

## Advance Curved Surface Screen Printing Machine



### Engineering

**KEYWORDS:** printing, flat surface printing, curved surface printing, pneumatic system

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### ABSTRACT

The work of printing is very ancient and lot of development is taken place with time eclipsed, due to this printing find an important application in newspaper industries, manufacturing industries, textiles, medicals etc. Most of the work done on flat surface printing machine as compared to curved surface screen printing machine. Curved surface printing is difficult and required lot of innovative work on it, so curved surface screen printing machine lacks behind in its modification. Form our project point of view we have decided to do automation on conventional method of curved surface printing; conventionally it is done manually by doing the screen to and fro so for convenience we are using pneumatic system for its operation. By making it pneumatic operated cost and time of printing is reduced and so the requirement of skill worker. This automation will make this machine more reliable than manually printing machine. Main intention behind the research work is to improve the productivity curved surface printing. We are confident and faithful that our project will succeed and have scope of future modification on it.

## I. INTRODUCTION

### A. Printing

Printing is a process used for reproducing images or content in the textual form typically with ink on paper using a printing machine or press. It is usually carried out considering as a large-scale as well as small scale industrial process and is an essential part of publishing and transaction printing.

The earliest form of printing was woodblock printing<sup>[1]</sup>, with existing examples from dated before 220 A.D. in China and Egypt to the 4<sup>th</sup> century.

### B. Screen Printing

Screen printing technique uses a woven mesh to support an ink-blocking stencil to receive a desired image. The stencil attached forms open areas of mesh that transfer ink or other printable materials which can be pressed through the mesh as a sharp-edged image onto a substrate<sup>[2]</sup>. A squeegee is moved across the screen stencil, pumping ink which is forced through the mesh openings to wet the substrate during the squeegee stroke. It is the process which uses a mesh-based stencil basically used to apply ink onto a substrate, like stickers, shirts, vinyl, wood, advertisements and other material.

Screen printing is also a stencil method of print making in which a design is imposed fine mesh screen of polyester or with blank areas coated with an impermeable substance. By the fill blade ink is forced into the mesh openings and onto the printing surface during forward stroke of squeegee. Due to action of rebounding away from the substrate the ink remains on the objects (substrate) on which printing is done. It is also known as silk-screen printing or serigraphy

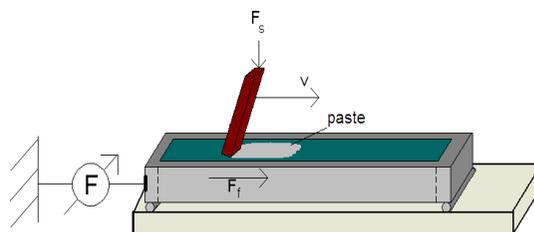
printing. Only single color is printed at a time which makes it mandatory to use several screens produce a multi-colored design or image. Screen printing technology is way to optimize and obtain the most cost effective facility for applying and patterning the different layers for hybrid electronics industry since a thick film circuit usually contains printed and dielectric layers con-

ductive lines resistive. Because of its good technological design and relative cheapness it is still widely used in the assembly of electronic circuits in masses.

The technology has a large application field extending to a decorative sticker manufacturing. It is also plays a significant role in balloon and cloths patterning and textile production. Most optimum machine to produce signs and displays, decorative automobile trim and truck signs and last but not least use in printed electronics<sup>[4]</sup>. The main intention of our project is to reduce printing time, to make machine compact and portable, reduce cost of machine & inherit product shape and size varying ability in it. Combine the advantage PLC operated and Manual Surface Printing Machine.

## II. MEASURING THE FRICTION FORCE BETWEEN THE SCREEN AND SQUEEGEE

The paste we have applied in our experiment was PC 3000 conductive adhesive paste. In the process of screen printing the friction force between the screen and the squeegee plays an important role. While the squeegee passes the screen due to the friction force the position of the mask shifts.



**Fig.1 Measurement setup for determining the friction force between the squeegee.**

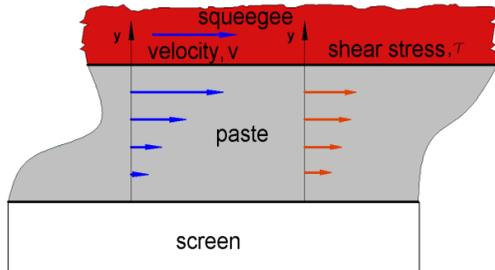
By this measurement the relationship between the friction force ( $F_f$ ) and the printing speed ( $v$ ) and squeegee force ( $F_s$ ) was estimated. Every thick film paste is viscous and has a non-Newtonian rheology suitable for screen printing. The shear stress,  $\tau$ , for this kind of fluids can be described by the Ostwald de Waele

relationship:

$$\tau = K \left( \frac{dv}{dy} \right)^n \tag{6}$$

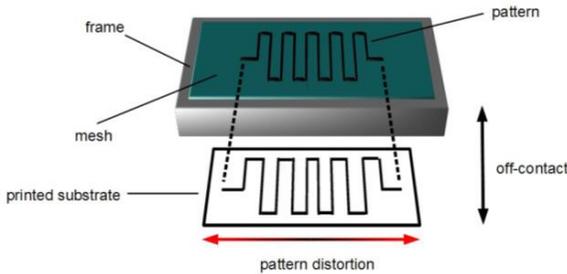
Where,

$K$  is the flow consistency coefficient (Pa/sn),  $\partial v/\partial y$  is the shear rate or the velocity gradient perpendicular to the plane of shear (s<sup>-1</sup>),  $n$  is the flow behaviour index (-)



**Fig.2** Appeared shear stress and the velocity of paste during screen printing.

In addition the elongation of the screen – which is greater if the off-contact is greater – results in image shift as well [5]. The effect of these lateral shifts demonstrated in Fig. 2 has also to be taken into account.



**Fig.3** Shows the shear stress and paste velocity during screen printing. Thick film paste is a shear-thinning fluid, thus  $n$  is positive but lower than 1.

The image shift was examined, where the screen tension was in the region of 2– 3.3 N/mm, the off-contact was 0.9–1.5 mm and the applied friction force was based on the measurement. The reduction of screen tension can affect the quality of the printing in other respects. The deflection force of the screen is decreasing, so the separation of the substrate and the screen cannot start right after the squeegee passes on the screen. This off-contact distance has to be modified in the function of screen tension to keep the screen from sticking to the substrate during printing because adhesion causes many separation problems that damage the quality of the printed film.

**III. EFFECT OF THE FRICTION FORCE AND SCREEN TENSION IN THE QUALITY OF SCREEN PRINTING**

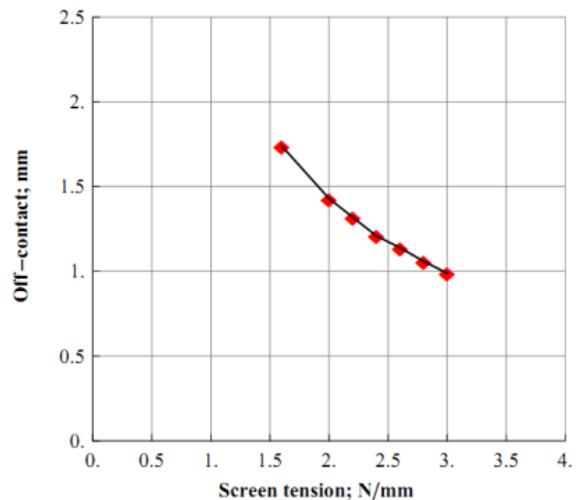
The model was supplemented by the friction force in order to determine the shift of the patterned screen.

Table I summarizes the friction force between the screen and the squeegee as a function of the squeegee force and speed.

**TABLE.I** The friction force between the screen and the squeegee

Speed [mm/s] \ Squeegee pressure [N]	20	40	60	80	100	120	140	160
10	2.2	3.4	4	4.6	4.6	5.2	5.6	5.6
20	2.6	4	4.4	5.2	5.4	5.6	6	6.2
30	3.4	4	4.6	5.2	5.6	5.8	6.8	6.6
40	3.6	4.2	5	5.4	5.8	6	6.8	7
50	3.6	4.6	5	5.4	5.8	6.2	7	7
60	3.8	4.6	5.2	6	5.8	6.4	7.2	7.4
70	4.6	5	5.6	6.2	6.2	6.6	7.4	8
80	4.8	5.6	5.8	6.6	6.6	6.9	8.4	8.4

Evaluating the results of Table I it can be determined by regression of least squares method, that  $n$  is between 0.2 and 0.4 in Eq. 6 for this type of adhesive paste. Even if the applied friction force was 8.4 N, the off-contact was 1.5 mm and the tension of the screen is reduced to only 2 N/mm the resulted shift is less than 2.7 μm. The image deformation arising from the elongation of the screen is less than 0.5 μm in the printing area of the screen in case of 1.5 mm off-contact. Obviously it is lower if the off-contact is lower. Accordingly the deposition shift is negligible under 1.5 mm off-contact and if the friction force is in this region. However, if there is not enough paste on the screen the friction force can be multiplied, so the shift can reach 10 μm. On the other hand the quality of the printing is maintainable if the reduction of screen tension is compensated. The screen tension is reducing in the screen caused by repetitive printing – which can be handled as a cyclic mechanical load – when the elongation of the screen is increasing. As the tension is decreasing the deflection force of the screen is also decreasing, so the screen usually adheres to the substrate and the separation cannot start right after when the squeegee has passed on the screen. The deflection force is maintainable if the off-contact distance is modified. In our study the initial screen tension was 3 N/mm and the off-contact was the industrial standard (1 mm) which resulted in adequate printing quality. In order to avoid adhering, the off-contact has to be increased according to Fig. 4.



**Fig.4** Off-contact compensation in the function of screen tension.

As the squeegee force has not been changed, the paste is being printed with the same pressure, and due to the modified off-contact the elastic force resulting from screen deflection and the paste adhesion has the same force condition as at the initial screen tension and off-contact.

**IV. FUTURE SCOPE**

Printing is necessary in every industry for marketing; aesthetic

look so it having wide scope. Manual curved surface printing machine can be used for various cylindrical products like bottles, pipe, glass, pens, drums and so many. The machine be converted in to fully automatic machine works on pneumatic system by using three DCV.

**TABLE.II COMPARISON BETWEEN DIFFERENT EXISTING MACHINES.**

Sr. No.	Parameters	Manual Operated M/C	Semi-Automatic M/C	PLC Operated M/C
1	Cost	250000 To 350000	41000	100000 To 150000
2	Time/Product*	3 Min	1 Min	0.5 Min
3	Labour	2	1	1
4	Printing Quality	As Per Operator	Better	Better
5	Construction	Simple	Less Complicated	Complicated
6	Use In Industries	Small Scale	Small, Medium & Large Scale	Large Scale

(\* Time shown in minute for specific diameter of job) (Data is collected from market survey)

## V. CONCLUSION

In manual printing on curved surface every time the force on the squeeze does not remains constant which can affect the printing quality but in this machine the force on the squeeze remains constant due to pneumatic cylinder which gives the same printing quality on every print.

This semi-automatic machine is less in cost as compared to PLC operated machine. As the machine is semi-automatic, it requires only one operator to operate the machine and to place the object where in manually operated machine it requires two operators to operate the machine. As the machine is semi-automatic it does not required any skilled worker.

The pneumatic operation is fast which decreases the printing time half and increases the production as compared to manual machine. This machine can be used in small as well as high scale industries.

## ACKNOWLEDGMENT

The research was sponsored by CLIMBER'S ENGINEER, Pune. The authors are indebted to Prof .Naidu SKNCOE, for his encouragement and everybody involved in this project directly & indirectly for their active support and involvement during designing and testing.

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