equalization on the screen. Mesh equalization is the process of filling the mesh openings with emulsion and building up a thick enough emulsion layer to equalize (or smooth out) the surface structure of the woven mesh. In other words, mesh equalization means achieving a smooth emulsion coating on the uneven surface of the mesh.

Mesh equalization is essential for sharp, sawtooth-free printing. The screen must be smooth on the substrate side to ensure good contact between the stencil edges (image shoulder) and the substrate. This contact prevents the ink from running under the image edge and causing sawtooth prints.

Since direct emulsions are water-based systems with a maximum of 50% solids, the dried coating will be at least 50% thinner than the wet coating. As the water evaporates during the drying process, the emulsion shrinks in the mesh openings and creates a concave surface (● ***Figure 1***). This concave form can prevent good contact (or gasket-like seal) between the substrate and the screen. Although a gap may exist between the stencil and the substrate at some points, if this gap is too large, ink will run under the printing shoulder and create the sawtooth effect or smear the image, both of which cause uneven line edges in the print.

Such gaps or uneven screen surfaces cannot be detected with a normal magnifying glass or microscope. It is possible to view this uneven surface with an electron microscope (● ***Figure 2***); however, this equipment is prohibitively expensive and not appropriate for normal production conditions. Currently, the only practical means to evaluate the screen is to actually print with it and judge the resulting printed-image quality.

Measuring mesh equalization

Measuring the surface flatness of a material is a common production technique in other industries and is often used as a quality-control specification. Until now, however, this technology has not been applied to screens coated with emulsions. We have found that it is possible to measure the ''roughness'' of the stencil surface with some of the same techniques and test instruments used in other industries. Not only does the resulting test data offer insight into how the stencil will print, but it also provides information on the characteristics of the emulsion.

The measuring instrument Our research indicates that a roughness meter (● ***Figure 3***) can be used to evaluate the surface quality of a stencil. The Feinpruef Perthometer M4P (Feinpruef Corp., PO Box 7547, Charlotte, NC 28217. Telephone: 704-525-7128) measures the stencil surface by automatically pulling a probe over a specified distance (4 mm) of the stencil to establish the profile of the coating (● ***Figure 4***).

The measuring method The screen is placed on a stable surface with the substrate side up. It is essential that no vibration occurs during measurement as this movement will show up in the final results. Although you don't need to test on a granite slab, we do not recommend testing in areas where vibration is likely. In order to further stabilize the mesh/stencil, place a small piece of glass under the portion of the stencil to be measured. This will prevent the probe from pushing down on poorly tensioned mesh and skewing the results.

Position the probe so that it is at a 22.5⁰ angle to the threads. This ensures that the probe will travel over the lowest (middle of the mesh openings) and highest (knuckles of the fabric) points of the surface. If the probe travels parallel to the threads of the mesh, the results will contain false values.

The meter pulls the probe over the specified length of the stencil surface. The total length is divided into five sections and the maximum height differences in microns of all five sections are averaged to produce the R_z value. ● ***Figure 5A*** illustrates a sample tape readout from the meter. You can see the minimum and maximum readings in each of the five sections. In each section, these two positive numbers are added together to establish the actual undulation of each section and thus the entire measure length. The following calculation reflects this computation:

$$R_{max} + R_{min} = R_z$$

R_{max} = maximum reading for a section
R_{min} = minimum reading for a section
R_z = value of mesh/emulsion equalization for a section

The average of these five sections is then established as the R_z value for this particular emulsion/mesh combination (● ***Figure 5B***).

Since mesh equalization is, to a great extent, dependent on the solids content of the emulsion, the R_z value will vary at the same coating thicknesses with the different emulsions that are used.

Interpreting the results

The test will reveal an R_z value in microns. The higher the numeric value, the more undulation present in the stencil. Lower values, on the other hand, indicate a smoother surface. Obviously, the printer is looking for the lowest possible R_z value at the appropriate stencil thickness for the required ink deposit. Sample R_z measurements for typical screen-printing substrates are shown in ● ***Figure 6*** for comparison purposes.

It is also possible to correlate emulsion thickness with the R_z value and establish data about different emulsions. If a sample emulsion is coated on the same

● ***Figure 2***

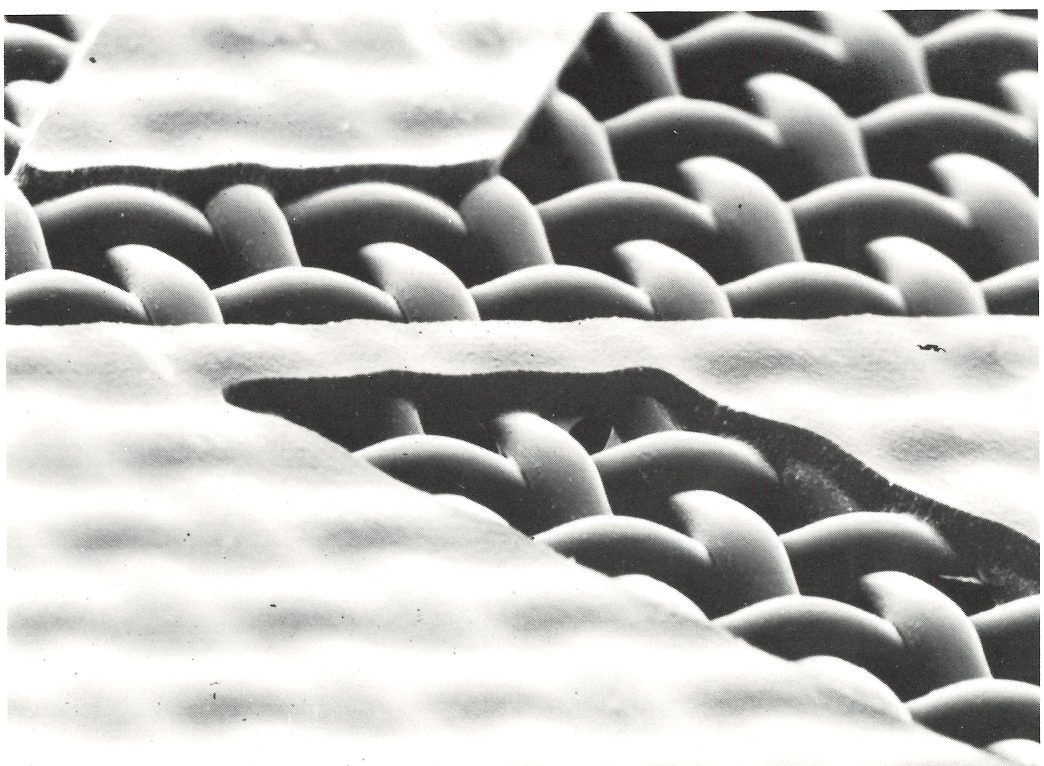


Photo courtesy of Kissel & Wolf GmbH

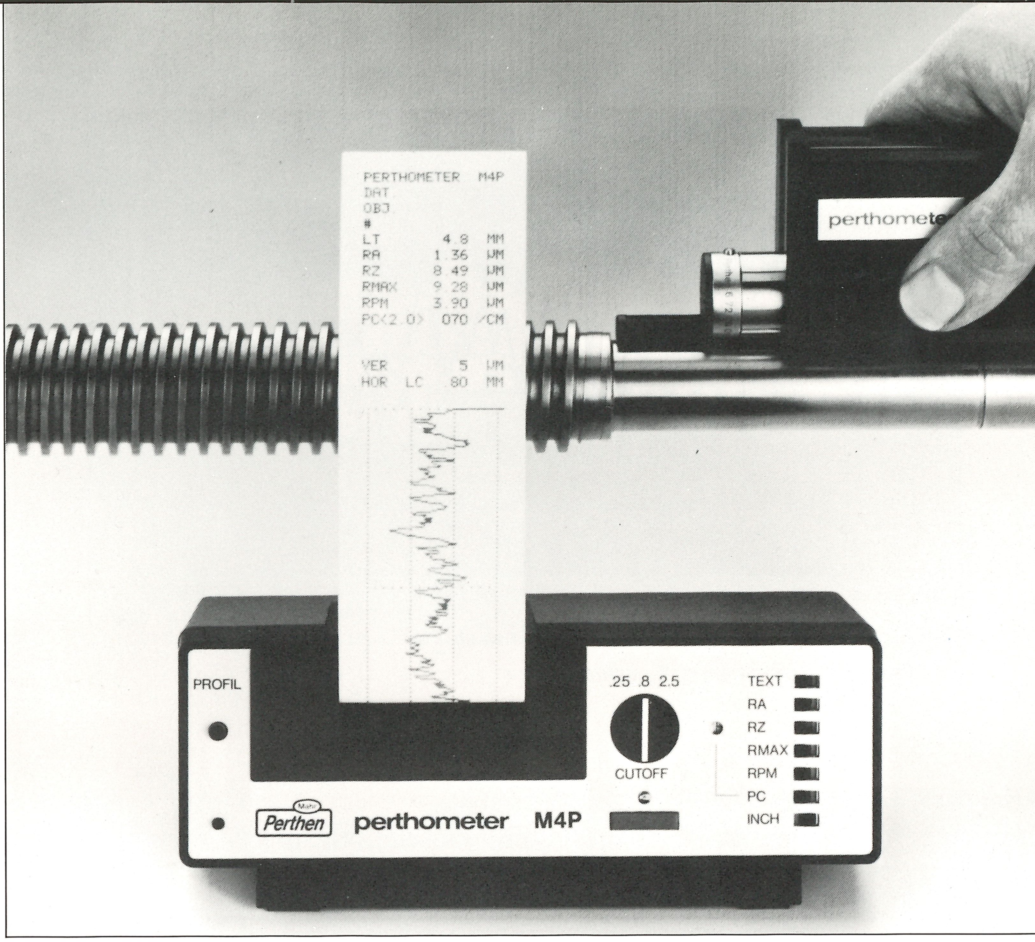


Photo courtesy of Feinpruef Corp.

● ***Figure 3***

screen under the exact same conditions, the R_z value and the emulsion buildup would be the same. Different emulsions, however, will produce different R_z values, even if the emulsion-over-mesh ratio is the same.

Since mesh equalization is, to a great extent, dependent on the solids content of the emulsion, the R_z value will vary at the same coating thicknesses with the different emulsions that are used. For example, a traditional, high-grade diazo-sensitized emulsion with 27-28% solids might have an R_z value of approximately 9 microns. A diazo-sensitized photopolymer with 35-36% solids that is coated to the same wet thickness on the same mesh might have an R_z value of 7 microns. Obviously, the solids content of these emulsions has determined the difference in the total shrinkage and thus the lower R_z value for the higher-solids, photopolymer emulsion.

R_z value benefits

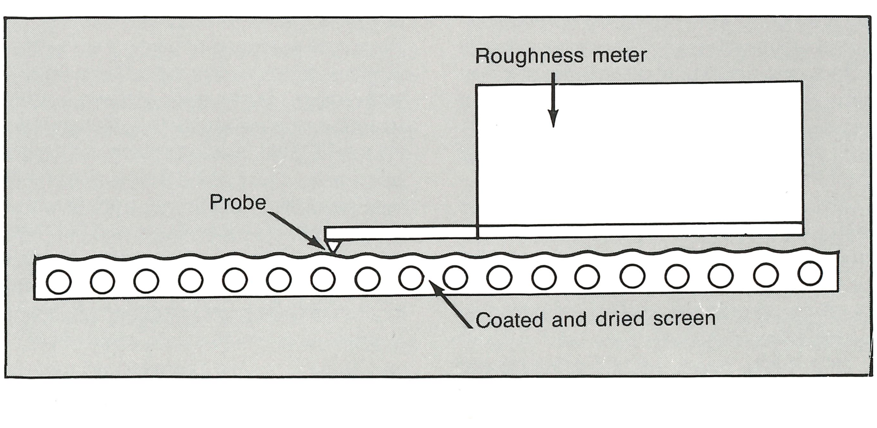
Until now, the screenmaker and printer could only rely on the printed result as a reliable means of evaluating stencil quality. Yet, even this judgment is flawed because so many other factors affect the final print quality: squeegee pressure, substrate, squeegee durometer, squeegee angle, ink viscosity, mesh choice, etc. Even the perfect stencil can produce an unacceptable print if these other variables are not controlled. With the development of quality-control parameters and measuring techniques, however, it is necessary to start with the best stencil possible for the printing conditions. The use of R_z values provides the screenmaker or printer with quantifiable and repeatable stencil characteristics rather than subjective judgment.

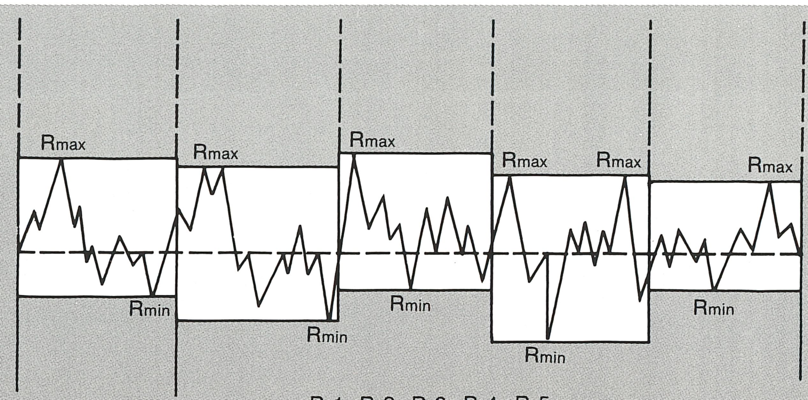
In addition to the quality of the stencil surface, the emulsion buildup can be measured on the wide range of mesh counts used in a typical screen-printing plant, and this information can be recorded and used for future applications.

Our research indicates that it is possible to provide printers with the R_z values of various emulsions on specific mesh counts with the range of typical coating techniques, eliminating the need for the screenmaker to test all the available products. Such information, if provided by the manufacturer, would help the screenmaker evaluate the different emulsions and choose the right product for a particular job. It would also serve as a guide to the correct use of the emulsion to obtain the most desirable stencil thickness and R_z value.

The use of the R_z value could take much of the guesswork out of choosing the right emulsion and using it correctly. Extensive tests have shown that R_z values under 10 microns are required to

● ***Figure 4*** *Measuring stencil undulation*



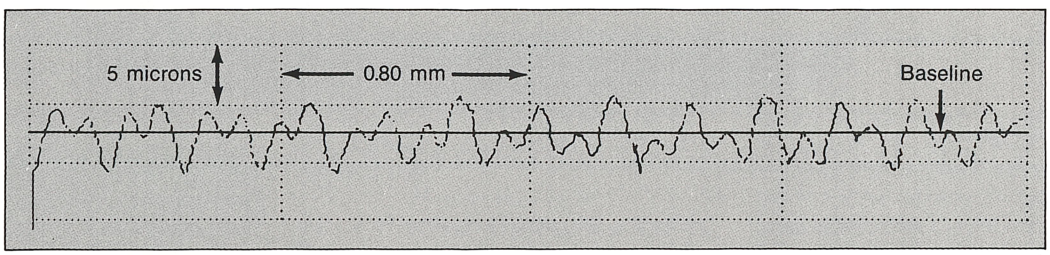


$$R_z = \frac{R_z1+R_z2+R_z3+R_z4+R_z5}{5}$$

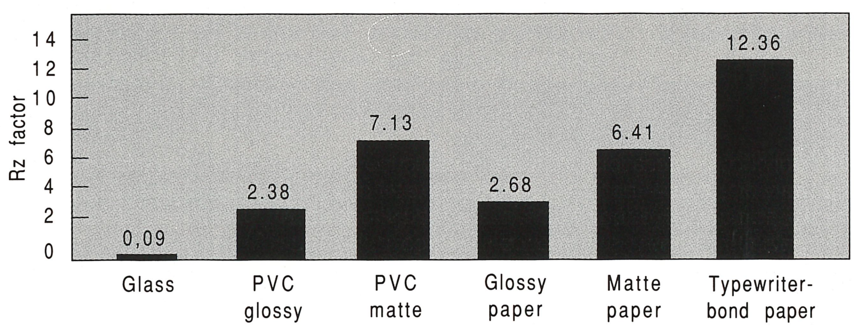
For each of the five sections, the Rmin and Rmax are added together (each is a positive number) and then the totals are added and averaged to determine the final R_z value for the stencil coating on this particular mesh.

● ***Figure 5B** Determining R_z value*

● ***Figure 5A** Sample readout from meter*



● ***Figure 6** R_z factor comparison of various materials*



achieve good print results on smooth surfaces, while values of 3-7 microns will provide a very good print on virtually any surface. (Please note that when printing on highly absorbent materials, such as textiles, the R_z value of the stencil material is of little significance.)

The R_z value can provide the printer with a new method of measuring stencil quality before the screen goes on press. In addition, it provides another means of qualifying emulsions and specific coating techniques.

In a future issue, we will examine the range of variables that influence stencil thickness and quality using the R_z value as one criterion for evaluating coating techniques. These tests include coating speed, emulsion viscosity, solids content, trough-fill level, mesh tension, and mesh open area. It is hoped that further investigation of the relationship between coating procedures/techniques and final stencil quality will assist the printer in establishing in-house quality-control standards for stencilmaking with direct emulsions. ■

Wolfgang Pfirrmann is manager of the Applied Research Laboratory for Kissel & Wolf GmbH (Wiesloch, West Germany). Pfirrmann completed a three-year screen-printing apprenticeship at Firma Domberger KG (Filderstadt, West Germany) and then served the industry for a number of years as a consultant. Prior to joining Kissel & Wolf in 1988, he was responsible for the Technical Training Center at Svecia Silk-screen Maskiner AB (Norsborg, Sweden).

Reprinted from *Screen Printing*, June 1990 issue