Productivity Improvement in A Small-Scale Paper Mill - A Case Study

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ABSTRACT

Small-scale paper and paperboard mills face a typical problem that they are unable to produce paper/paperboard upto the quality mark. Previously, in the mill under study, samples were cut-off from the process, after the calendering section, and tested at fixed intervals. This presented two difficulties, viz., disruption of the production line and the material between unacceptable samples was rejected, and recycled, thereby the marketable production/day was reduced. With an objective of improving productivity, a simple device was fabricated which would present the paper/paperboard thickness on-line. Since the weighment is given out continuously, any variation in the quality can be immediately attended to and thereby the scrap is minimised and thus marketable production increased.

ABOUT THE COMPANY

The paper mill under study is a small-scale paper and paperboard mill located near Pondicherry. This is a manually operated plant with a rated capacity of 10 tons/day.

OBJECTIVES

A detailed study of the above mill showed the existence of the following problems and the objective of the following problems and the objective of this case study was,

- to improve the out-going quality of the product. [There was variation in the product dimension due to manual adjustment of the process].
- to improve the marketable production. (Since the material between unacceptable samples were rejected and recycled, the
- to eliminate the down time due to the frequent disruption in the production line. [Samples were cut-off from the process after the calendering section, at fixed intervals, and tested for the required dimension) i.e. the thickness of the paper, measured in terms of GSM - Grams per Square Metre). This was done at frequent intervals to maintain uniform and required thickness and hence the down-time]

  marketable production was lower than anticipated
- to relieve skilled labour of unskilled tasks

A careful analysis showed that by suitably incorporating a device to monitor continuously the paper and paperboard thickness, the entire process can be adjusted so as to, eliminate the down-time, improve product quality, reduce the rate of rejection and recycling, and also to reap the associative benefits which may result due to total automation - the ultimate goal of the company.

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Consequently, a device was fabricated that was simple in design and at an affordable investment by the company (Figure 1).

DESCRIPTION

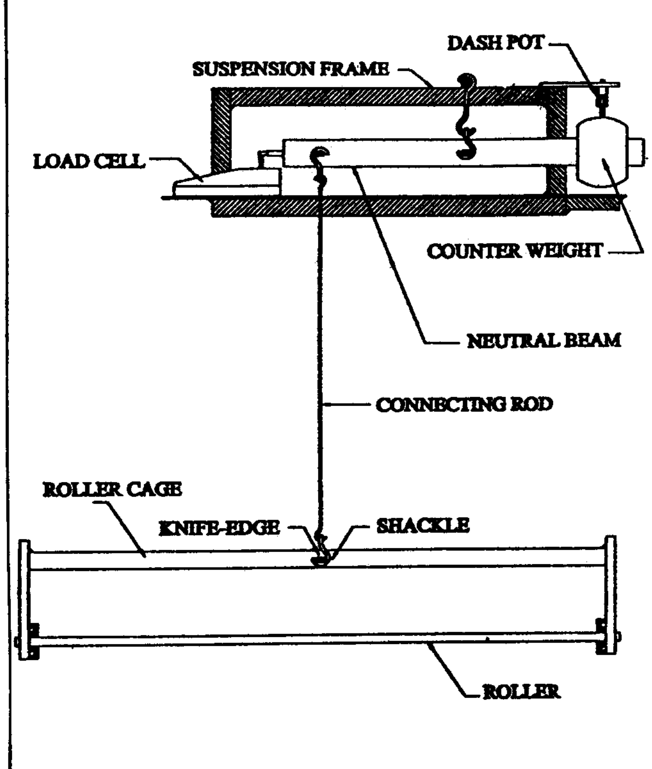
1. **Roller:** There are two numbers of Aluminium rods of ϕ25.4mm X 1651mm long with suitable bearing fitted on both the ends. This is the main part of the device as this acts as the weighing platform.

2. **Roller cage:** Three pieces of mild steel flats of 25.4mm x 12.7mm cross section are welded to form a Π-section. The height of the frame is 305mm and length 1651mm. The rollers and the roller cage will be hereafter called as the roller-platform.

3. **Knife-edge:** Cast iron pieces are shaped to size and are welded to place. There are three knife-edges. They are fitted to the fulcrum point of the roller cage and two on the neutral beam, with one on the load end (Left end).

4. **Shackle:** Shackle is made of cast iron. The hook end of the shackle supports the knife-edge. The knife-edge and shackle pair provides free-swing motion.

Fig. 1: Fabricated view of the device



5. **Connecting rod:** The weight of the roller platform is transmitted to the neutral beam, which in turn is transmited to the suspension frame through the connecting rod. It is made up of a mild steel rod and both the ends are bent in form of hooks and are connected to the shackles.

6. **Neutral Beam:** This is made up of mild steel-bronze alloy for rigidity and coated with Zinc powder for improved corrosive resistance with cross sectioinal dimension: 25.4mm x 76.2mm. A protrusion provided at the left end bottom of the beam rests on a load cell.

7. **Counter-balance weight:** It is a mild steel block that can be slid and fixed on to the left side of the neutral beam to balance the weight of the roller-platform on the left end. The weight block is so adjusted and fixed that the beam is in the neutral position.

8. **Damper:** A damper is used to restrict the oscillation of the beam and to quickly arrive at the reading. It works on the principle of air restriction. It is an aluminium cylinder within which an aluminium plate moves. When the beam moves, the aluminium plate that is fixed to the neutral beam also moves. The cylinder fixed to the cage does not move and consequently due to air restriction the oscillation of the beam is damped.

9. **Suspension Frame:** This suspends the neutral beam along with the other parts as described above. This is fabricated out of mild steel angle 610x305x305mm. A 6.35mm plate is welded to the bottom of the frame to accommodate the electronic weighing system. There is corresponding opening for the connecting rod to pair with the neutral beam. Two sliding bolts are also provided to hold the neutral beam when not in use.

10. **Electronic weighing system:** This mainly consists of a load cell and other electronic gadgets. The load cell is an instrument used to measure the load applied on it, due to the deflection of the neutral beam. This is of digital type and the maximum capacity is 0.400Kg.

FABRICATION

The Aluminium rollers were turned and trued to dimensions. Two ball bearings of ϕ25.4mm ID and ϕ31.75mm OD were provided on both the ends of the rods. These rollers along with the ball bearings were fitted to the aluminium flats on both the ends for support. One of the knife-edges was provided on the fulcrum position at the top of the roller cage. The roller cage was fastened to the aluminium flats, with bolts. This roller platform was checked for equilibrium.

Shackles were provided on the knife-edges of the roller and at the left end of the neutral beam. Using the hook ends of the connecting rod, the roller platform was hung to the left hand side of the neutral beam. The neutral beam was suspended from the suspension frame . The counter-balance weight was added, slid, and adjusted, on the right hand side of the neutral beam, and then fixed in place so that the entire setup is in equilibrium.

WORKING

The device, after fabrication, is fitted after the calendering section of the mill. The finished paper (after calendering) is made to flow on the rollers of the device. Due to the weight of the paper, the neutral beam, which was in equilibrium, deflects. Due to this deflection, the protruding pin of the neutral beam acts on the load cell. This force would give out a reading proportionate to the deflection. The GSM value corresponding to this reading can be easily found out from the chart provided.

CALIBRATION

This device was put to use and trial runs were then conducted. The output readings from the load cell i.e., the weight of the paper over the rollers were noted. The actual GSM was also measured manually and tabulated (Table-1). Since the actual output GSM values and the required output GSM values were not found so erratic, these values were plotted on a graph (Graph 1) to calibrate the device. From the graph, it was found that the device possesses linear characteristics and hence much suitable to use for this application.

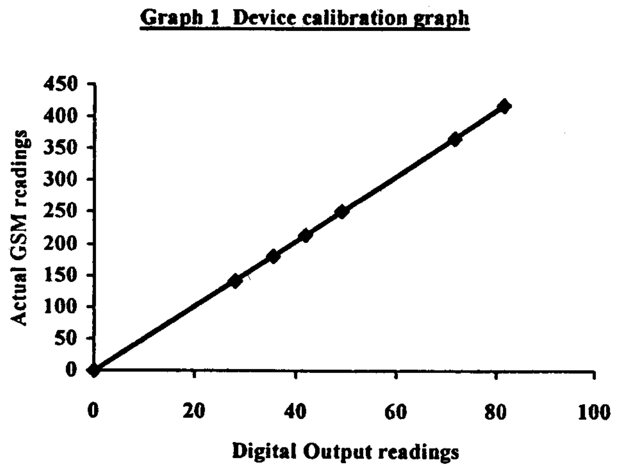
Further trial runs were conducted for a full working month, with this device, and it was found that the scrap rate was reduced drastically. As the thickness of the product is measured on-line there is no disruption of the process. Table-2 & Table-3 show the random samples of GSM values noted before and after installation of the device.

Table-1
Trial-run values used for device calibration

Digital Readings		GSM Values		
Actual	Mean	Required	Actual	Mean
27.2			136.25	
26.9			134.75	
29.4			150.00	
27.8			142.50	
28.4	27.9	140	145.00	141.7
33.2			169.90	
37.1			190.50	
36.2			184.50	
34.8			177.00	
35.7	35.4	175	182.00	180.8
41.1			210.50	
40.4			206.50	
42.7			219.00	
41.2			210.50	
43.4	41.8	210	220.50	213.0
50.1			257.00	
48.2			247.50	
49.4			253.50	
47.9			243.00	
49.2	49.0	240	250.50	250.2
70.1			358.00	
71.2			365.00	
73.4			374.50	
70.9			361.50	
71.8	71.5	360	366.50	365.1
79.9			407.00	
82.6			421.50	
81.2			414.50	
83.6			424.50	
80.7	81.6	410	412.00	415.9

RESULTS AND CONCLUSION

The cost benefit analysis carried out showed that for an investment of a little over Rs. 22,000, the



overall production rate was increased by 17.5%. Also, the projected increase in turnover per year will be around 15.0%. This has been proved by the fact that the average output per day before the installation of this device was 5.95tons/day and after installation of the device was 7.00 tons/day.

Furthermore, this is the first step towards automation. More degree of automation can be achieved, at any point of time, with the existing device and by using automatic valves and its associated instrumentation.

ACKNOWLEDGEMENT

The authors express their heartfelt gratitude to the Management and Staff of M/s. Rajaganapathy Board Mills Pvt. Ltd., Pondicherry, M/s. Pondy Weighing Systems, Pondicherry and Mr. Agoram Chandrasekar, Managing Partner, Edison Electrical Works, Manalur.

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Table-2
Before Installation of the device

Sample	Output, Tons	Actual GSM	Required GSM	Error, GSM
01	5.7	381	360	+ 21
02	5.9	383	360	+ 23
03	6.4	160	180	- 20
04	6.0	200	180	+ 20
05	6.2	200	180	+ 20
06	5.7	263	240	- 23
07	5.9	218	240	+ 22
08	6.4	283	360	+ 23
09	6.0	381	360	+ 21
10	5.2	432	410	+ 22
11	6.0	431	410	+ 21
12	6.0	433	410	+ 23

Table-3
After Installation of the device

Sample	Output, Tons	Actual GSM	Required GSM	Error, GSM
01	6.9	178	180	- 02
02	6.9	177	180	- 03
03	6.7	182	180	- 02
04	7.1	242	240	+ 02
05	7.3	237	240	- 03
06	7.5	362	360	- 02
07	6.8	359	360	- 01
08	6.6	357	360	- 03
09	6.7	413	410	+ 03
10	7.4	408	410	- 02
11	7.1	412	410	+ 02
12	7.2	411	410	+ 01