Modification and Design of Mechanism for Mackintosh Cleaning Machine for Performance Optimization

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Abstract **-** This paper is a case study based on industrial problem solving. The problem encountered at Vikamshi Fabrics Pvt.Ltd. situated at MIDC Khamgaon. In this paper we have designed a cleaning mechanism for cleaning machine for the effective cleaning of the industrial product i.e. mackintosh rubber sheets. Also we have suggested many other important solutions that have been proved beneficial to achieve the maximum cleaning action. This causes the human effort to reduce up to a great extent and also the better health conditions.

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I. INTRODUCTION

A. Introduction of the Industry and Products

Name of Industry : - Vikamshi Fabrics Pvt. Ltd.
Address : - B/27-29, M.I.D.C., P. B. No. 13, Khamgaon – 444303.
Liaison Office **:** - 304, Parshva Chambers, 17-21, Issaji street, Vadgadi, Mumbai - 400 003.

Keeping pace with the global industrial growth and emerging trends, Vikamshi Fabrics Pvt. Ltd. popularly known as "Vikamshi" is a privately owned and managed company, leading manufacturer & marketer of Rubberized Consumer Durables with indigenous leadership in Hospital Rubber Waterproof Sheets (Mackintosh). [1]

Mackintosh Sheeting is Bright Coloured, High Quality Flexible Fabric, rubber laminated from both sides, available in one side blue/ green and other side Red in our Standard range as Vikamshi Supreme. Other products are Handy bags, Flexi portable tanks, Dosing bladders, Inflatable boats, Frame supported tanks, Gas balloon, Air mattress, Impression and anti-static sheets etc. [1]

Fig.1 - Photograph of Mackintosh [1]

B. Manufacturing of Mackintosh

- Raw rubber in mixed with sulphur, color and many other essential ingredients in mixer.
- Then it is brought up to the calendaring machine where this mixed rubber is spread on the cotton net from two both the sides to make sheet.
- After that starch powder is spread over the sheet the sheet is allowed to cure for around 1 min over conveyer and then roll of 100m is formed.
- Then this roll is put in vulcanizer where steam is given to these rolls for nearly 45 minutes.
- After that this roll is cleaned in cleaning machine and then sends to inspection.
- In inspection sheet is checked for different kind of defects. The approved sheet is then cut to 4m length roll which is then send for packing and dispatch department.
- After that sheet is packed and dispatched to the warehouse.

C. Actual Machine and Related Data

The machine installed in the industry is discussed as below.

Fig.2 - Photograph of Actual Machine Installed at Industry [2]

The machine consists of four rollers two of which are black brush rollers and the remaining two are the cushion rollers having some cushion material over its surface. The rollers are arranged side by side as shown in the fig. in the above installation the rubber sheet is passed in a specific manner and when the rollers are allowed to rotate the desired cleaning action is achieved. [2]

TABLE I – ACTUAL MACHINE DATA [2]

Sr.No.	Parameters of Machine	Specifications
01	Cost Of Machine	Rs. 130000/-
02	Cost of Brush Roller	Rs. 22000/-
03	Cost of Cushion Roller	Rs. 25000
04	Length of rollers	160cm.
05	Dia. Of roller(with brush)	14.4cm
06	Height of roller from ground	103cm
07	Maximum working area of roller i.e, width of sheet	130cm
08	Diameter of 5 Holes on either side of machine	15cm
09	Old Suction Port Dimension	9 X 3 inch
10	So clearance available on each side	2.5 inch

Fig. 3 – Holes on the Either Side of Machine

D. Timely Modifications

- Previously the machine was in horizontal position i.e. all the rollers were in a single line later the vertical installation has come in to picture in which the black rollers are installed above the white rollers.
- Initially the machine won't have the suction system installed but later company installed it with a single port and with 1HP motor.
- The suction port was at the top of the machine frame.
- That was not enough hence the capacity of suction system motor increased to double.
- Machine also modified earlier with the replacement of two sint rollers with the brush rollers. Previously all the rollers were of Horse hairs roller, now out of that, two rollers have been provided with the cushion (felt) material.
- Later industry also installed a rotary seal system for the separation of moist powder and air.

Fig. 4 – Rotary Seal System

II. PROBLEM DEFINATION

The major problem in the industry is in the efficient and proper cleaning of the rubber sheet. After the manufacturing and processing of sheet removal of starch powder must be done. As 100 m of rubber sheet requires approx. 4 kg of starch powder during processing. Out of 4 kg about 80% of powder *i.e.* approximately 3.2kg of powder get absorbed in the sheet during heating in vulcanizer. So at the entrance to the cleaning machine the sheet is holding approx. 800gm of starch powder. This should inevitably be reduced to the desire level i.e. 200-250 gm per roll. Before modifications nearly 400 gm powder was there on the sheet after cleaning which was not desirable.

The powder thus removed by the brush roller is flying away but. One suction port at the top alone was not sufficient to suck the flying off powder as every powder particle has its own weight due to gravity the powder is again fall down.

The main problem is with brush roller when it removes the powder over from the 4-5 rolls of sheet (each roll is of 100m length), the powder removed get accumulated in the brush itself as shown in figure below. While removing the powder over next sheet accumulated powder in the brush falls down on the sheet and thus doing the reverse process than desirable. This must be avoided for the proper cleaning of sheet. Before modifications workers were used to clean the brush roller manually before the processing of the next roll of sheet.

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Fig.5 - Photograph of Accumulated Powder in Brush Roller

III. IMPLEMENTED SOLUTIONS

To achieve the proper amount of powder on the sheet following modifications are done in the machine.

A. Change in Suction Port Location

As soon as the power from the sheet surface is fly off it should be properly sucked so that it does not get mixed in the atmosphere and also the powder can be reused. For the same purpose suction unit has came into picture.

Previously only one suction port was provided at the top of the machine but later to achieve the higher effectiveness the ports can be installed at both the sides of the machine so that the powder which falls by gravity in the downward direction can also be sucked effectively.

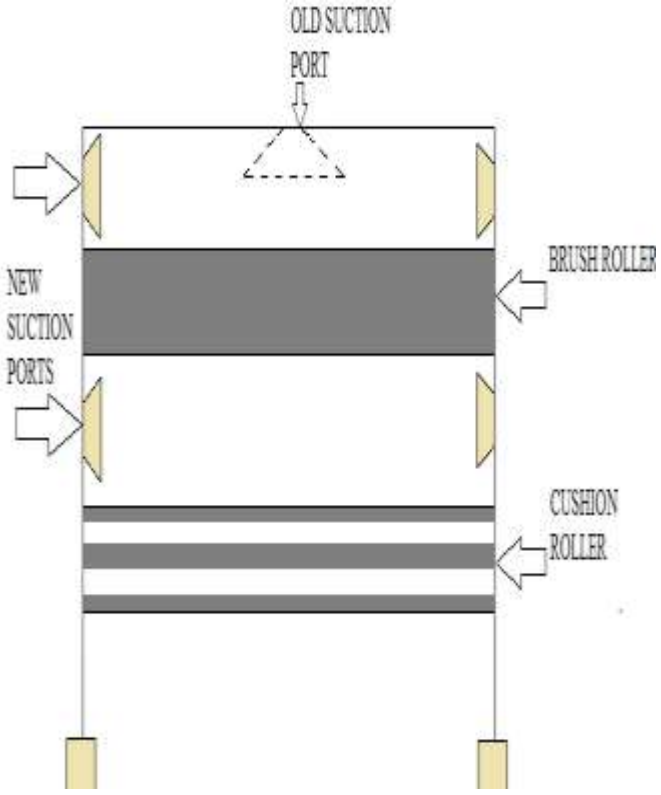

Fig.6 - Change of Suction Port

Fig.7 - Photograph of Change in Suction Port Position

Fig.8 - Photograph of Change in Suction Port Position

Fig.9 - Photograph of Change in Suction Port Position

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B. Implementation of Scrubber Mechanism

As we discuss in the earlier section the powder accommodated in the brush roller falls back on the sheet hence before processing of the next sheet this powder must be removed so avoiding it to fall down back on the sheet. The powder removal from the brush is done with the help of scrubber mechanism which is shown in the following diagram.

The scrubber is made up of Fiber Reinforced Plastic because it is light in weight, have high surface finish inside so that it will not cause wear of brush roller. The scrubber can be operated manually and with the help of lead screw mechanism between the unloading of cleaned sheet and loading of the next roll of sheet so no extra time is needed for the operation of scrubber. Scrubber is having number of holes on its surface so that powder removed from the brush must be get removed from the scrubber also. The inside diameter of scrubber is intentionally kept to 130 cm so that there should be little rubbing action takes place in between brush and scrubber surface. The length of the scrubber is kept to 15 cm which is equal the clearance available on the either side of the brush as length of brush is 160 cm and maximum width of the sheet is 120 cm.

The lead screw and nut for the said mechanism are designed and fabricated to the following specifications.

TABLE II – SPECIFICATIONS OF MECHANISM [3]

Sr.No.	Type of Data	Nomenclature	Specifications
01	Core diameter screw	d_c	8 mm
02	Nominal diameter screw	d_o	10 mm
03	Pitch of screw	p	2 mm
04	Height of nut	h	10 mm
05	Number of threads in engagement	n	5
06	Speed of motor	N_s	1
07	Thickness of thread at base	t	1 mm
08	Motor power	P_m	1200 rpm
09	Number of start	N	12 W
10	Material for Nut	---	Phosphorus Bronze
11	Material for Lead screw	---	Medium Carbon Steel
12	Material for Scrubber	---	Fiber Reinforced Plastic

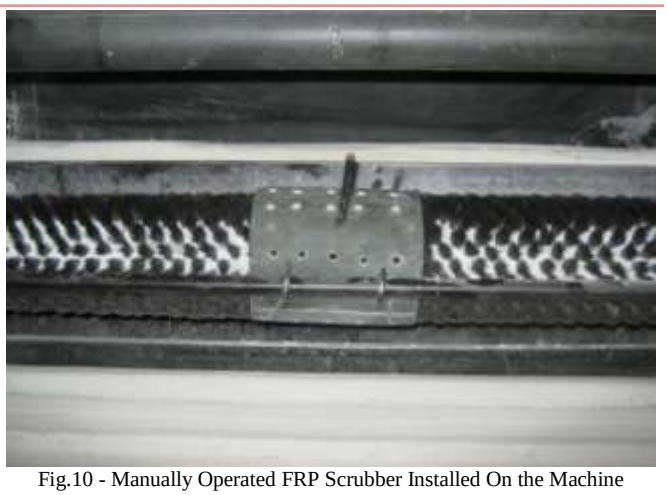

Fig.10 - Manually Operated FRP Scrubber Installed On the Machine

Fig.11 - FRP Scrubber with Lead Screw and Nut Mechanism

C. Change in Path of Sheet

The sheet path through the cleaning machine is reconstructed so as to increase the contact of sheet with the roller surface. The new implemented path of sheet is as shown in the fig below. Due to implementation of the new path the new path the contact of sheet surface with roller increases with great extent which causes the better powder removal rate. [2]

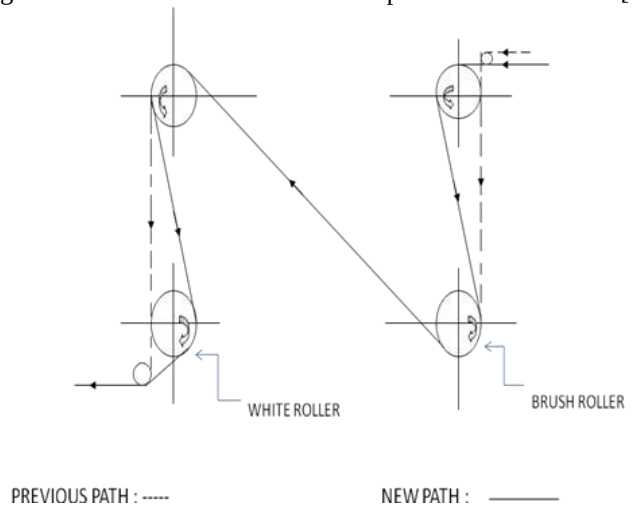

Fig.12- Change in Path of the Sheet

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For Previous Path

As discussed earlier the total angle of contact of sheet with the brush roller is 120^0 for each roller and that for cushion roller is negligible.

So, Area of sheet with contact to brush roller = A_{BR}

A_{BR} = 1/3 × perimeter of brush roller × length of brush roller

A_{BR} = 1/3 ×π×14.4×130

A_{BR} = 1960.35 cm^2/ roller

Therefore for two rollers

A_{BR} = 2×1960.35 = 3920.7 cm^2.

Area of sheet with contact to cushion roller = A_{CR} = 0

Therefore total area of sheet in contact = A = A_{BR} + A_{CR}

A = 3920.7 + 0 = 3920.7 cm^2.

For New Path

As discussed earlier the total angle of contact of sheet with the brush roller is 120^0 for each roller and that for cushion roller is 90^0 each roller.

So, Area of sheet with contact to brush roller = A_{BR}

A_{BR} = 1/3 × perimeter of brush roller × length of brush roller

A_{BR} = 1/3 ×π×14.4×130

A_{BR} = 1960.35 cm^2/ roller

Therefore for two rollers

A_{BR} = 2×1960.35 = 3920.7 cm^2.

Area of sheet with contact to cushion roller = A_{CR}

A_{CR} = 1/4 × perimeter of cushion roller × length of cushion roller

A_{CR} = 1/4 ×π×14.4×130

A_{CR} = 1470.27 cm^2/ roller

Therefore for two rollers

A_{CR} = 2×1470.27 = 2940.54 cm^2.

Therefore total area of sheet in contact = A = A_{BR} + A_{CR}

A_{NEW} = 3920.7 + 2940.54 = 6861.24 cm^2.

IV. PERFORMANCE ANALYSIS

After designing and modifying the new system the testing of each modified system is done to obtain the effectiveness of work done.

- As per the manufacturing requirements of mackintosh sheet the 100 m of rubber sheet requires approx. 4 kg of starch powder during processing.
- Out of 4 kg about 80% of powder *i.e.* approximately 3.2kg of powder get absorbed in the sheet during heating in vulcanizer.
- So at the entrance to the cleaning machine the sheet is holding approx. 800 gm of starch powder. This should inevitably be reduced to the desired level of 200-250 gm per 100 m of roll.
- Previously along with the suction system & vertical installation of machine nearly 400 gm of powder remains on the sheet after cleaning.

Now as the three modifications have been implemented in the existing machine the performance analysis is given as follows.

- After changing the suction port position the sample of cleaned sheet is taken. There is nearly 350 gm of powder available for the 100 m of sheet roll.

- After that we modified the path of sheet in the machine to increase the contact of sheet with rollers. The percentage increase in the area of contact is

Percentage increase in area = (A_{NEW} - A) × 100 / A

= (6861.24 – 3920.7) × 100 / 3920.7

= 75.003%

Where, A = total area of sheet in contact with old path

A_{NEW} = total area of sheet in contact with new path

Hence using the new suction port position and newly modified path of sheet the100 m of sheet roll contains 300 gm of powder after cleaning.

- Then After the use of scrubber mechanism and with earlier modifications the sample of cleaned sheet is taken. There is only 230 gm of powder remains on the sheet which is in the desirable level prescribed by the industry.

- The Cleaning efficiency of cleaning machine is improved.

Initially the powder removed by system = $PR_{(i)}$ = 400gm

After modifications powder removed = $PR_{(m)}$ = 570 gm

So, Percentage increase in the cleaning efficiency of machine

= ($PR_{(m)}$ - $PR_{(i)}$) × 100 / $PR_{(i)}$
= (570 - 400) × 100 / 400
= 42.5%

V. RESULTS OBTAINED

After doing the performance analysis the following results are obtained.

1. By using scrubber the previously deposited powder over the brush roller surface is removed without any manual efforts.

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2. By changing the position suction ports at both the sides rather than a single port at the top more powder is removed from the sheet surface which results in better cleaning action. Before changing the suction port position approximately 400 gm of powder is collected at suction unit. After changing the suction port position 550 gm powder is collected.
3. The change of path of sheet passing through rollers cause to increase in the contact surface area by nearly 75% contributing to better cleaning action.
4. By using the scrubber actuation mechanism the manual cleaning of the brush roller is eliminated thus it also eliminates the hazardous working conditions of the machine. It also not requires much time to operate as it can effectively operate between the unloading of the cleaned sheet and loading of the next sheet to the machine. Thus ensuring no extra time for the cleaning.
5. Earlier the cleaning cycle time for cleaning of the sheet roll of 100m is 5 minutes included of loading and unloading of sheet roll from machine, which remains constant for the modified system.
6. Thus all the above implemented solutions ensure the optimum performance of the cleaning machine by increasing the cleaning efficiency by nearly 42% with not increase in the cleaning cycle time for cleaning of the sheet roll of 100m.

The results obtained and discussed above are shown graphically as follows.

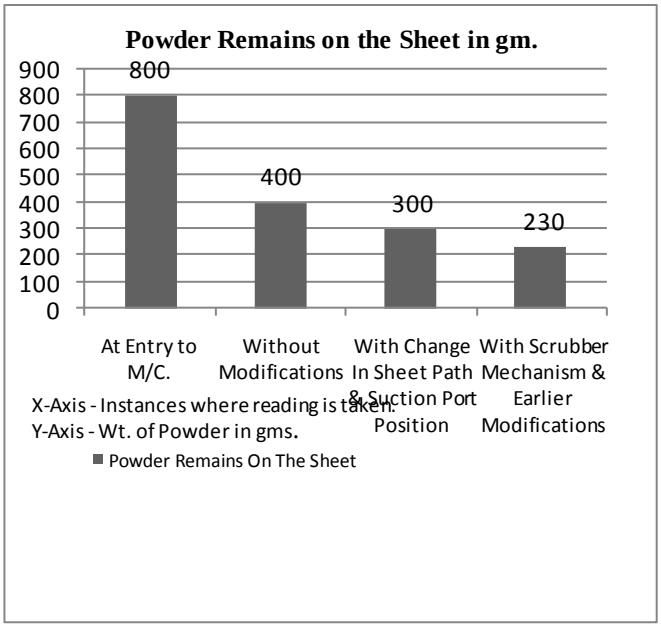

Fig. 13 –Graphical Representation of Results obtained of Modified System

VI. CONCLUSION

As from the earlier performance analysis and obtained results we can conclude that using the scrubber mechanism with the change of position of the suction ports and the modified process path of the sheet the objectives decided in the work are achieved.

1. By using scrubber mechanism the previously deposited powder in the brush roller is removed before the next sheet processed. Thus ensuring correct amount of powder i.e. 230 grams per 100 m sheet length.
2. Using the scrubber actuation mechanism additional human efforts in terms of manual cleaning of brush rollers are reduced.
3. Changing the position of suction ports150 grams more powder is collected from earlier of 400 grams which results optimum utilization of suction system. This collected powder can be reused.
4. The change of path of sheet passing through rollers increases the contact surface by nearly 75% resulting in more cleaning action.
5. Thus it also ensures the better working conditions for the workers.
6. Thus the cleaning efficiency of the cleaning machine is increased by 42%.

Fig. 14 –Cleaning machine after all the modifications

REFERANCES

[1] https://www.vikamshi.com/catalogue.pdf.
[2] Cleaning Machine Manual, Vikamshi Fabrics Pvt. Ltd., 2004.
[3] Design Data Book, PSG College of Technology, Coimbatore, 2010.