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Design and Experimentation of Automatic Cloth Dyeing Machine

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Abstract— Dyeing is a method which enhances beauty of the textile by applying various colours and their shades on to a fabric. Colour is applied to fabric by different methods and at different stages of the textile production processes like Stock dyeing, Top dyeing, Piece dyeing, Solution pigments or dope dyeing, Garment dyeing, Yarn dyeing. . It is the process by which uniform colouring of the cloth is achieved & it can be categorized into three types like Batch Dyeing Process, Continuous Dyeing process & Semi-Continuous Dyeing process. This work includes the study of problems that were faced during the manual dyeing of clothes for commercial purpose. By studying such problem the need of efficient Cloth Dyeing Machine was developed. If the developed machine is commercialized, the problems occur during manual dyeing will get mitigated and shop owner will get benefited. The purpose of this research is to design, develop and evaluate automatic cloth dyeing machine. This research work includes the design description, development by using Pro-E wildfire 4.0 and evaluation of automatic cloth dyeing machine. Required key features in the model show good conformity and they will satisfy all the essential requirements of the customer as well as shop proprietor as it may avoid temperature drop and decreases dyeing time.
Keywords - Methods of dyeing, types of dyeing process, dyeing, manual dyeing, automatic dyeing machine, etc.

I. INTRODUCTION

In textile sector dyeing is an important process. Dyeing is the steps on which uniform colouring of the cloth is depend. Now a day's dyeing of the cloth is doing only by deep process. Deep process is very time consuming and difficult process. Uniform dyeing produces fine garments. Dyeing is a method which imparts beauty to the textile by applying various colours and their shades on to a fabric. Dyeing can be done at any stage of the manufacturing of textile- fibre, yarn, fabric or a finished textile product including garments and apparels. The property of colour fastness depends upon two factors- selection of proper dye according to the textile material to be dyed and selection of the method for dyeing the fibre, yarn or fabric. Dyeing is the process in which a dye molecule gets thoroughly dissolved and dispersed in the carrier. It can be in water or some other carrier also, but it must be able to penetrate and colour the textile materials in the process. In the textile dyeing process the dyeing is carried out at different stages like polymer, yarn, fabric and garment or even at the product stage.

Dyeing process is categorized into 3 types i.e. Batch Dyeing Process, Continuous Dyeing process, Semi-Continuous Dyeing process. Batch Dyeing Process is the most popular and common method used for dyeing of textile materials. Batch dyeing is also sometimes referred to as Exhaust dyeing. This is because in this process, the dye gets slowly transferred from a comparatively large volume dye bath to the substrate or material that is to be dyed. The time taken is also longer. The dye is meant to 'exhaust' from dye bath to the substrate. In batch processes, textile substrates can be easily dyed at any stage of their assembly into the desired textile product. This includes fibre, yarn, fabric or garment. A Continuous dyeing process typically consists the following. Dye application, dye fixation with heat or chemicals and finally washing. Continuous dyeing has been found to be most suitable for woven fabrics. Mostly continuous dye ranges are designed for dyeing blends of polyester and cotton. The step of padding plays a key role in the operation of continuous dyeing. Sometimes Nylon carpets are also dyed in continuous processes, but the design ranges for them is unlike that for flat fabrics. Warps are also dyed in continuous process. Very good examples of such warp dyeing are long chain warp dyeing and slasher dyeing using indigo. In the process of semi-continuous dyeing that consists of pad-batch, pad-jig, pad-roll the fabric is first impregnated with the dye-liquor in, what is called a padding machine. Then it is subjected to batch wise treatment in a jigger. It could also be stored with a slow rotation for many hours. In the pad-batch this treatment is done at room temperature while in pad-roll it is done at increased temperature by employing a heating chamber. This helps in fixation of the dyes on to the fibre. After this fixation process, the material in full width is thoroughly cleansed and rinsed in continuous washing machines. There is only one point of difference between Continuous and semi-continuous dyeing process is that in semi-continuous dyeing, the dye is applied continuously by padding. The fixation and washing remaining discontinuous. Liquor Ratio in semi-continuous dyeing is not of much importance and is not taken as a parameter. One of the widely used techniques for semi-continuous dyeing process is the Pad Batch Dyeing a schematic diagram is given here for the semi-continuous process.

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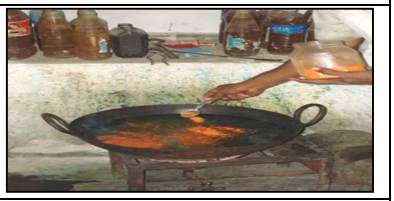
Colour is applied to fabric by different methods and at different stages of the textile manufacturing process viz. stock dyeing, top dyeing, piece dyeing, Solution pigments or dope dyeing, Garment dyeing, yarn dyeing. Stock dyeing is used to dye fibres. In this process, the staple fibres are packed into a vessel and then dye liquid is forced through them. Although the dye solution is pumped in large quantities, the dye may not penetrate completely into the fibres and some areas may be left without dyeing. However, the following blending and spinning processes mix up the fibres in such a thorough way that it results in an overall even colour. Woolens are usually stock dyed. Top is the combed wool. In this method, the fibre is dyed in the stage just before the appearance of finished yarn. Piece dyeing, in this method, small batches of constructed natural colored fabric are dyed according to the demands for a given colour. It is the process in which the entire roll of the cloth is dyed and then cut as needed or cut pieces of cloth are dyed before the garment is assembled. In this process the cloth is placed in dyeing machine and passed through the dye solution for specified length of time. Once the cloth is dyed it is cut according to your pattern and sewn using the same colour thread. Dye is added to the solution before it is extruded through the spinnerets for making synthetic filaments. Garment dyeing Dye is applied to finished products such as apparels and garment. Stock dyeing is used to dye fibres. In this process, the staple fibres are packed into a vessel and then dye liquid is forced through them. Although the dye solution is pumped in large quantities, the dye may not penetrate completely into the fibres and some areas may be left without dyeing. However, the following blending and spinning processes mix up the fibres in such a thorough way that it results in an overall even colour. When dyeing is done after the fibre has been spun into yarn, it is called yarn dyeing. In this method, the dyestuff penetrates the fibres to the core of the yarn. There are many forms of yarn dyeing- Skein (Hank) Dyeing, Package Dyeing, Warp-beam Dyeing, and Space Dyeing.

II. PROBLEM STATEMENT

Traditional process of cloth dyeing in commercial stores is very time consuming and also difficult to perform. With this process only one cloth can be coloured in one attempt. As per the observation, time required for a cloth to be coloured is 90 minutes (average). Also the process is completely manual thus dyeing rate is also less. Operating time and dyeing rate are the most important parameters in dyeing process. They are measured as the performance and efficiency of the process. The main achievement with this machine is not only increased dyeing rate but also time required for dyeing is decreasing drastically. Because of its closed system, temperature drop is very slow continuous heating is not required thus energy is saved and two or more clothes can be coloured at a same time. Moreover dipping & stirring are done automatically. Following table shows the entire manual process.

TABLE I

METHOD OF EXISTING PROCESS

Step No.	Action Performed	Photograph
1.	Adding dye into the water for the cloth. For 1 litre of water, 10 grams of dye (required colour) should be used.	
2.	Mixing the dye in water and heating it at 80’c to make the dye bath.	
3.	When dye and water are mixed in fixed proportion then heating is continuously upto temperature 800c then dye bath are ready to add the cloth.	

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4.	Dye and water are mixed properly then dip the cloth in dye bath and continuously stirring the cloth upto 90 minute(Average) and can see by naked eye cloth are coloured or not.	
5.	Then finally coloring the cloth are ready then afterward it through to the atmospheric air to dry the cloth.	

III. OBJECTIVES OF RESEARCH

The objectives of present study is to develop a low cost, simple in design an Automatic cloth dyeing machine with conventional source of Energy & which will be economical, user friendly and highly efficient. The aim of this automatic machine is to reduce operating time and also to increase dyeing rate.

IV. SCOPE OF RESEARCH

To provide Innovative design of a cloth dyeing machine which is very simple even an unskilled labour can operate it.
To achieve no drop in temperature so that continuous heating of water should not require.
To analyse the performance of machine in terms of operating time.

V. DESIGN AND DEVELOPMENT OF COMPONENTS AND MACHINE

Following main components used in the design of Automatic Cloth dyeing machine along with the component's specifications. The specifications came after following the conventional analytical design procedure.

TABLE II
METHOD OF EXISTING PROCESS

Component No.	Component	Specification
1.	Motor	Power = 0.5 HP R.P.M. =1440
2.	Drum	Capacity Of Drum = 190 litres Diameter = 550m Height = 850 mm
3.	Smaller Pulley	Width=13 mm Thickness=8 mm D_{min}= D1 = 75 mm
4.	Bigger Pulley	D_{max}=D2=375 mm
5.	V-Belt	Length = 1656.85 mm Width = 81.20 mm
6.	Shaft (SAE 1030)	Diameter = 28 mm
7.	Pedestal Bearing	As per shaft dia.

Automatic Dyeing machine is incorporated with following elements like A.C electric motor (0.5 HP), V-Belt and pulley, Speed Variable, Shaft, Pedestal Bearing (Rolling contact), stand, drum, etc.

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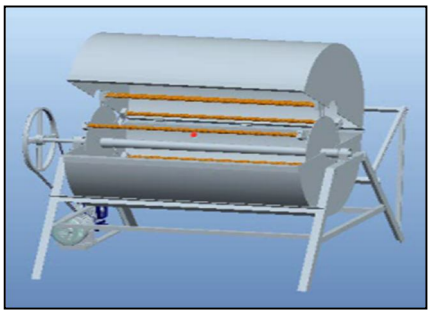

Fig 1: Front view of Cloth Dyeing Machine

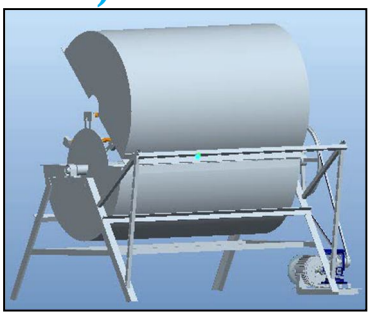

Fig 2: Back view of Cloth Dyeing Machine

Fig 3: Side view of Cloth Dyeing Machine (Actual Photo)

Fig 4: Clothes tied on drapery rod

VI. OPERATING PROCEDURE

Take 50 litres water in the drum.
Heat the water upto 80^{o}C.
Now add dyeing chemical in drum and stir it well.
Again heat the dyeing solution till temperature rise up to 80^{o}C if any temperature drops.
Now tie the cloths on drapery rod in such a way that it should be little far from each other.
Close the drum cover and rotate the supporting plate with motor.
Continue the process up to 15 min.
Now open the drum cover and see that all cloths are dyed or not?
Remove all colouring chemical from the drainage valve.
Again close the drum cover and rotate the cloth for 15 mins after that open the drum cover and see those cloths little dried as water is thrown out by centrifugal force.

VII. RESULT AND DISCUSSION

The experiment is carried out for denim jeans, cotton T-shirt and one cotton shirt. By following procedure following observations were recorded shown in table below. Time required as well as temperature drop is observed after the end of the dyeing process.

TABLE III
OBSERVATION TABLE

Item	Time taken for dyeing manually (minutes)	Time taken for dyeing with machine (minutes)	Time saved (minutes)	Temperature at the start of process (^{o}C)	Temperature at the end of process (^{o}C)
Jeans	90-110	60-80	30	80	79.1
T-Shirt	60-80	40-50	20-30	80	78.7
Shirt	80-100	40-60	40	80	78.4

Since time required dyeing the above clothes are getting reduced reasonably well. Also the machine showed efficiency in terms of energy saving as due to enclosed system very less temperature drop is obtained.

VIII. CONCLUSION

The performance of Automatic Dyeing machine was investigated and there is a substantial progress in dyeing time and temperature drop. Thus in this way the Designing and Fabrication of automatic cloth dyeing machine is successfully done. This Kind of model can be useful in cloth dyeing shops. We are clearly able to see the difference of effort required between the manually and the automatic cloth dyeing mechanism. There are many aspects of the Design which needs further modification. This machine provides an effortless cloth dyeing. Though this mechanism is innovative in its own respect, still it has scope to elaborate the mechanism and can be studied further for obtaining better results.

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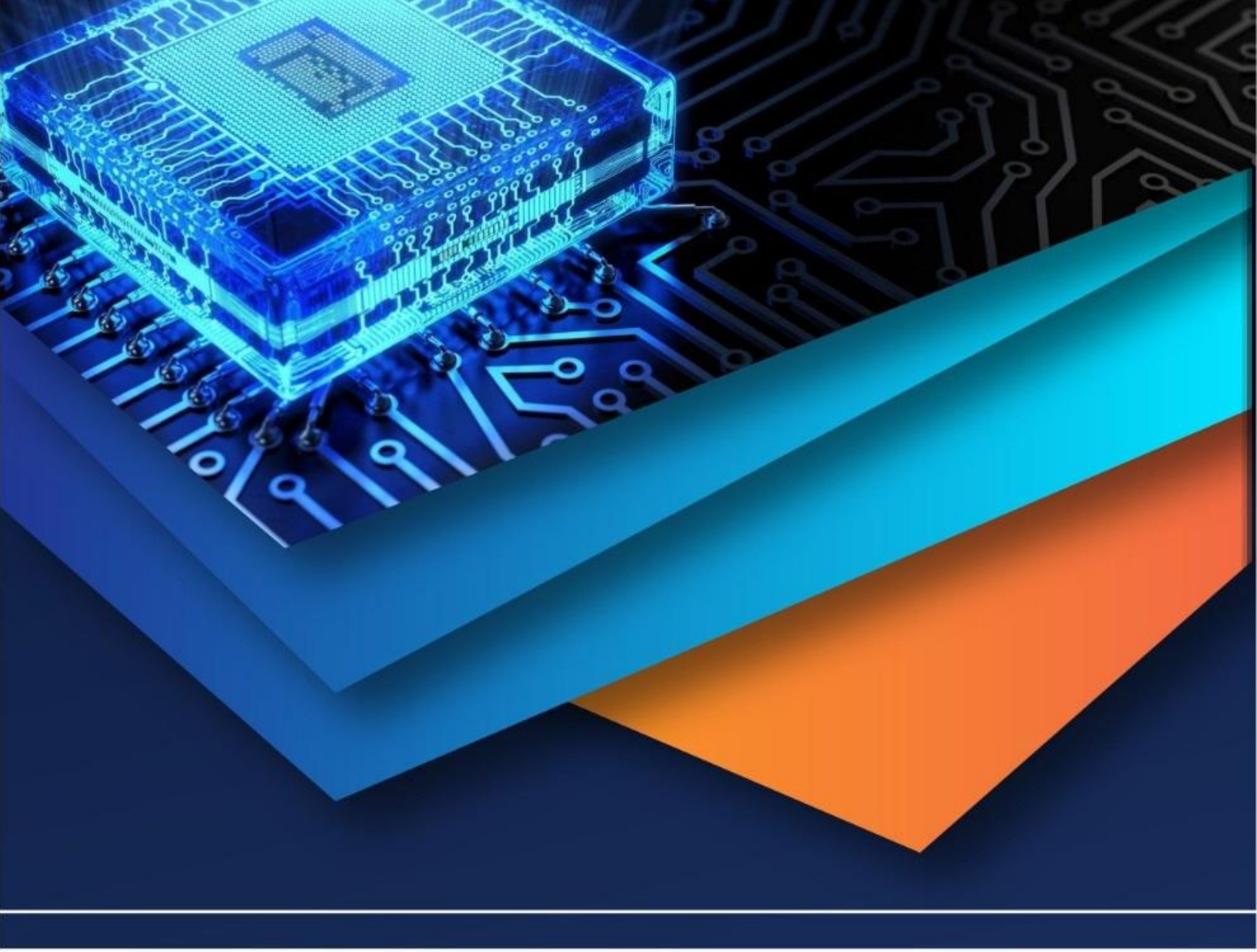

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