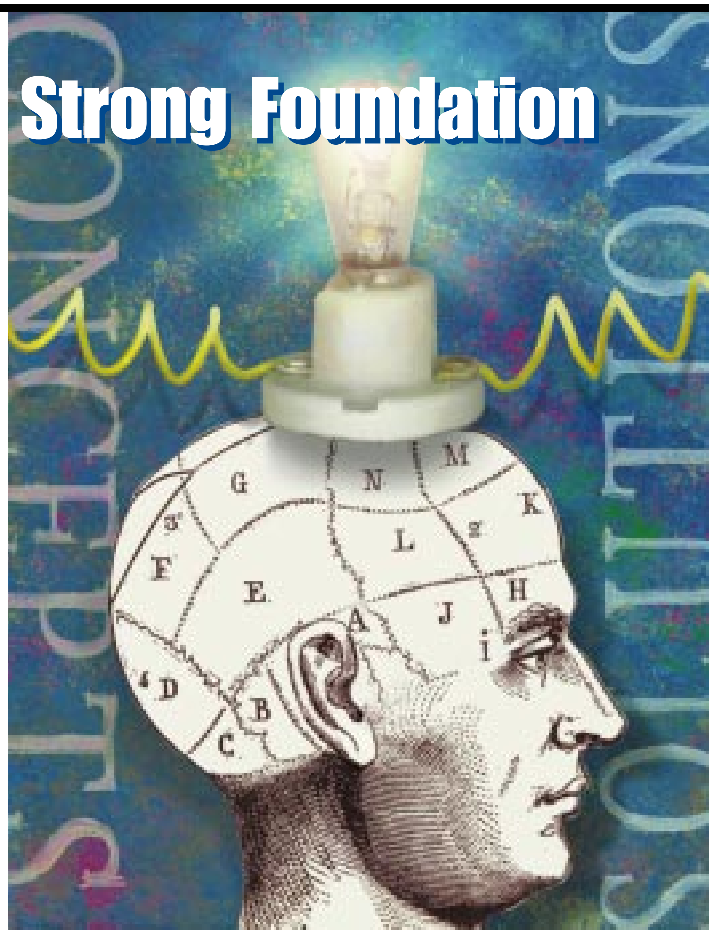
Building a Strong Foundation

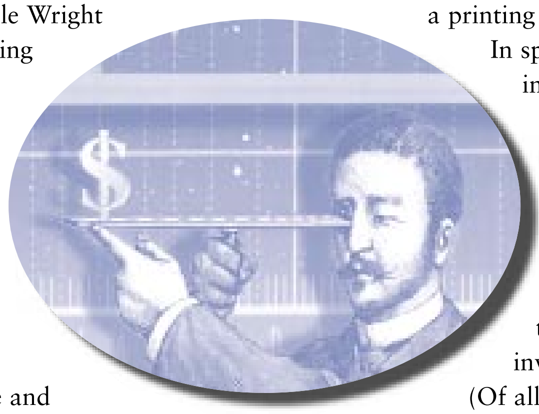
The Challenges and Rewards of Innovation



by Dennis Hunt,
Director of Research
Screen Printing
Technical Foundation

In the latter half of the nineteenth century "knowledgeable" professionals of the day suggested that the age of invention was coming to an end and that the U.S. Patent Office should be closed. After all, what else could be invented?

Only a few years later, on December 17, 1903, at 10:35 am, Orville Wright shocked the world by lifting off the beach at Kitty Hawk, North Carolina, and doing what men and women had only dreamed of doing for centuries … he flew.



In a flight lasting only 12 seconds and covering just 120 feet, bicycle mechanics Orville and Wilbur Wright changed the way we think forever.

How is it possible that two people who built bicycles for a living were able to solve the complex problems of flight?

They were not trained scientists with advanced degrees, nor did they have the luxury of unlimited time and government-funded research. Neither of the brothers finished high school. Wilbur excelled and would have graduated from high school if his family had not moved during his senior year. Orville, an average student known for his mischievous behavior, quit school before his senior year to start a printing business.

In spite of the seeming improbability of a successful outcome, the Wrights systematically solved each technical challenge, overcoming a series of obstacles that had thus far prevented the invention of the airplane. (Of all the early aviators, Wilbur alone recognized the need to control an aircraft in its three axes of motion: pitch, roll and yaw.)

What is the basic mechanism that produced these amazing achievements and can we still benefit from their approach to systematic problem solving?

The Wright Brothers went from making a printing press out of a damaged tombstone and buggy parts to lifting off in flight over Kitty Hawk. Here are a few lessons SPTF has harnessed from their unbridled imaginations.

I believe Albert Einstein had the right idea when he said, "Imagination is more important than knowledge."

In order to go beyond where we are today, we first must be convinced that our ability to conceptualize the desired outcome is at least as important as the physical steps necessary to get there.

In order to go beyond where we are today, we first must be convinced that our ability to conceptualize the desired outcome is at least as important as the physical steps necessary to get there.

Contrary to popular belief, a lack of higher education or important technical resources are not necessarily the limiting factors. Even the distinct advantage of great personal ability or vast resources can be severely limited by an inability to think beyond either the present circumstances or the "Conventional Wisdom" of the day. The Wright Brother's "Flights of Fancy" became flights of reality due in part to their highly refined ability to "nurture" and "cultivate" their dream. Imagination is the garden plot where the seeds of innovation often explode into reality.

Unfortunately in our society a "wild" imagination is also one of the first things to go when we become adults (remind me to never grow up). The price of discouragement and continuous ridicule from well-meaning friends or colleagues is for many people a price they are unwilling to pay. Without the internal motivational power necessary to succeed, most truly visionary people or ideas will never reach their full potential, resulting in a loss to both the individual and to society.

In this particular example the loss incurred by society would have been unimaginable had the Wright Brothers listened to the "Voice of Reason" and given up the desire to engage in what most would call pure esoteric fantasy. In fact, everything we now enjoy once only existed in someone's imagination.

Before the Wright Brothers could become the world class aviators that we know today, they had to develop a paradigm consistent with the thinking processes necessary for spontaneous invention. Remember, pure genius is often simply recombining the pre-existing parts in a new way.

One of their first examples of this was, believe it or not, a printing press, which they constructed from a damaged tombstone and buggy parts (we all knew printers have great imaginations). With this early example of creative aptitude they printed odd jobs as well as their own newspaper.

From there they graduated to repair of and eventually building (innovating) their own bicycles called "Van Cleves" and "St. Clairs." By the time they turned to gliders (Wilbur built his first in August 1900) they had developed the essential skills of information gathering, analysis and critical thinking. They used these hard-won skills to carefully analyze their "non-successes," using them as building blocks — not obstacles — to the ultimate goal of achieving the first heavier-than-air, machine-powered flight in the history of the world.

INNOVATION AT WORK TODAY

At the Screen Printing Technical Foundation's research and development lab in Fairfax, Virginia, we are also very deliberately analyzing both our accomplishments and failures to establish building blocks that will lead to even greater success.

Although the goals of the SPTF are not as lofty as manned flight, they are probably almost as difficult from a perspective of technical challenges. Our assignment in a nutshell is the complete analysis, explanation and application of the 50-plus variables in the screen printing process. That is probably an overly optimistic goal to achieve in this lifetime. However, we are making significant progress by coming up with new ways to combine those variables into smaller, more manageable groups. One recent example of this approach is the invention of the Screen Printer's Tack Tester.

CALCULATING TACK

The Screen Printer's Tack Tester (Figure 1) represents the successful development of an entirely new category of force analysis instrument, capable of providing useful information about the process through the measurement of what could be referred to as "apparent" tack. The term apparent tack is used here to provide the reader with the distinction necessary to differentiate from the more traditional "pure" tack measurement used by ink chemists and as described by Stephen's Law of Tack (Figure 2). A typical laboratory tack measurement

The Screen Printer's Tack Tester measures tack of a predefined print area through the use of an electronic load cell attached to a small (6"x 6") test screen suspended above the platen. A computer-controlled stepper motor is used to regulate the platen's ascending and descending speed as it pulls the substrate (secured by vacuum) and ink away from the test screen after the on-contact print stroke. Force, elapsed time and speed data are then analyzed to produce a Printing Energy Index number, representing the combined effect of the three variables. Information can be collected and recorded as a stand alone instrument via the built-in printer or downloaded to a computer for graphing.

This device will initially find its greatest use as a research and development tool for lab personal and suppliers of screen printing products, resulting in a trickle down effect of improved information, first to the large and then medium to small printers.

SPTF is currently testing the relationship of PEI numbers to printing results in the lab and will publish additional reports on the progress as more information becomes available.

Figure 1

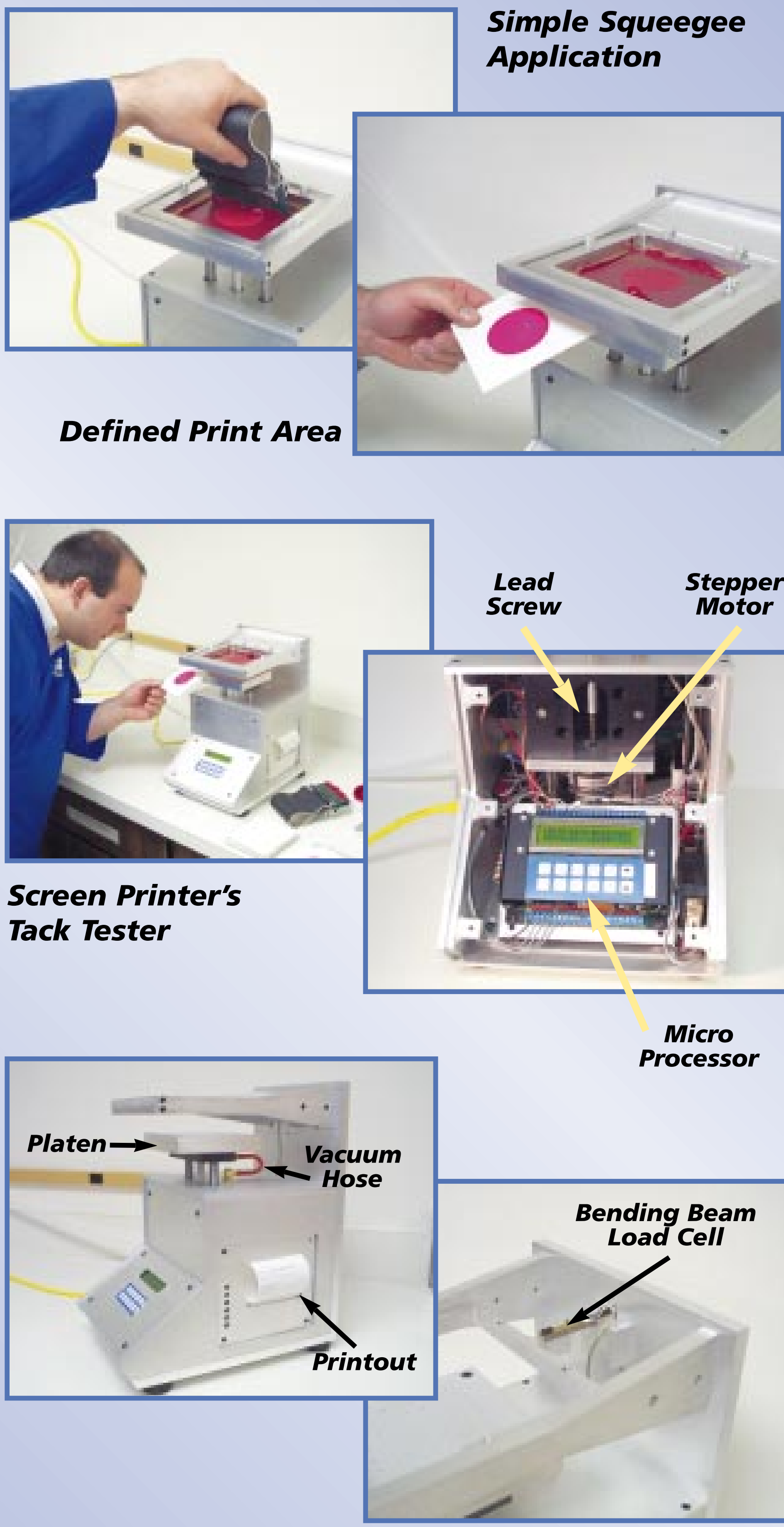


Figure 2

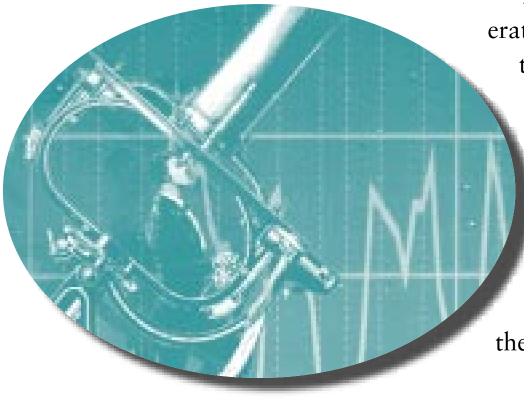
Stephen's Law of Tack

$$\text{Tack Force} = \frac{\text{Area} \times \text{Viscosity} \times \text{Speed}}{\text{Distance}^3}$$

Stephen's Law of Tack is defined by a simple equation and works reasonably well under laboratory conditions. This illustration defines the distinction between a pure tack measurement and the apparent tack measurement that is used to calculate the Printing Energy Index.

approach usually consists of two parallel plates or surfaces with an ink or similar liquid sandwiched between (Figure 3). Some mechanical means is then employed to pull the plates apart at a fixed rate of speed with the maximum force being recorded.

Tack can then be calculated based on the total surface area of the two plates, the distance between the plates, the speed used to separate the two surfaces from the ink, and the viscosity of the ink. However, the apparent tack referred to when describing the Screen Printer's Tack Tester is the force required to pull the ink, mesh and substrate apart under conditions similar to those experienced by the fabric during the off-contact, lifting or peeling action. In the pure tack measurement, both parallel plates are identical with only the liquid between the plates changing. This makes for nice, clean calculations and easy-to-achieve repeatability, but still leaves the results several steps removed from actual printing conditions. In a sense the data generated on the Screen Printer's Tack Tester has become a measurement of real world rheology. These are down and dirty numbers that are achieved in a manner very similar to the process we use to release and then transfer ink to the substrate.



COMBINING THREE KEY VARIABLES USING PEI

In addition to just measuring the force required to separate the ink/screen/substrate combination, we are also reducing the dynamics of the separation to a single meaningful number called a Printing Energy Index or PEI for short.

The PEI takes into consideration not only the peak force required to separate the ink/screen/substrate but also the time it takes for the peak force to occur. These two measurements — peak force and time — generate the data necessary to form a two-axis (x,y) graph that monitors the slowly increasing holding force. Meanwhile the ink/screen/substrate assemblage attempts to maintain its mechanical bond. At the exact point of separation the graph descends abruptly, ending the data gathering cycle. A carefully defined portion of this curve is then mathematically converted to an "area under the curve" number that becomes our Printing Energy Index. This approach not only takes into consideration the combined surface energy of the ink, screen and substrate, but also includes ink rheology and the elastic nature of the screen at a particular tension.

WHY IS PEI IMPORTANT?

So what do these numbers really mean to the average person? Let's examine some basic relationships that PEI could have with the real world of screen printing.

First, the higher the PEI number the more energy or work will be required to cause the screen to separate from the substrate and deposit the ink. Conversely, lower PEI numbers can indicate, among other things, that less energy will be required to produce the same printing result. Reasoning then follows that some or all of the following could conceivably be affected by the PEI. [1]

- PEI may determine the speed at which you can print certain designs, such as coatings, fine lines or halftones.
- PEI will determine the off-contact for any given screen tension.
- PEI could affect the selection of screen meshes.
- PEI affects the speed at which you can print any one ink type.
- PEI may determine the speed at which you can print any one color of the same ink type.
- PEI may determine the speed at which you can print certain substrates.
- PEI will detect small coating differences in similar substrate materials and may predict the printability of those materials.

[1] "Problems and Ideas: The Mystery of Tack," by Tamas Frecska, *Screenprinting*, December 1996

Preliminary experimental results from the tack tester suggest that a small change in any one of these three critical screen printing variables — ink, substrate or mesh — will result in a change in the measured PEI. This change in PEI will almost certainly affect printing results for better or worse depending on the desired outcome.

An interesting example of this becomes apparent when four different four-color process inks are measured on the Screen Printer's Tack Tester while keeping the screen and substrate the same. Although some process inks can produce very similar PEI numbers between their four colors, others most definitely do not. Those that measure the same will print the same with little or no modification to the ink or the press set up parameters. Those that measure large differences in PEI will either require modification to the ink or to the way the ink is set up to run on the press.

The real advantage to using PEI data over just measuring the viscosity or even the rheology of the ink is that PEI also evaluates how the ink will react to the other two materials that affect the ink transfer. However, since the body of research required to effectively evaluate this instrument and its potential uses is just beginning, we are still not sure how different the numbers can be before they require an entirely different press set up, ink modification or other processing changes. But wouldn't it be nice to know if one of the colors needed a little tweaking before they actually got to press? This and other kinds of fundamental information will continue to become more available in the not too distant future as the SPTF research helps to make the sometimes complex at least a little more understandable.

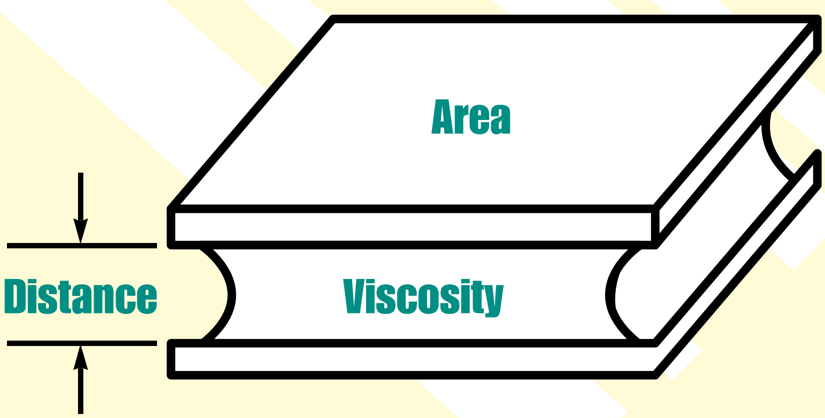
Hopefully, the ideas and information presented here have been informative and will further help to awaken the creative genius inside each one of us. Remember, most of our limitations are in a very real sense self imposed, and will only remain obstacles to us as long as the imagination — how we continue to think about it — remains on the limiting side of the roadblock.

An important safeguard to freedom is to minimize or eliminate exposure to negative people. The term "paradigm paralysis" is an expression used to describe the symptoms of people who are completely incapable of processing new or different information. For these folks, their world is so small and clearly defined that there just isn't any place to put a new idea. Any further discussion is just a waste of time as far as they are concerned. Believe it or not, this disease runs rampant in scientific circles. Albert Einstein described it well when he said, "Common sense is just a collection of prejudices arrived at before the age of eighteen."

A common expression used to describe any visionary undertaking that probed the frontiers of human experience was "the sky is the limit." That was a self-imposed roadblock for mankind until July 20, 1969 at 10:56:15 p.m. EDT, when Neil Armstrong first set foot on the moon, causing imaginations to finally leap beyond the sky.

Figure 3

Stephen's Law Illustrated



A typical laboratory tack measurement using Stephen's Law of Tack usually consists of two parallel plates or surfaces with an ink or similar liquid sandwiched between. Some mechanical means is then employed to pull the plates apart at a fixed rate of speed with the maximum force being recorded. Tack can then be calculated based on the total surface area of the two plates, the distance between the plates, the speed used to separate the two surfaces from the ink, and the viscosity of the ink.