Technological Advances in Rotary & Flatbed Printing (Part 1)

By:
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Introduction:

Textile printing is an extensive industry and having a history of about 2000 years. But intensive developments activity both from technological advancement and machinery developments in printing took place in last decade only to meet present days highly fashion oriented demands. Over the years various developments from the point of technology with respect to styles of printing, methods of printing and print paste were going on.

Today, 5% of all fabrics produced as white and 70-75% are dyed. 5% is woven from dyed yarns and rest 20% is printed. In industrialized countries, 49% of all printed goods are used for apparel, 37% for home textiles, and 9% to make other articles like umbrellas, linings and camping materials, 4% as a carpet and 1 % for technical textiles.

Screen-printing is arguably the most versatile of all printing processes. It can be used to print on a wide variety of substrates including paper, paperboard, plastics, glass, metals, fabrics and many other materials including paper, plastic, glass, metal, nylon and cotton. Some common products from the screen-printing industry include posters, labels, decals, signage and all types of textiles and electronic circuit boards. The advantage of screen-printing over other print processes is that the press can print on substrates of any shape, thickness and size. A significant characteristic of screen-printing is that a greater thickness of the ink can be applied to the substrate than is possible with other printing techniques.

This allows for some very interesting effects that are not possible using other printing methods. Because of the simplicity of the application process, a wider range of inks and dyes are available for use in screen-printing than for use in any other printing process.

Table No.1: Relative Contribution of Printing Methods

Printing methods	1978	1982	1986	1990	2001
Table Ptg.	3	2	2	2	1
Transfer	5	6	6	6	6
Flatbed	18	17	18	18	20
Roller	32	27	22	16	1
Rotary	42	48	52	59	72

Utilization of screen printing presses has begun to increase because production rates have improved. This has been a result of the development of the automated and rotary screen printing press, improved dryers, and U. V. curable ink. The major chemicals used include screen, emulsions, inks, and solvents, surfactants, caustics and oxidizers used in screen reclamation. The inks used vary dramatically in their formulations [1].

Historical Development

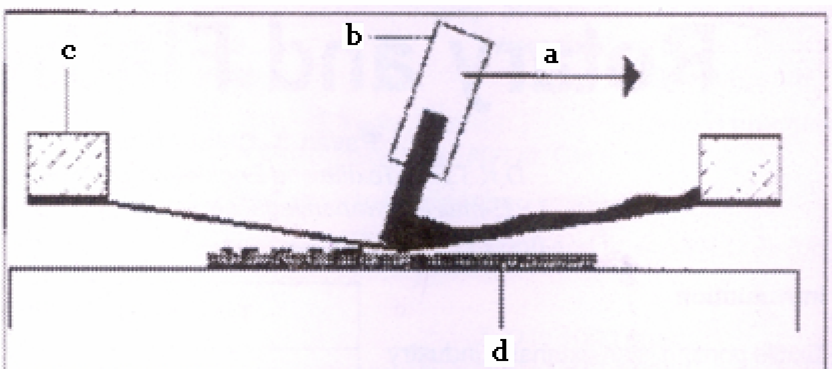
The techniques of stencil printing initially used simple patterns on walls and for lettering were developed into an intricate craft for fabric printing. In Japan, in the 17th century idea of tying together parts of stencil with human hair initiated the developments. Then in 1850 in Lyon, the first use of silk gauze as a supporting stencil base was employed and the techniques soon becomes known as screen printing.

The use of hand screen-printings grew up in the period of 1930 to 1954 and was ideal for growing quantities of man made fabrics. With the successful mechanization of flat screen printing and ultimately the use of rotary screen machine copper roller printing becomes the obsolete. In the 1990, the worldwide production from copper roller printing was estimated to be only 16%of the total and 59% from the rotary screen printing in the 1992 the share of share of rotary screen printing ~as grown up to 82.8%the machine which was introduced in the 1785 and roller printing which rules industry more than 150 years disappeared. The relative contribution of printing methods to the total world printed textile products (in %) is given in Table No.1.

Very fast developments have taken place in the printing technology during the last decades with respect to machinery used for printing and production of prints and after treatments of the printed textiles. In this paper development regarding the screen-printing, in that flatbed and rotary method is discussed.

Screen Printing

Screen-printing consists of three elements: the screen which is the image carrier; the squeegee; and ink. The screen-printing process uses a porous mesh stretched tightly over a frame made of wood or metal. Proper tension is essential to accurate color registration. The mesh is made of porous fabric or stainless steel mesh.



a= printing direction, b= squeegee, c=printing frame, d= substrate

Fig. 1: Principle of Screen Printing

A stencil is produced on the screen either manually or photo chemically. The stencil defines the image to be printed in other printing technologies this would be referred to as the image plate.

Screen printing ink is applied to the substrate by placing the screen over the material. Ink with a paint-like consistency is placed onto the top of the screen. Ink is then forced through the fine mesh openings using a squeegee that is drawn across the screen, applying pressure thereby forcing the ink through the open areas of the screen. Ink will pass through only in areas where no stencil is applied, thus forming an image on the printing substrate.

The diameter of the threads and the thread count of the mesh will determine how much ink is deposited onto the substrates. They are depicted in Figure No.1.

Many factors such as composition, size and form, angle, pressure and speed of the blade (squeegee) determine the quality of the impression made by the squeegee. At one time most blades were made from rubber, which, however, is prone to wear and edge nicks and has a tendency to warp and distort. While blades continue to be made from rubbers such as neoprene, most are now made from polyurethane, which can produce, as many as 25,000 impressions without significant degradation of the image [2].

Rotary Screen Printing

Most people think of screen-printing as a flat printing process because the substrates are usually flat and decorated in a horizontal position. Screen printing is also associated with piece-decorating applications, in which individual sheets of substrate are printed one by one, usually on semi and three-quarter-automatic flatbed presses that require manual loading and/or unloading. When screen-printing is used as a piece-printing process with manual material handling, screen shops sacrifice productivity. Businesses that invest in automatic, multicolor, inline flatbed systems regain some of this productivity by eliminating manual handling from all or most of the sequence. Yet throughput continues to be limited because every sheet of substrate still must pause at each printing station to receive the image.

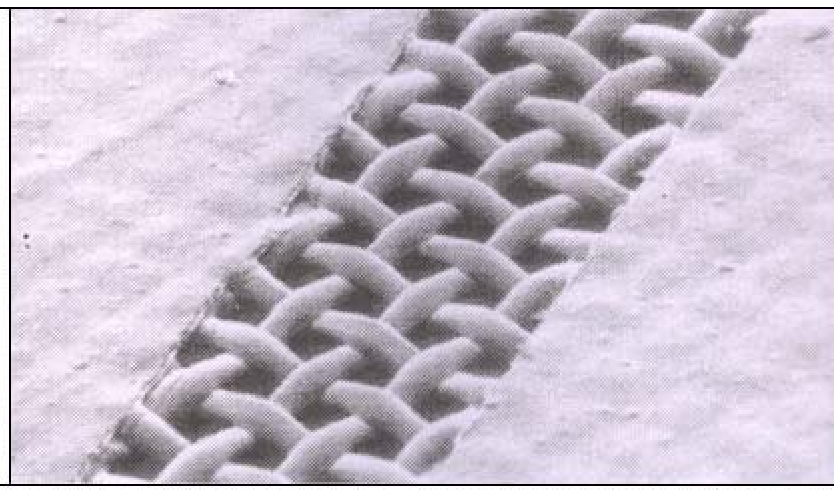


Fig 2: Photomicrograph of Stencil on Mesh [Sefar AG 1999, B]

The good news is that you don't have to sacrifice the benefits of screen printing to overcome the limitations of flatbed printing technology. For many applications requiring efficient, high volume, high-quality printing and rotary screen-printing may be the answer.

What is Rotary Screen-Printing?

Rotary screen-printing is so named because it uses a cylindrical screen that rotates in a fixed position rather than a flat screen that is raised and lowered over the same print location. Rotary presses place the squeegee within the screen. These machines are designed for roll-to-roll (web) printing on flexible materials ranging from narrow web films to wide-format roll textiles.

In rotary printing1 the web travels at a consistent speed between the screen and a steel or rubber impression roller immediately below the screen. (The impression roller serves the same function as the press bed on a flatbed press.) As the web passes through the rotary unit, the screen spins at a rate that identically matches the speed of substrate movement.

The squeegee on a rotary press is in a fixed position with its edge making contact with the inside surface of the screen precisely at the point where the screen, substrate, and impression roller come together.

Ink is automatically fed into the center of the screen and collects in a wedgeshaped "well" formed by the leading side of the squeegee and the screen's interior surface. The motion of the screen causes this bead of ink to roll, which forces ink into stencil openings, essentially flooding the screen without requiring a floodbar. The squeegee then shears the ink as the stencil and substrate come into contact, allowing the ink to transfer cleanly to the material.

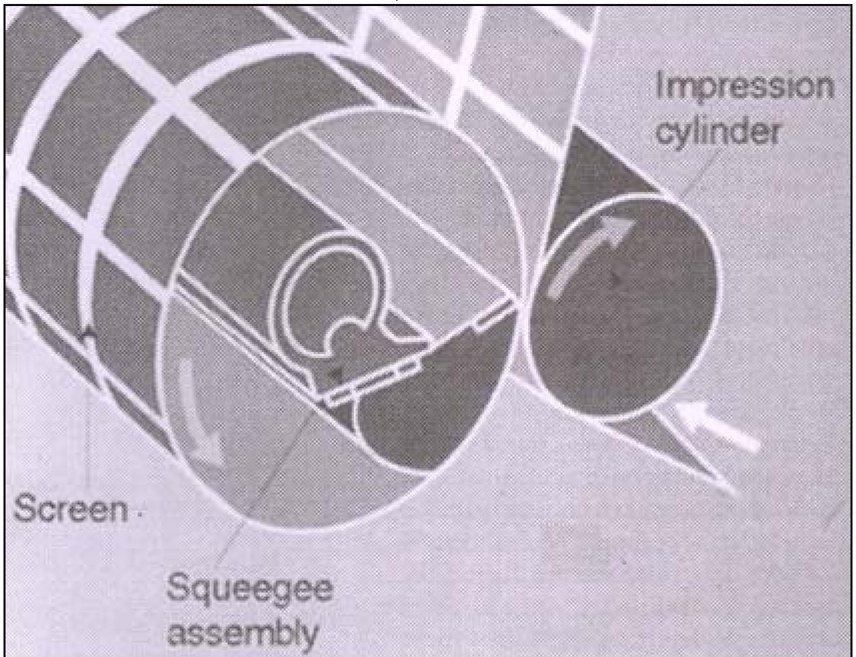


Fig. 3: Image Transfer in Rotary Screen Printing

In short, rotary printing is a continuous, step less image-transfer method. The geometry of the screen and the position of the squeegee within the screen combine to provide both the screen flooding and image-transfer functions in a single smooth operation that repeats with every revolution of the screen.

Rotary vs. Flat Screen-Printing

The virtues of rotary screen-printing are most apparent when the process is compared to traditional flat screen printing.

Productivity:
Among the biggest attractions of rotary screen-printing is its production speed. On a rotary press, images are applied to the entire width of the substrate as the material moves continuously through the printing mechanism-substrate size really has no impact on press speed. The only factor that determines the production rate is the speed of screen rotation/substrate movement (remember, these values are the same), which is limited primarily by the type and rheology of the ink being used.

Because of the way rotary presses operate, their production rates are reported as linear measurements and typically fall within a range of 100-450 tVmin (30-100 m/min), depending on the model and the specific application. The situation is a little different with flatbed presses. On a flatbed press, printing is a two-step process that involves a pass over the screen by the flood bar to fill mesh openings with ink, followed by a squeegee pass to bring the stencil and substrate into contact for ink transfer. As previously noted, the flooding and printing action on a rotary system is all part of the same continuous motion, and separate strokes for these functions are not required. Not only does this approach reduce printing times but it also removes the flood bar as a variable from the printing process.

Furthermore, to maintain good edge definition and ensure registration accuracy on multicolor prints, each sheet printed on a flatbed is held stationary (usually with vacuum draw down from the press bed) during the print cycle. When you add the separate flood and print strokes to the equation, it is clear that a flatbed's productivity is influenced by substrate size because the larger the substrate, the greater the distance the flood bar/ squeegee assembly must travel and the longer the time required for each print cycle. If we look at manufacturer specifications for a range of common flatbed presses and convert their quoted production rates into linear speeds, it's safe to say that these machines will support a printing speed up to 35-50 ft/min (10-15 m/min).

Material handling:
Because rotary presses work with web-fed materials, they eliminate the need to feed substrates into the press piece by piece, as is common with flatbed units. Users simply thread the desired material into a rotary machine from a reel at one end, and the machine continues to pull more material through as needed. The substrate may continue through a drying unit after printing. Subsequently, it may be directed to a rewinding unit or on to another printing or finishing operation configured inline with the rotary press. With standalone flatbeds and multicolor in-line systems, getting the printed sheets to other finishing areas usually requires more cumbersome and time-consuming manual handling methods.

Off-contact and image integrity:
Off-contact distance between the screen and substrate during the print cycle is a critical issue for those who use flatbed screen-printing equipment. It is a non-issue for those who employ rotary presses. In flatbed printing, screens are usually made from polyester mesh that has been stretched onto a frame. In order to achieve good printed edge definition and detail, press operators leave a small gap between the stencil and the substrate.

During the printing cycle, the squeegee closes this gap, bringing the screen and substrate into contact by depressing the screen. The tension of the fabric causes it to "snap off" the substrate immediately behind the moving squeegee, allowing the transferred ink to retain the detail of the stencil. Without off contact, the screen would tend to stick to the printed substrate and the image would be smeared or blurred. The problem is that the process of depressing the screen to transfer the ink also stretches the screen and the image it contains. This results in distortion to the printed image. The closer that the squeegee is to the edges of the screen, the greater this distortion becomes. This entire means is that some degree of image distortion always occurs with flatbed screen-printing.

In contrast, rotary screen-printing bypasses the whole off-contact/image-distortion issue. This is because on rotary presses, the surface of the cylindrical screen just makes contact with the web as it moves between the screen and the impression roller. Rotary-press users as often refer to maintaining this line of contact "kiss printing." The off contact in rotary printing is essentially zero because creating snap-off is unnecessary--the rotation of the screen away from the print surface serves the same basic function [2].

Screen Materials and Preparation Overview

Screen Preparation:

Screen (or image transfer) preparation includes a number of steps. First the customer provides the screen printer with objects, photographs, text, ideas, or concepts of what they wish to haxe printed. The printer must then transfer a "picture" of the artwork (also called "copy") to be printed into an "image" (a picture on film) which can then be processed and eventually used to prepare the screen stencil. Once the artwork is transferred to a positive image that will be chemically processed onto the screen fabric (applying the emulsion or stencil) and eventually mounted onto a screen frame that is then attached to the printing press and production begins [3].

Frames:

There are two types of screen frames, metal and wood. Metal frames, both static (solid) and retentionable, have become the industry standard. Retentionables do not require the use of adhesive products. Metal frames have been replaced by wood because they do not warp from water like wood frames do. The most commonly used types of wood are cedar and pine. Pine is preferred because it is more water resistant while it is lightweight. Metal screens are made out of aluminum or steel. Aluminum is commonly preferred because it is lightweight, yet sturdy. There are some applications - such as very large printing frames used for long printing runs - where steel is preferred.

Fabric:

Screen making - there are two types of threads for screen fabric:

Monofilament - Single strands woven into fabric.

- Primarily used in commercial printing and other applications.
- Advantage: Monofilament is easier to clean than multifilament.
- Monofilament mesh has become the industry standard.

Multifilament - Multiple strands wound together like a rope, then woven into fabric.

- Primarily used in textile printing.
- Disadvantage: ink tends to build up on screen, more difficult to clean.

Fabric Types

Today commercial screen-printing primarily uses four types of fabric for making screens. They are silk, cotton organdie, nylon, and polyester. Silk was the original material used to make screens for screen printing. By far, the most widely used fabric is monofilament polyester followed by multifilament polyester and nylon.

Silk - multifilament weave

* Looses tightness with frequent use

* Reclaiming chemicals containing bleach or chlorinated solvents destroy the silk.
* Today silk is primarily used for printing art, not commercial use as before.

Cotton Organdie - multifilament weave

* Same disadvantages as silk. Nylon· multifilament/monofilament • Good for stretching.

Nylon – multifilament/monofilament

* Good for stretching.
* Compared to polyester, lacks stability.
* Less rigid than polyester.
* Not suitable for closely registered colors.

Table 2 : Relative Contribution of Printing Methods

Advantages	Disadvantages
Very intense colours can be printed with very good covering power and opacity.	Print production speeds are relatively slow.
Screen-printing can print onto almost any substrate and thickness.	It is difficult to reproduce very fine detail and small type.
It is possible to print onto curved, uneven and fragile surfaces.	Halftone reproduction requires coarse screen rulings.
High degrees of light fastness and durability can be achieved (depending on ink system).	Stencil making is a slow and labour intensive process.
It can print unusual ink formulations and Specialist coatings.	Ink costs represent a considerable portion of the job cost.

Polyester - multifilament or monofilament (calendared monofilament polyester, metallized monofilament polyester)

* Primary material used in commercial screen printing.
* Polyester is strong and stable when stretched.

Other screen materials

* Carbonized polyester
* Glass
* Wire mesh
* Stainless steel

Screens made of the same material can differ in thread diameter, number of threads per inch, and choice of mono- or multifilament fibers. The need for various characteristics such as wearability and dimensional stability will help to determine the fabric selected for a particular screen printing job. Diameter of mesh thread and number of threads per inch determine the amount of ink transferred to the substrate during the printing process [4].

Screen Mesh:

Screen mesh refers to the number of threads per inch of fabric. The more numerous the threads per inch, the finer will be the screen. Finer mesh will deposit a thinner ink deposit. This is a desirable affect when printing a very fine detail and halftones.

Typically, a fabric should be 200-260 threads per inch. Water based inks work best on finer mesh. These are generally used in graphic and industrial printing. Course mesh will deposit a heavier ink deposit. This type of screen is used on flatter, open shapes. Typically, a course screen mesh will be 160-180 threads per inch. These are generally used in textile printing.

Emulsion/Stencils:

The words emulsion and stencil are used interchangeably in screen printing. Applying the emulsion is the chemical process of transferring image to a screen. The function of the emulsion (or stencil) is to cover the non-printing area of the screen. The stencil process works due to the use of a light sensitive material that hardens when exposed to ultraviolet light.

The stencil material must be of a material that is impermeable to the screen printing ink. Materials used for stencils include plain paper, shellac or lacquer coated paper, lacquer film, photographic film, and light-sensitive emulsions.

Stencil types available include: handcut film, photographic film, direct coating, direct/indirect photostencil, and wet-dire~ photostencil. The stencil is composed of either a liquid product that is poured onto the screen mesh or a film product. There are two types of photographic film, presensitized and unsensitized, available for use in the preparation of stencils. Presensitized film is ready to use as purchased, while unsensitized film must first be treated with a photosensitization solution.

In preparing the stencil, the film is exposed to a positive film image in a vacuum frame. It is then developed in a solution that renders the unexposed image areas soluble in water. The soluble areas are removed and the remaining film is bonded to the screen fabric. If the item was printed on a manual or automatic screen press the printed product will be placed on a conveyor belt, which carries the item into the drying oven or through the UV curing system. Rotary screen presses feed the material through the drying or curing system automatically. Air-drying of certain inks, though rare in the industry, is still sometimes utilized. The advantages & disadvantages of screen printing are illustrated in Table 2.

Stages of Developments in Printing Technology

Hand or Semiautomatic Screen Printing

The practice of hand printing is now mainly restricted to colleges of arts, small scale units and high fashion industry as it is a craft rather than productive method of printing. Here printing is carried out on a flat solid table covered with layer of resilient felt and washable blanket. Heat for drying the printed fabric may be provided either under the blanket or hot air fan s above the table. When screen-printing is carried out by hand alternate repeat s are normally printed along the full length of table and gaps are filled in this allows time for print paste to penetrate the fabric and partially dry.

The manual process has been semiautomised by mounting a screen on a carriage and driving the squeezee mechanically across the screen table length is about 20 -60 mtr/min hand or semiautomatic printing the colors are printed one after another with time for drying i.e. wet on dry printing. Hence sharper results than printing the colors in more rapid succession i.e. wet on wet printing [5].

Fully Automatic Flat Screen- Printing

In order to increase the production of printing, all colors should be applied on screen simultaneously. But flat screen are not suitable coloration units for truly continuous process, and here color is applied through the screen when it is stationary. In this machine, the entire screen for the design (one screen for each color) is placed on the top of the long endless belt known as blanket. This machine on average has space for 16 colours. The width of the gap between the areas printed by any two adjacent screens must be whole number of length way design repeat.

The fabric is gummed to the blanket at entry end and moves along with the blanket in an intermittent fashion. One screen repeat distance at a time after printing, it is pulled off and passes into dryer a soiled blanket is washed and dried during the return passage on the underside of the machine.

The machine has the following key sections:

- Fabric feeding unit
- Gumming (adhesive system) unit
- Printing unit
- Drying units (printed fabric)
- Blanket washing and drying unit

The rate of screen-printing production was once dictated by the drying rate of the screen print inks. Due to improvements and innovations the production rate has greatly increased.

Some specific innovations, which have affected the production rate and also increased screen press popularity, are:

1. Development of automatic presses versus hand operated presses which have comparatively slow production times.
2. Improved drying systems which significantly improves production rate.
3. Development and improvement of U.V. curable ink technologies.
4. Development of the rotary screen press which allows continuous operation of the press. This is one of the more recent technology developments [6].

General Developments

Adhesive System:
A water-based adhesive is applied to the blanket at the entry end with the help of set of rollers by using tackey, semi permanent or permanent adhesive coating on the blanket. This coating becomes tacky when heated and heat can be applied either directly to the adhesive layer to the fabric.

Squeezee System:
Many factors such as composition, size and form, angle, pressure, and speed of the blade (squeegee) determine the quality of the impression made by the squeegee. ,At one time

most blades were made from rubber, which, however, is prone to wear and edge nicks and has a tendency to warp and distort. While blades continue to be made from rubbers such as neoprene, most are now made from polyurethane, which can produce, as many as 25,000 impressions without significant degradation of the image. It may be either by pair of parallel rubber blade squeezee magnetic rod squeegee.

Squeegee Modification:

With traditional squeegees, the effect of screen tension across the print width also is an issue. The tensioned mesh creates additional resistance and deflection to the squeegee toward the ends of the blade closest to the frame edges, as shown in the Figure No.4.

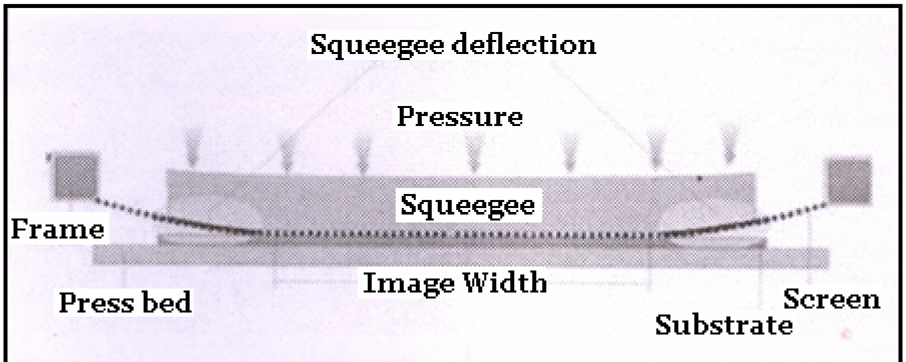


Figure 4: Blade-End Deflection

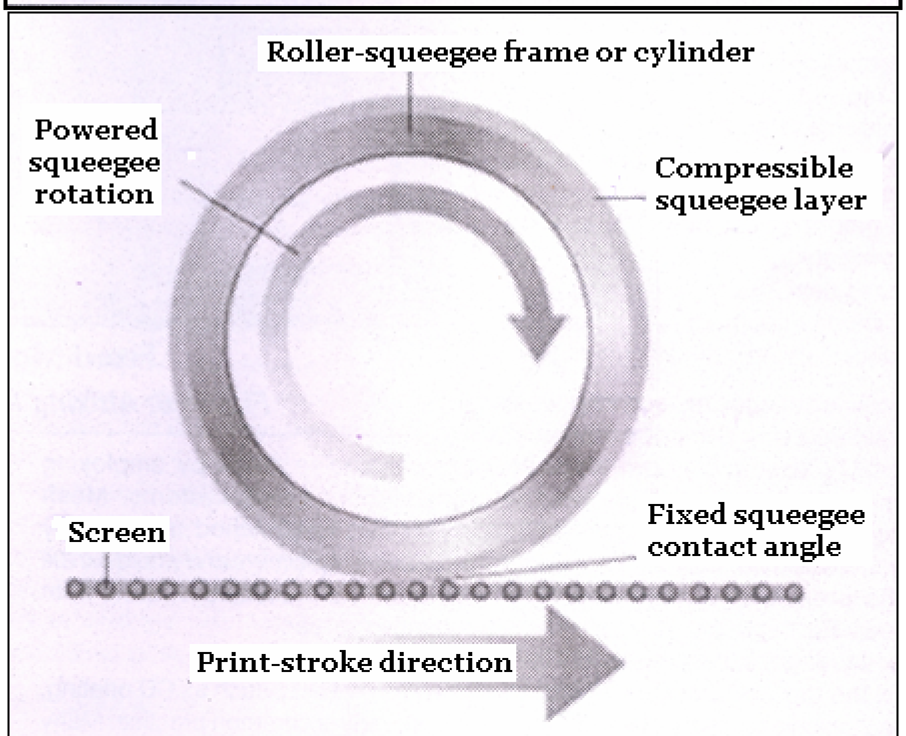


Figure 5: Roller Squeegee

The variables introduced by squeegee pressure, friction between the squeegee and mesh, and screen tension are the basis for many of the repeatability and consistency problems that plague the screen-printing process. To achieve the higher print speeds demanded, the effects of friction and applied pressure 'must be made much less significant in the process.

Another undesirable characteristic of squeegee blades is their tendency to deflect as their ends approach the frame, resulting in non-uniform ink-transfer characteristics.

The best current squeegees options for increasing production speeds are to use squeegees that feature special support layers or use rigid back plates to prevent deflection. These specialized blades and accessories tend to limit your latitude in setup, but lead to more consistent and repeatable setups once you get used to them. The downside to these solutions is that the higher printing speeds they promote significantly increase friction at the contact point, which can reduce the life of the screen and/or squeegee.

When looking at the technologies used in other print processes, the obvious solution that emerges is to replace the squeegee blade with a roller squeegee (Figure No.5). This device allows greater speed to be achieved while maintaining an excellent and consistent ink-film thickness. The roller squeegee is a concept that particularly suits web and cylinder press formats, and it may even prove viable for flatbed presses.

It is proved that the rotary-squeegee concept worked, achieving 50% greater ink deposits than a traditional squeegee. Research also showed that powering the squeegee's rotation (rather than allowing it to rotate freely in response to screen motion) was the best way to minimize the effects of frictional drag on ink transfer.

Roller-squeegee systems actually achieve twice the hydrodynamic force of the conventional squeegee, and provide a controlled and highly supported contact region and very little deflection. Such squeegees provide consistent contact across the width of the image during printing. A limitation of the roller squeegee is that it requires a heavier construction than the conventional squeegee blade, especially because it must be independently driven to rotate. This also makes it more difficult to set up, which is why its application in flatbed presses may be limited [7].

A promising solution to the limitations imposed by traditional squeegee blades is the roller squeegee. It features a cylindrical frame surrounded by a compressible layer of squeegee material. The squeegee is rotated during printing, rolling over the screen so that friction forces are virtually eliminated. The-result is controlled and consistent ink transfer.

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