

# Productivity Improvement with Innovative Ideas

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## ABSTRACT

This paper gives the various improvements and innovations done on Paper Machine #2 to increase the productivity by speeding up the Paper Machine from 450 M/Min. designed speed to the currently operating speed of 510 M/Min. and at a lowered GSM at 45 from 48. The paper deals with the changes made like bigger dia press rolls, increasing felt conditioning, Uhle box slot width, design of fan pump impeller, closing the water loop, optimization and selection of better wet-end chemicals which ultimately brought substantial saving in production cost and quality improvement.

### Introduction

Indian paper Industry is making itself more competitive due to globalization. Cost of production is increasing due to higher cost of raw material, water, power, chemicals etc. Hence it is essential for survival to improve the productivity & quality of paper by adopting best practices & using innovative ideas. We have imported second hand paper machine from Portugal in the year 1995 to manufacture writing & printing papers. The machine is 2.9 meter wide and the designed speed was 450 MPM. This machine had run at Portugal at a maximum speed of 420 MPM and with various modification and changes made, the machine is now running at 510 MPM speed and producing good quality of newsprints at 45 GSM.

### Configuration of The Machine at 450 MPM

The machine approach flow consists of Back pull ESDF type Fan pump, Feed to hydraulic Head Box through 3 stage Centri Cleaner. The accept after Centri Cleaners go through 2 nos. centripetal Holes screen. Before entering the stock into the hydraulic head box a pulsation attenuator is there to reduce pulsation. Wire part FDR- couch combination Fourdrinier type with trivac, duovac and other dewatering elements. Press is Binip press; Dryer section has open gear drives, Swimming Calendar and Pope. Drives through Line shaft with couch and 2<sup>nd</sup> press sectional drive arrangement.

### Modification & Improvement

The Modification & improvements done are briefed as below:-

- 1) Increase of Paper Machine speed from 450 M/Min. to 470 M/Min.
  - a) Press Uhle box size changed from 150 mm to 200 mm with ceramic top from poly pick
  - b) Main motor changed from 334 KW x1650 rpm to 400 KW x 1000 rpm
  - c) Main motor pulley size increase to 610 mm from 450 mm

- 2) Increase of Paper Machine speed from 475 M/Min. to 490 M/Min.
  - a) One new Cutes vacuum pump 120 cu M replaced with old vacuum pump.
  - b) Head box lip changed.
  - c) FDR and Couch gearbox changed
  - d) Fan pump impeller changed with modified new closed impeller
- 3) Increase of Paper Machine speed from 490 M/Min. to 495 M/Min.
  - a) Headbox electro polish
  - b) New couch roll installed
  - c) Pope drum replaced with grooved pope drum.
  - d) Slot pressure screen replaced the old hole pressure screen
  - e) Pre dryer gearboxes changed
  - f) Uhle box slot increased to 12.5 mm from 10 mm
- 4) Increase of Paper Machine speed from 495 M/Min. to 510 M/Min.
  - a) Centre roll dia increased to 850 mm from 825 mm
  - b) Maxi flex doctor installed at Centre press roll
  - c) Groove roll dia. increased from 570 mm to 585 mm
  - d) One more hydrofoil unit (5 blades) added in wire part.
  - e) Ortho flow unit (9 blades) installed in place of HDPE top low box

### Upgradation of The Approach Flow

The approach flow system consists of Fan pump, Centri cleaners and 2 nos. hole pressure screens. The Fan pump is almost its capacity not suitable to further speed up. The Back pull type ESDF fan pump create stock pulsation also. The flow of pump is less which manages with increase in consistency and throttle recirculation and rejects. The capacity of the fan pump was 19000 lpm when machine speed was 465 mpm at 0.9%-1.0%

consistency at head box and 60% retention. It was difficult to run the machine with marginal low consistency 0.8% by reducing recirculation and rejects. Looking a new Fan pump is so costly that the investment was not suitable. A new impeller was procured indigenously in modified construction.

The figure below shows the differences



6 vane staggered old Semi open impeller

adjusting top lip angle and projection. (Kept 4 mm.)

- ❖ After attending the above activities the machine efficiency improved drastically. Even 3-4 days paper run without breaks. The record long run was 30 shifts continuously. The sheet and formation found uniform. The figure below shows the line sketch of position of lip corresponding to bottom apron and breast roll.



7 Vane staggered new Closed impeller

The New impeller Fan pump increases the throughput to 22000 LPM with less pulsation. The gland packing system replaces the dynamic seal arrangement which reduces air intake and eliminates foam breaks.

The Fan modified impeller pump capacity calculated according to machine speed 525 MPM considering the following factors.

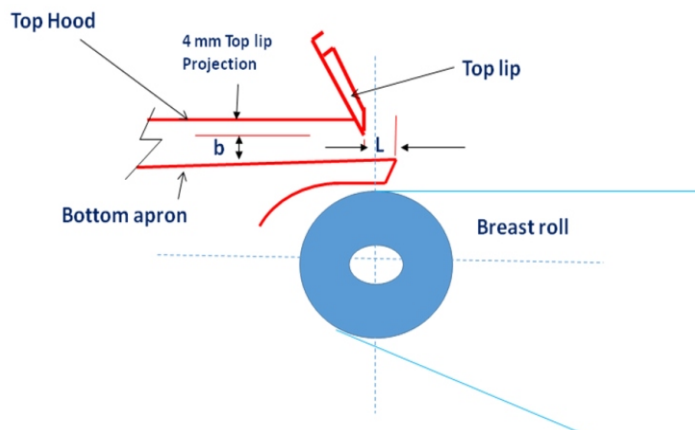
1. Stock consistency at headbox 0.8%
2. Retention at wire 60%
3. Reject of Primary Centricleaners cleaners, Screens and others as per chart shown below.

### Improvement in the Head Box

The following activities were carried out for improvement of the performance of old imported headbox made of M/s Essar Wyass year of manufacture 1963.

- ❖ The top lip replaced after developing the indigenous lip as the old lip found corroded and deformation takes on. The bottom apron and side wall also corroded and erosion observed.
- ❖ The bottom apron, and side wall and top panel inside electro polished at site position. All the scratch marks were eliminated by electro polish.
- ❖ The L/b ratio corrected to 1 according to machine speed and jet landing position.
- ❖ The Foam lumps breaks eliminated by

Particulars	Criteria	Total Flow	Reject & Recirculation	Criteria	Total Flow	Reject & Recirculation
Speed MPM		450			510	
GSM	45			45		
Pond width in metre	3.1			3.1		
Draw at wire kg/min	64.86			71.15		
Stock consistency %	0.80			0.80		
Flow through Head Box LPM		13514			14821.88	
Retention %	60			60		
With Recirculation head box LPM	5	14189	676	5	15563	741
With Recirculation fine control LPM	5	14899	709	5	16341	778
With Reject amount primary Screen LPM	5	15644	745	5	1715	817.06
With Recirculation coarse control LPM	9	17052.2	1408	9	18702	1544
With Reject amount primary Cleaners LPM	10	18757	1705	10	20573	1870
Impeller size mm in diameter		368			380	
Flow of pump LPM		19000			21900	
Head in Metres		35			30	
Motor		200 kw x 1450 rpm			200 kw x 1450 rpm	
Running amps		210			280	
Impeller Design		6 vanes staggered Two stage front semi open back closed			7 vanes staggered Two stage front closed back closed	



### Increase of Dryness After Couch

The measured dryness after couch at 450 MPM machine speed was very low 16% - 17%. The couch roll was bronze shell, 755 mm in diameter, drilling 6 mm straight hole with 16% open area and 200 mm wide box. The said suction couch roll was brought along with the machine and due to ageing and construction, continuous breakdowns occurred. To minimise the uncertain downtime for breakdown of the couch roll a stainless steel shell was procured with improved dewatering capacity. The internal vacuum box and opening was redesigned and fabricated indigenously by local manufacturer. The new counter shank drill hole shell having 7% more open area and than the old bronze shell.

After the drainage survey, a additional hydrofoil unit added in wire part dewatering system and ortho flow installed replacing the low vac box.

After the above modification the after couch dryness improved to 20%

### Deposits in Centre Press Roll And Lumps/Fiber Bundles Coming With Stock

Fines deposition on centre dynorock cover roll was a greater problem in paper machine 2. Every day about 1hr production was lost for cleaning the roll and doctor blade life was only 2-3 days. The hole screen in approach flow was giving lumps and fibre bundles. Replaced hole screen with 0.15mm slot screen to avoid this problem and rigid doctor was replaced with maxiflex doctor which has eliminated the centre press roll cleaning. This has increased the production about 200MT/annum.

### Increase of Dryness After Press And Reduction of Fluff in Paper

At 450 MPM the press dryness maximum 41% achieved. After crown correction, increase the slot width of Uhle box and roll diameter increase the dryness to 44.5% even at 510 MPM.

The Uhle box slot width was only 10 mm. Each felt consists 2 nos. 150 diameters Uhle box. Calculating the dwell time at 510 mpm we found 2 milliseconds. The Tappi standard is 2-4 milliseconds. For 500 mpm machine speed slot total width calculated is 19 mm to 32 mm. we kept 26 mm (3 milliseconds) slot in total with two boxes. Accordingly the box size has been changed.

The box size and piping designed such that the air velocity calculated 955 m/min below the ABTCP 2000 tappi 1069 m/min.

$$\text{Minimum box diameter/ piping diameter (mm)} \propto \sqrt{\text{Flow (m}^3/\text{hr)}} \times 19.89$$

The centre press roll and 2<sup>nd</sup> press grooved roll diameter is increased as much as possible at existing press configuration. Increased the diameter of the Centre press roll from 825 mm to 850 mm resulted 4 mm nip width increase with suction pick up roll and 3 mm at grooved roll. Additional nip width 2 mm also increased when the 2<sup>nd</sup> press grooved diameter increased to 585mm from 570 mm. The roll crowning also corrected by the formula

$$\text{Crown correction} = (We^2Wc^2) / (D1+D2)^2 \times D1D2$$

Where....

- C = Diametric crown deficiency (positive if too little crown, negative if too much crown)
- We = Nip width on the roll ends
- Wc = Nip width at the roll centre
- D1 = Diameter of roller 1
- D2 = Diameter of roller

The increased nip width also the result of correction of crowning. The crowning has calculated to close the nip load

1. 1<sup>st</sup> press 70KN/M and
2. 2<sup>nd</sup> press 90KN/M.

The effect of corrected crowning and their result are shown in below table

Date	Roll	Crowning (Dia.)	nip width	Dryness
18/04/2008	Suction pick up roll	0.795 mm	22 mm	41%
	2 <sup>nd</sup> Pr. Grooved roll	0.715 mm	18 mm	
24/06/2012	Suction pick up roll	0.954 mm	27 mm	44.65%
	2 <sup>nd</sup> Pr. Grooved roll	0.875 mm	21 mm	

Note: The dryness measured after 2<sup>nd</sup> press

The result of improved dryness helped to improve machine efficiency to 94%, Fluff deposit in dryers reduced substantially. There are no customer's complaints for fluff. Paper moisture increased to 7% from 5.5%

The most commonly used crown 70° cosine angle is applied while grinding the rolls at our grinding machine. The appropriate crowning improves sheet dryness across the width within limits. The Cosine factors are as follow for suction pick up :-

Roll crown 0.9545 mm on diameter

Station	70° cosine Factor	Target crown (mm)	Achieved crown (mm)
0 (roll Edge)	00.000	0.0000	0.0000
1	0.0112	0.0106	
2	0.0451	0.0430	0.0650
3	0.1009	0.0963	
4	0.1778	0.1697	0.2300
5	0.2748	0.2621	
6	0.3904	0.3726	0.4500
7	0.5226	0.4988	
8	0.6699	0.6394	0.7300
9	0.8298	0.7916	
10 (roll centre)	1.0000	0.9545	0.9550

## Change of Main Motor

The Main line shaft motor capacity was another bottleneck to maintain speed. We have replaced 334 KW D.C. Motor with 400KW/1300rpm motor which helped to go to the present speed of 510 mpm.

## Reduction of Open Gear failure by lubrication

The Polypropylene silent gear teeth failure was one of the larger mechanical downtimes. Additional spray lubrication introduced which kept the gear surface clean and avoided gear failure. The gear failure account is as below:

Years	No of gear failure
2007	4
2008	3
2009	1
2010	1
2011	2
2012	0

## Use of appropriate Chemicals

- Replacement of maize based low DS (0.020) cationic starch with tapioca based high DS (0.060) cationic starch reduced consumption from 6.5kg to 1.0 kg/ T of paper. This has given following advantage.
  - Improvement of surface strength i.e. wax prick increased from 7A to 9A.
  - Low BOD and COD of waste water
  - Reduction of paper manufacturing cost Rs 140./ T of paper.
- Replacement of suitable flocculent reduced the consumption from 400gm to 40gm/ton of paper & maintaining same FPR 65-66%. This has resulted saving of Rs 70/ T of paper.

## Results & Discussion

The improvements & developments have been done with less investment and giving considerable benefits in terms of reduction in manufacturing cost & improved quality. These modification and improvements done with very little investment of Rs.148 lacs in 4 years has given considerable return of Rs. 342 lacs by improvement of productivity, in

Particulars	2008-09	2009-10	2010-2011	2011-12	2012-13(P)
Speed (MPM)	450-465	475	490	495	510
Finished Production MT	28446	29417	29523	30685	31000(P)
Power consumption KWH/MT	480	450-440	450-440	450-440	445 - 440
Water consumption Cu M/MT	26	18	16	10	8
Steam consumption Kg/MT	2.0	1.64	1.6	1.6	1.6
Moisture in paper %	5.5	6.25	6.65	6.9	7
Calender nip load KN/Metre	73.5	87.5	95	97	97
Smoothness of paper ml/min	240/200	190/160	180/140	180/140	180/140
Starch consumption kg/MT paper	6.5	2.5	1.8	1.0	1.0
Flocculant gram/ ton paper	400-360	70	50	40	40
Investment Rs	11.76 lacs	20.5 lacs	54.5 lacs	34 lacs	24 lacs
Gain on Productivity Rs	---	48 lacs	54 lacs	112 lacs	128 lacs

Note: the figure above is based on finished paper.

addition to considerable reduction in steam, water, power and chemical consumption.

The achievement of Paper Machine # 2 was highly appreciated and further speeding up plan is being worked out.

## Conclusion

- ❖ Although machine designed speed was 450mpm, after in-house innovative measure's its speed increased up to 510mpm resulting increase in production 9.5mt/day. i.e., benefit of Rs 128 lacs.
- ❖ Machine runnability is considerably improved after modification in Head Box, changing of pressure screen & installation of mexiflex doctor in centre press roll. Steam consumption was reduced from 2MT to 1.6MT / Ton of paper by improving the dryness after couch & press. i.e. saving of Rs. 240/ ton paper or Rs. 75 lacs/ annum (steam cost Rs. 600/ton)
- ❖ Power consumption reduced from 480unit/T to 440unit/T of paper. i.e. saving of Rs. 200/ton paper or Rs. 62 lacs/annum (Power cost Rs 5 per unit)
- ❖ Considerable mechanical down time reduced by reduction of open gear failure
- ❖ Use of tapioca based high DS starch & suitable flocculent resulted reduction of cost of production by Rs. 210/ ton of paper i.e. Rs. 65 lacs / annum along with improvement in quality.

## Acknowledgement

The authors are thankful to the management of Emami Paper Mills Ltd for permitting this paper for presentation.

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