INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 4 - V7I4-1465)
Available online at: https://www.ijariit.com

Fabrication of flexography machine with heterogeneous operating modes

B. N. Durga
d.sowjanya2015@gmail.com
Avinashilingam University, Coimbatore, Tamil Nadu

D. Sowjanya
durgachinni2000@gmail.com
Avinashilingam University, Coimbatore, Tamil Nadu

R. Abitha
abithavp13@gmail.com
Avinashilingam University, Coimbatore, Tamil Nadu

N. Alagu Sundari
alagusundari124@gmail.com
Avinashilingam University, Coimbatore, Tamil Nadu

R. Viveka
viveka.balanagesh@gmail.com
Avinashilingam University, Coimbatore, Tamil Nadu

ABSTRACT

A commercial enterprise is important in an Indian financial system , it should give quality products to the consumers with cost-effectiveness. Now a day's print-on-demand is playing a prominent role within the print industry. Cost per copy is high for printing short-run jobs in conventional flexo printing machines, which are largely supported design and construction, and these are best suitable for production. to beat these problems, fabricating one color mini flexo machine which may be a manual machine, no power supply is given to run the unit of measurement and with fewer sub-systems (Unwinder, unit of measurement , drying unit, and Rewinder). As flexographic inks are liquid inks that need a dryer to calm down the ink permanently on the substrate, so using Two twenty V A.C supply for the drying unit alone. Therefore, cost are going to be reduced for printed electronics, print-on-demand purposes.

Keywords: *Print-on-Demand, Printed Electronics, Cost Effectiveness, Heterogeneous Operating Modes.*

1. INTRODUCTION

Manufacturing a machine may be a great challenge imposes on us. it's desirable to understand the fabric science, designing, and manufacturing process. To manufacture a machine, we've to verify it's profitable both technically and economically.

A simply constructed flexo machine is employed to print on flexible materials like paper, film, and foil, etc. the main components present in it are the infeed unit, unit of measurement, drying unit, and rewinding unit. The unprinted substrate is loaded on the infeed unit and after printing it's rewind within the re-winder. To overcome these drawbacks and to form cost-effective production for short-run and printing on-demand, "FLEX ON – DEMAND" – one color manual flexographic machine is meant the essential principle of this machine is predicated on reel-to-reel printing wherein when the printing is over it again rewinds within the rewinding station. This machine is found to be very economical and compact.

2. LITERATURE REVIW

A. Printing Requirements for Printed Electronics:

Printing technologies are demonstrated to be highly efficient and compatible with polymeric materials (both inks and substrates) enabling a replacement generation of flexible electronics applications. Conductive flexible polymers are a replacement class of materials that are prepared for a good range of applications, like photovoltaic solar cells, transistors molecular devices, and sensors and actuators. There are lot of possible printing techniques. This chapter provides a chance to review the foremost common printing techniques used at the economic level, the foremost commonly used substrates, and electronic materials, giving an overall vision for a far better understanding and evaluation of their different features. Several technological solutions (contact/noncontact) and their critical challenges also are presented. the most features of the various printing technologies, advantages, and main challenges also are compared [1].

B. Flexographic Printing Process:

Recent technological advancement in flexographic printing has allowed flexography to catch up with other R2R processes like gravure printing within the printed electronics field. However, there are many process parameters involved in flexography which will affect print quality. This work attempted to realize finer line printing compared to the present 45–100µm printed line width range of flexography by manipulating and studying these process parameters. A design of experiments was conducted to research the influence and interaction of varied

process parameters like anilox volume, anilox force, and printing force on the printed line width. After identifying the key process parameter from the planning of experiments. The results showed that the printing plate was elastically deformed with a variety of 50–400N printing forces. Beyond the 400N printing force, the printing plate experienced plastic deformation [3].

C. Printed Electronics Process:

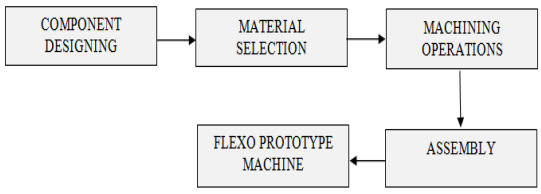
Various elements of the electronic fabrication process like layout, PCB wiring, harnessing, integration of varied sub-systems/systems, mechanical packaging, quality assurance, test, and evaluation, etc required for space-worthy hardware are discussed during this paper. ALONGSIDE this hybrid, Microwave microcircuit (MIC) and Surface Acoustic: Wave (SAW) device fabrication techniques have also been presented. Other upcoming techniques like Application-Specific microcircuit (ASIC), Multiple Chip Modules (MCM), Automated Optical Inspection (AOI), Computer Integrated Manufacturing (CIM), etc are briefly described.[4]. Fabrication of electronic devices on different flexible substrates is a NEIGHBOURHOOD of serious interest thanks to low cost, simple fabrication, and manufacturing at ambient conditions over large areas.

Over time, VARIETY OF PRINTING TECHNOLOGIES IS developed to fabricate a good range of electronic devices on nonconventional substrates consistent with the targeted applications. As an increasing interest of the electronic industry in printed electronics, further expansion of printed technologies is predicted in near future to satisfy the challenges of the sector in terms of scalability, yield, and variety, and biocompatibility. This chapter presents a comprehensive review of varied printing electronic technologies commonly utilized in the fabrication of electronic devices, circuits, and systems. the various printing techniques supported the contact/noncontact approach of the printing tools with the target substrates are explored. These techniques are assessed on the idea of simple operation, printing resolutions, the processability of materials, and simple optimization of printed structures. the varied technical challenges in printing techniques, their solutions with possible alternatives, and therefore the potential research directions are highlighted. the newest developments in assembling various printing tools for enabling high speed and batch manufacturing through roll-to-roll systems also are explored [5].

3. METHODOLOGY

Fabricating a prototype involves various stages of labor to be done. The below workflow shows the step-by-step process of fabricating a flexographic machine.

Workflow



A. Component Designing:

Designing may be a decision-making process to make a plant for creating a machine that might satisfy the need . it's an accurate process, which starts from a requirement and defines a system and therefore the method of its realization or implementation to satisfy the need . The below Figure 2 shows the front and view of the flexo machine.

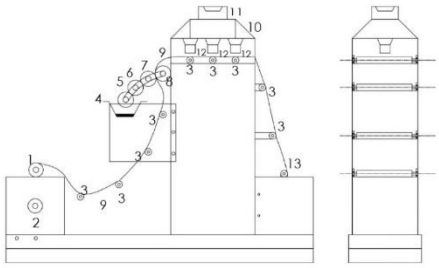


Figure 1 Front and Side view of Single color Flexo machine

1. Unwinder (700mmX450mm)
2. Break tensioner unit
3. Ideal roller (Ø50mm, L250mm)
4. Ink pan (75mmX250mmX150mm)
5. Fountain roller (Ø70mm, L245mm)
6. Anilox roller (Ø75mm, L245mm)
7. Plate cylinder (Ø85mm, L250mm)
8. Impression cylinder ((Ø75mm, L250mm)
9. Printing substrate
10. Hot air reservoir (500mmX200mm)
11. Hot air converter
12. Air delivery nozzle (250W, 18 drop)
13. Rewinder (450mmX700mm)

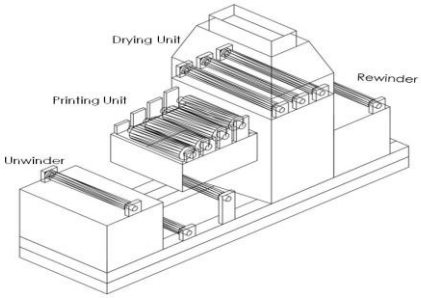


Figure 2 Flexo Machine Isometric View

B. Material Selection

Selection of a Material one among the choice the designer is named upon to form the choice is typically made before the dimension of the parts are determined.

Selection of EN8 mild steel
Selection of EN8 low-carbon steel

The term low-carbon steel applies to all or any low steel that doesn't contain any alloying elements in its makeup and features a carbon content that doesn't exceed 0.25%. The term “Mild” is employed to hide a good range of specifications and forms for a spread of Steel.

EN8 is an unalloyed medium steel that's utilized in applications where better properties than low-carbon steel are required but where the prices don't justify the acquisition of a steel alloy. EN8 are often heat treated to supply an honest surface hardness and moderate wear resistance by flame or induction hardening processes. From the automotive trade to wider general engineering applications, EN8 is popular steel within the industry. Key Features:

- Unalloyed medium steel
- Reasonable lastingness
- are often flame or induction hardened
- Readily machinable
- Moderate wears resistance if heat treated

Selection of nitrile rubber

NBR Rubber Sheet may be a synthetic material that's utilized in a good range of applications thanks to its resistance to most petroleum-based fluids, oils, and greases. Nitrile offers moderate

mechanical properties and has satisfactory resistance to aromatic hydrocarbons, but isn't suitable to be used with ketones.

Key Features
• Shore Hardness: 60° ± 5°.
• Temperature: -20°C up to +70°C.
Selection of EN24
EN24 may be a very high-strength steel alloy that's supplied hardened and tempered. The grade may be a nickel-chromium-molybdenum combination - this offers high tensile steel strength, with good ductility and wear resistance characteristics. With relatively good impact properties at low temperatures, EN24 is additionally suitable for a spread of elevated temperature applications.

Key Features
• Very high strength steel alloy
• Easy to heat treat and temperature
• Supplied hardened & tempered
• Good combination of strength, ductility, and wear resistance

C. Machining Operations
Machining is that the manufacturing process and it means the shaping of objects by removing excess material from purchased material Machining is used for the subsequent reasons:
- For proper fitting and accurate orientation.
- Machining can make some small precise component

Frame making: The frame is kept vertically during a flat table V-type Magnetic block is employed to support the frame, which holds the frame a vertical position. Over the surface of the frame, use wet chalk to mark the drilling points. With the assistance of a vertical vernier micro-meter, mark the points are drilling.

Lathe machine work: A lathe may be a machine that's want to remove unwanted metals from the work piece to offer desired shape and size. the most function of the Lathe machine is to get rid of excess material within the sort of chips by rotating the work piece against a stationary cutter. this is often accomplished by holding the work securely and rigidly on the machine then turning it against the cutter which can remove metal from the work. to chop the fabric properly the tool should be harder than the fabric of the work piece, should be rigidly persisted the machine, and will be fed or progress during a definite way relative to the work.

Milling: Milling is that the process of removing metal within the sort of chips by rotating a multi-point cutter.
The various milling process performed by different milling cutter classified as
• Up milling (or) Conventional milling
• Down milling (or) Climb milling

Up milling: It is a process of removing metal when the cutting teeth move upward and therefore the cutter rotates to the direction of feed of the work piece. In up milling, the chip thickness is minimum at the top of the cut. The cutting action of the teeth is upward.

Down milling: Metal is removed when the cutter teeth move downwards. Here the cutter rotates within the same direction because the travel of the work piece. In down, milling chip thickness is maximum at beginning of the cut and reduces to the utmost at the top of the cut. The cutting action of teeth presses the work downward. This helps in clamping the work.

Cylindrical grinding machine work: Cylindrical grinders are generally wont to grind external surfaces like cylinders, taper cylinders, Faces, and shoulders of labor. Cylindrical grinding is performed by mounting and rotating the work between centres during a cylindrical grinding machine. The work is fed longitudinally against the rotating emery wheel to perform grinding. The upper table of the grinding machine is about at 0° during the operation.

Surface grinding machine work: Surface grinding machines are employed to end plain or flat surfaces horizontally, vertically, or at any angle. There are four differing types of surface grinders. They're Horizontal spindle and reciprocating table type, horizontal spindle, and rotary table type, vertical spindle and reciprocating table type, vertical spindle, and rotary table type. The bulk of surface grinders are of horizontal spindle type. within the horizontal sort of the machine, grinding is performed by the abrasives on the periphery of the wheel. Though the world of contact between the wheel and therefore the work is little , the speed is uniform over the grinding surface and therefore the surface finish is sweet . The emery wheel is mounted on a horizontal spindle and therefore the table is reciprocated to perform the grinding operation. Vertical spindle surface grinding machines on the face or sides of the wheel are used for grinding within the vertical type surface grinders. the world of contact is large and stock are often removed quickly. But a criss-cross pattern of grinding scratches is left on the surface. Considering the standard of surface finish obtained, the horizontal spindle type machines are widely used.

Radial drilling machine work: Drilling Machine is to makes circular holes on the components with the assistance of Drill bits. But, the aim of the Radial Drilling Machine is employed to drill the holes within the given radial distance and this may be used, when the component size is large in terms of height. When the component is large, it cannot fit its structure within the Machine vice. Therefore, the component has got to be placed on the bottom and therefore the Radial arm of the drilling machine has got to be rotated with the component to try to the operation.

Tapping machine work: A tapping machine may be a machine shell, end face, like nuts, flange with different specifications of the opening or blind hole of the inner side of the opening of the parts compute internal threads, screws or tooth buckle mechanical processing equipment. Tapping machine is additionally called the tapping machine, thread tapping machine, tapping machine, automatic tapping machine, etc.

Tapping machine may be a high degree of automation, at work, as long because the part blank into the hopper are often automatic feeder, automatic positioning, automatic clamping, automatic tapping, automatic discharging, a worker can operate multiple devices at an equivalent time, high production efficiency can save labor costs significantly. Tapping machine has novel design, reasonable structure, easy to use, high degree of automation, easy to use, high efficiency, maintenance-free, extremely high-cost performance, top quality of nut tapping machined out of all types of nut thread finish high, and high product quality.

A. ASSEMBLY
Most of the products are formed from an outsized number of single parts produced at different times and by various production processes. the target of assembly is to make a neighbourhood of upper complexity with specified functions during a specified period from the individual parts. Most of the products are formed from an outsized number of single parts produced at different times and by various production processes. the target of assembly is to make a neighbourhood of upper

complexity with specified functions during a specified period from the individual parts.
Printing unit assembly: Unit of measurement assembly involves assembling the printing frame, fountain roller, anilox roller, plate cylinder, impression cylinder, ink tank.

Printing frame assembly: Printing frames, which have a dimension of about 1230mmX500mm (horizontal primary frame), 750mm X 500mm (Vertical secondary frame) are taken and kept aside from one another during a required position. Within the rod , the supporting phase is fixed with the assistance of a circlip, at both ends. Printing frames are connected by fixing four connecting rods at four corners - within the inner side of the frame.

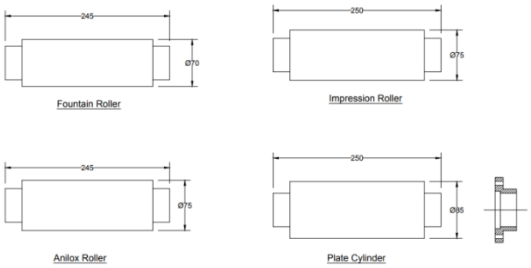


Figure 3 Printing unit components

Fountain roller assembly: The fountain roller is that the roller that takes up ink from the ink tank and transfers it to the anilox roller. As shown in Figure 5 it's a length of about 245mm and a pitch circle diameter of about go 70mm. On the operator side, spur wheel of diameter 100mm having 44 teeth is fixed within the fountain Roller. A Self-aligning bearing is fitted inside the eccentric housing. the entire found out i.e., eccentric housing alongside the self-aligning bearing is fixed to both the ends of the fountain roller shaft. The below figure shows the fabricated fountain roller.

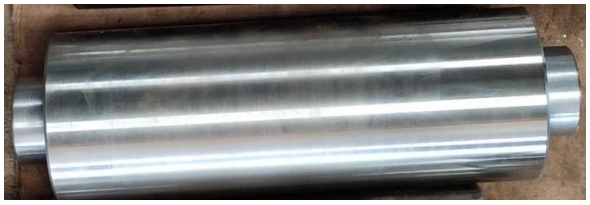


Figure 4 Fountain Roller

The fountain roller is fixed to the frame. Stoppers are fixed with the assistance of an M6 hexagonal bolt on each side of the frame to avoid the bearings beginning of the frame. Eccentric housing has a projection that's offset within the center. When it's rotated, the self-aligning bearing sails support and help to maneuver the fountain roller up and down eccentrically.

Anilox roller assembly: Anilox roller is that the main roller in flexography, for the metering of ink that's about 75mm in diameter and having 245mm length as shown in Figure 5. Needle-type clutch bearing HF2520 of diameter 32mm is fixed with the gear of diameter 88mm having 44 teeth. The gear alongside the bearing is fixed to the anilox roller shaft on the operator side. A deep groove needle bearing is fixed to the frame. Gera of diameter 88mm having 44 teeth is fixed to the shaft of anilox roller within the gear side and is tightened with the grub screw. A nylon washer of thickness is fitted on either side of the gear, to avoid metal-to-metal contact, when the anilox roller is rotated separately for the metering of ink without the engagement of drugs with the assistance of an aluminum handle provided within the gear side. The below figure shows the fabricated Anilox roller.

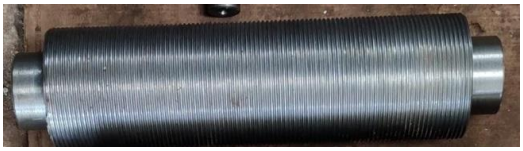


Figure 5 Anilox Roller

Metals when are available contact while moving, will increase the were and produce heat also. The roller is fixed to the frame. Stoppers are fixed with the assistance of an M6 hexagonal bolt on each side of the frame to avoid the bearings beginning of the frame.

Plate cylinder assembly: The plate cylinder is that the main cylinder on which the polymer plate is pasted, which carries the image. Its pitch circle diameter is about 85mm having 250mm long. Deep groove needle bearing is fitted to the gear of diameter 88mm having 44 teeth. The below figure shows the fabricated plate cylinder.

Figure 6 Plate Cylinder

The gear along with the bearing is fixed to the end of the block cylinder shaft in the gear side. On the other side of the shaft, the eccentric gage plate is fixed along with the bearing, which is mounted on the top of a two-pressure adjustment bearing. This eccentric gage plate is a metal runner that is having a projection that is offset in the centre, to which two deep groove ball bearings, are fitted. In the block cylinder shaft a lever is fixed, so that impression can be put on and off by moving the handle. The eccentric gage plate will move eccentrically according to the motion of the impression lever. So that when the impression lever is put on, then the eccentric gage plate will move down and comes in contact with the impression cylinder. When the impression lever is put off, then the eccentric gage plate will move up and release the contact. The pressure adjustment bearing is fitted exactly in the circular slot of the pressure adjustment plate. So the pressure of the block cylinder can be adjusted, according to the substrate used. The roller stopper is there, one on the operator side and two at the top of the roller on either side to stop the roller from movement i.e., to avoid vibrations.

Impression cylinder assembly: The impression cylinder, which pressurizes the substrate, has a pitch circle diameter of about 75mm and a length of about 250mm as shown in Figure 5. Deep groove ball bearing is fixed to the gear of diameter 88mm having 44 teeth. The gear along with the bearing is fixed to the impression cylinder shaft on the gear side. Ball-bearing is fixed to another side of the shaft. Impression cylinder if fixed to the frame. Stoppers are fixed with the help of an M6 hexagonal bolt on both sides of the frame to avoid the bearings coming out of the frame. The below figure shows the fabricated impression cylinder.

Figure 7 Impression Cylinder

Ink tank assembly: An ink tank may be a reservoir that stores ink from which ink is supplied. it's of length 450mm and width 150mm having a height of 75mm. it's an oblong projection at rock bottom on either side of the tank. Therein projection, two circular slots are there for about 16mm diameter. This provision is to repair the ink tank lock pin, which supports and holds the tank.

Reel stand assembly: The reel stand block is fixed within the channel with an M5 hexagonal bolt. The reel rod alongside the reel-tightening cone is mounted on the reel stand and it's tightened with a knob.

Rewinder unit assembly: it's a reel rod made from low-carbon steel , which is lying next to the drying unit. it's got a hook, which is locked within the rod . Where the printed web gets rewind to the reel rod/ Rewinder at substantially constant tension within the rewind station.

Pressure setting: To urge quality printing i.e. Proper transfer of ink to the substrate, Pressure setting is vital . Pressure should be set to an optimum. If it's too high the printed image deform from its original shape and size, this is often due to the high on the polymer plate. If pressure is just too low, then there'll be no transfer of ink to the substrate. Adjusting the pressure adjustment plate can set pressure. The pressure adjustment bearing is fixed within the circular slot of the pressure adjustment plate. Loosen the bolt within the pressure adjustment plate, in order that when it's moved, the pressure adjustment bearing rotates accordingly. Then tighten the bolt within the plate inside the slot.

4. POWER TRANSMISSION

Power transmission is that the transfer of energy from where it's generated to an area where it's wont to perform works using simple machines, linkages, and mechanical power transmission elements. There are some ways to get power but sometimes it's impossible to get power where it's needed or within the right form or direction or magnitude. Hence electrical & mechanical power transmissions are vital for any engineering product design.

A. Flexo machine:

The energy is converted into rotational energy by the wheel handle. The handle is usually wont to drives the machine and therefore the machine tools. the facility from the wheel handle is transferred to the pulley within the main drive shaft situated within the unit of measurement .

Within the unit of measurement, the gear teeth of the most drive shaft mesh with the teeth of the impression cylinder, then the mechanical power is transferred. Likewise, the plate cylinder receives the facility from the impression cylinder. The anilox roller possesses 2 gears. On the gear side, it receives power from the gear of the plate cylinder and on the operator side, it transfers power to the fountain roller.

B. Drying unit:

220 Volts A.C into 200 Watts induction heater and high-velocity impellor fan both together area single built-in unit made from ABS plastic.

5. COST CALUCULATION

A. Cost Calculation

Cost is one of the main factors in order to choose the most suitable solution, so accurate estimation in the early design phases is fundamental. The below table shows the cost of the components, material, process and the total cost of the fabricated machine.

Table 1: Cost Caluculation

S.NO.	COMPONENTS	MATERIAL/ PROCESS	COST (In Rs)	QUANTITY (In Number)	UNIT COST (In Rs)
1.	IMPRESSION ROLLER	R.M COST	1500	1	5500
		Fabrication	500	1	
		Machining	1500	1	
		Hard chrome plating cost	1000	1	
		Dynamic Balancing Cost	1000	1	
2.	PLATE CYLINDER	R.M. COST	1500	1	4500
		Fabrication	500	1	
		Machining	1500	1	
		Hard chrome plating cost	1000	1	
3.	ANILOX ROLLER	R.M. COST	1500	1	9000
		Fabrication	500	1	
		Machining	1500	1	
		Dynamic Balancing Cost	1000	1	
		Electronic Laser etching Cost	4500	1	
4.	FOUNTAIN ROLLER	R.M. COST	1500	1	7000
		Fabrication	500	1	
		Machining	1500	1	
		Dynamic Balancing Cost	1000	1	
		Rubber Lagging Cost	2500	1	
5.	BASE FRAME	R.M. COST	6500	1	11500
		Fabrication Cost	3500	1	
		Sundry Drilling / Tapping	1500	1	
6.	IDLE ROLLERS	Aluminium Idle Rollers along with bearings and Axle shaft	1250	8	10000
7.	DRYING UNIT	Drying chamber, including Hot Air Convector	5000	1	5000

S.NO.	**COMPONENTS**	**MATERIAL/PROCESS**	**COST (In Rs)**	**QUANTITY (In Number)**	**UNIT COST (In Rs)**
8.	INFEED AND REWINDER UNIT	Unwinder/Rewinder shaft sets along with core Supporters and screw Jacks	3000	2	6000
9.	SHAFT HOLDER	Shaft holder and lock for above	1500	2	3000
10.	GEARS	50 Teeth	2500	1	
		44 Teeth	2000	3	8500
11.	UNWINDER UNIT	Unwinder Brake Tensioner Set	3500	1	3500
12.	FOUNTAIN ROLLER	Primary Slider Set	3500	1	3500
13.	PLATE ROLLER	Secondary Slider Set	3500	1	3500
14.		Tertiary Slider Set	3500	1	3500
15.		Carrier Frame	3000	1	3000
16.		Doctor Blade Set	3750	1	3750
17.	INKING UNIT	Ink Tray Set	2000	1	2000
18.	MISCELLANEOUS MATERIAL	Misc. expenditure, including Hardware, Nickel plating, paint powder coating, etc.	5000	1	5000
	TOTAL COST	**RS. 97750**			

B. Cost Comparison

Cost advantage between a conventional flexo machine and the test machine being made by us is as follows:.

1. One printing station of a conventional flexo printing machine will cost approximately Rupees three lacks as against our test machine which will cost Rupees ninety two thousand seven fifty due to the following reasons:

a. We have so designed the machine that its weight will be only 25 percent of that of a conventional machine due to its modular design and hollow subsections

b. The cost reduction will also take place as the principles of " Economies of scale " will apply due to increased demand as a result of substantially lower cost

c. The cost will also decrease due to lesser dependence of labour as the incidence of handling becomes significantly lesser.Below figure shows the comparison of existing and proposed flexo machine cost.

S.NO.	**UNIT**	**EXISTING SYSTEM COST (In Rs)**	**PROPOSED SYSTEM COST (In Rs)**
1.	UNWIND	19500	6500
2.	IDLE ROLLER	30000	10000
3.	PRINTING UNIT	150000	68250
4.	DRYING UNIT	15000	5000
5.	CHILLING UNIT	12000	-
6.	INLINE FINISHING OPERATIONS	30000	-
7.	REWINDING	9000	3000
8.	MISCELLANEOUS MATERIAL	15000	5000
9.	POWER SUPPLY	19500	-
	TOTAL COST	**RS. 300000**	**RS. 97750**

6. CONCLUSION

"FLEX ON – DEMAND" – a modified, simple, and compact flexo machine that is cost-effective. The least expensive and thereby small-scale industries afford easily for print on demand purpose. Following are the advantages of FLEX ON - DEMAND

- Printability to a variety of materials
- Economic
- Less wastage
- Reduced power consumption
- Reduced manpower
- Occupies less space

7. REFERENCES

[1] Sílvia Manuela Ferreira Cruz, Luís A. Rocha, and Júlio C. Viana, Printing Technologies on Flexible Substrates for Printed Electronics, Submitted: December 4th 2017Reviewed: March 2nd, 2018, Published: July 25th 2018, DOI: 10.5772/intechopen.76161

[2] Prof. Dr.-Ing. Habil. Helmut Kipphan, Handbook of print media Technologies and Production Methods, Published: 1997,

[3] Z. W. Zhong Icon, J. H. Ee, S. H. Chen &X. C. Shan, Parametric investigation of flexographic printing processes for R2R printed electronics, Pages 564-571 | Received 24 Sep 2019, Accepted 14 Feb 2020, Published online: 05 Mar 2020.

[4] C Lal, M V Shah &S C Bawa, Fabrication Techniques for Space Electronics, IETE Technical Review, Volume 10, 1993 - Issue 5: Space Electronics.

[5] Saleem Khan, Shawkat Ali and Amine Bermak, Smart Manufacturing Technologies for Printed Electronics, Submitted: June 25th 2019Reviewed: August 27th 2019Published: November 12th, 2019, DOI: 10.5772/intechopen.89377

