



HARNESSING
ARTIFICIAL INTELLIGENCE (AI) IN TNPL
PAPER CONVERSION PROCESS

IPPTA - 60TH ANNUAL GENERAL MEETING & SEMINAR
IMPROVING PRODUCTIVITY AND QUALITY
THROUGH EMERGING AI TECHNOLOGY

PROBLEM STATEMENT

**Deckle Utilization of 534 CMS in Winder
against capacity of 544 CMS**

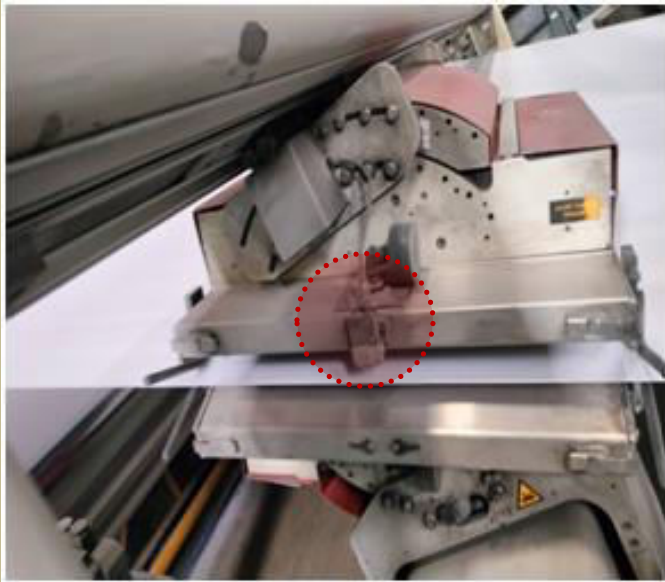
GOAL STATEMENT

Increasing Deckle Utilization by 5 CMS

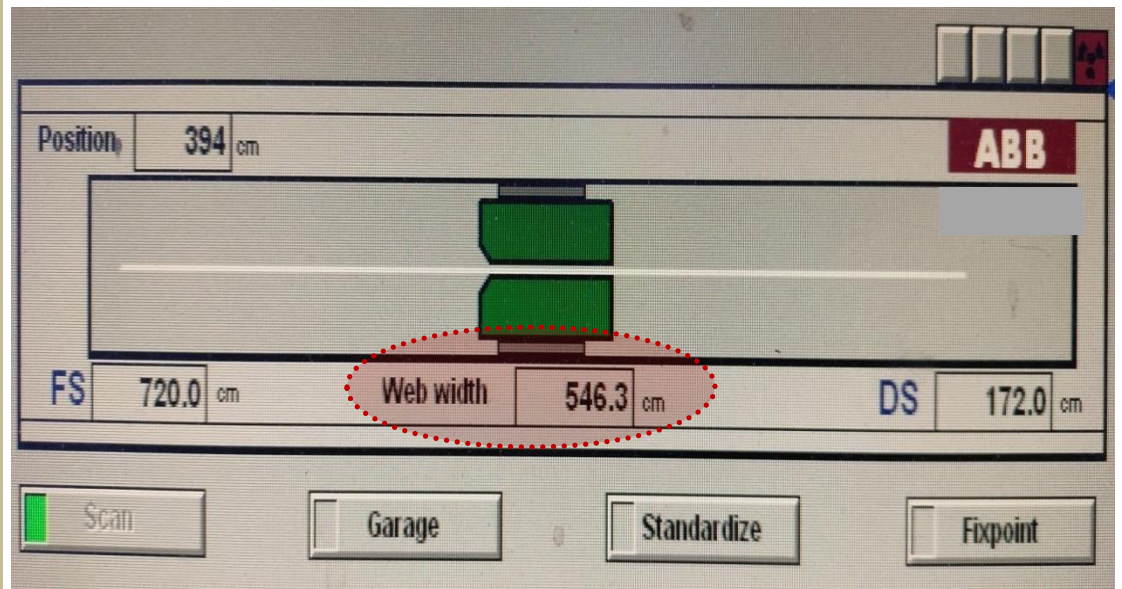
BUSINESS CASE

**1 CM increase in Deckle Utilization will incur 1 MT of Paper
Production/day which intern Rs. 10 millions/Annum**

<u>Sale Order Details</u> RDP 57 GSM 88 CMS REEL 21 MT, RDP 57 GSM 73 CMS REEL 42 MT	Parent Roll Deckle – 545 CMS
Available Deckle after Minimum Trim of 3 CMS in both edges	539 CMS
Size Combinations	1. $73^6+97^1 = 37$ MT 2. $88^3+73^2+62^2 = 43$ MT
Utilized Deckle CMS	535 CMS & 534 CMS
Excess Quantity	18.1 MT (97 & 62)
Trim Loss %	1.93



**Auto Edge Off Sheet
Sensor**



**Sheet Width Measurement &
Display in DCS Graphics**

3



RISK PRIORITY NUMBERING (RPN)	Severity	Occurrence	Detection	Total Points
Bow Spreader Roll Condition	3	3	3	27
Restriction in Number of Reels	3	6	6	108
Trim Chute Alignment	9	6	6	324
Lower Deckle Jumbo Roll	9	9	9	729
Poor Roll buildup at edges	9	6	6	324
Poor size Combination	9	9	9	729
Type of order (Reel/Sheet)	9	9	6	486
Edge cuts in Jumbo Rolls	9	6	6	324

FACTORS TAKEN FOR NEXT LEVEL ANALYSIS

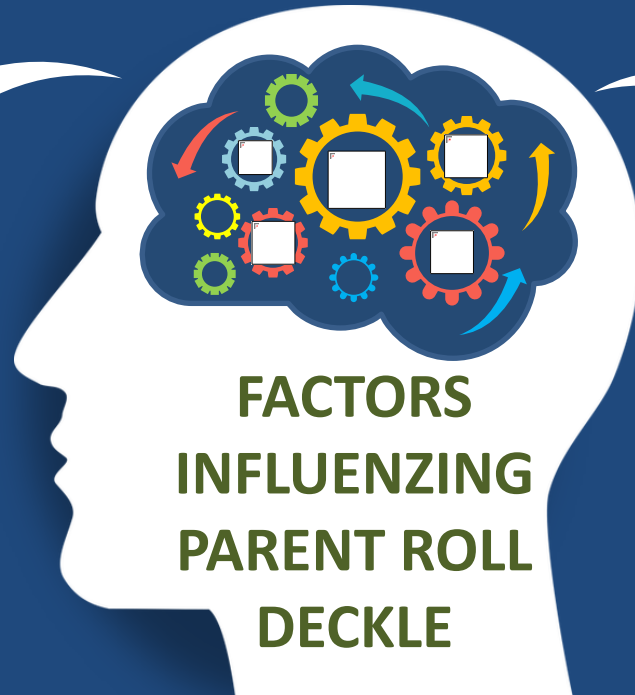


FACTOR : 2
BASIS WEIGHT

FACTOR : 1
FURNISH RATIO

FACTOR : 3
**PROFILE OF
SIZE PRESS
METERING ROD**

FACTOR : 4
**JET WIRE SPEED
DIFFERENCE**



**FACTORS
INFLUENZING
PARENT ROLL
DECKLE**

DECKLE MONITORING FOR 4 FACTORS

Table: 1 – Comparison between Furnish & Deckle

HWP %	CBP %	DIP %	DECKLE METERS
100	0	0	5.49
75	20	5	5.48
55	35	10	5.46
50	40	10	5.44
45	45	10	5.42

Table: 2 – Comparison between Basis Weight & Deckle

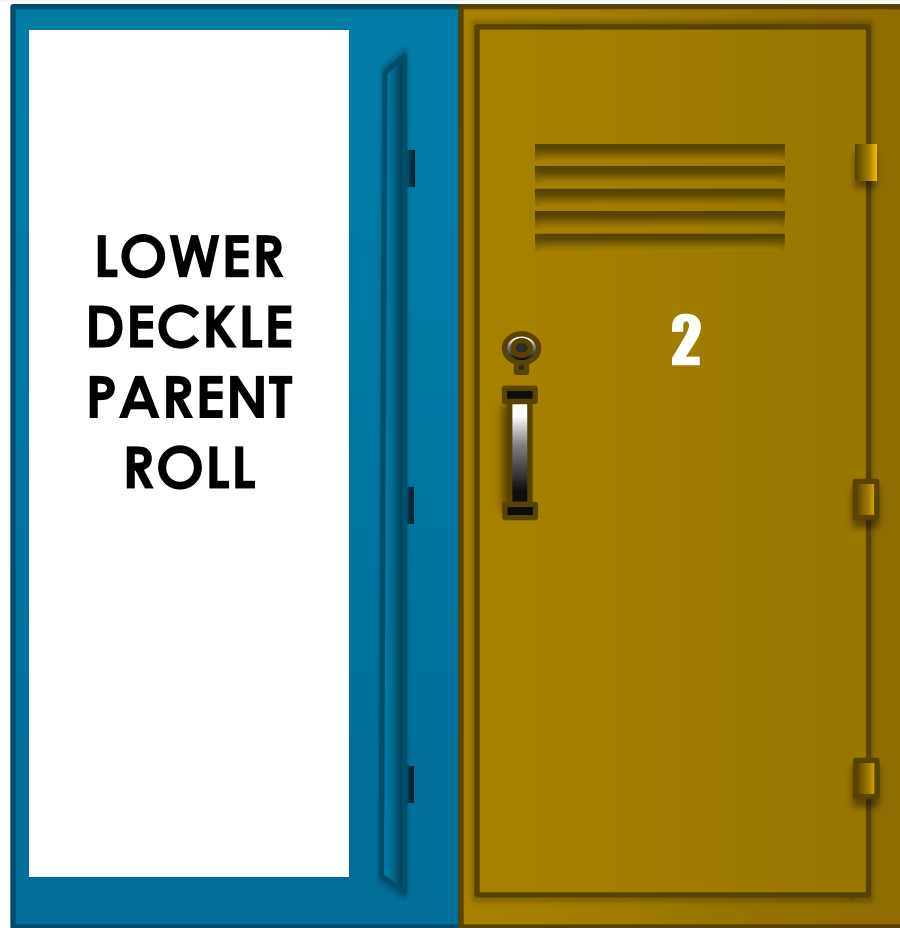
BASIS WEIGHT GSM	DECKLE METERS
54	5.44
60	5.44
64	5.45
70	5.47
80	5.48

Table: 3 – Comparison between Sizer Metering Rod & Deckle

BOTTOM ROD PROFILE NO	TOP ROD PROFILE NO	DECKLE METERS
11	11	5.45
9	9	5.45
8	8	5.46
7	7	5.46
6	6	5.47

Table: 4 – Comparison between Jet/Wire Speed Difference & Deckle

JET/WIRE SPEED DIFF. MPM	DECKLE METERS
-25	5.495
-15	5.490
5	5.485
15	5.480
25	5.475



INPUT DATA	PROCESS	MANUAL WORKINGS	CALCULATED OUTPUT DATA
Variety Details With Basis Weight	Deckle Matching using Spreadsheet by Different types of Permutation & Combination	Variety Details With Basis Weight	Total Nos. of Reels per Combination
Reel Size in CMS		Size combinations for matching deckle	Total Quantity of Combination
Order Quantity in MT		Quantity matching as per Sale order	Total Deckle Width of Combination
Reel Diameter		Reel Diameter	Size needed for operating winder with Max. Trim
Remarks			Size needed for operating winder with Min. Trim

Order Card BY RBLPS TNPL - Microsoft Excel

WINDER SIZE COMBINATION				
SALE ORDER NO	REEL SIZE	NO.OF REELS	CARD QUANTITY	
1	90.0	2	50.0	
2	89.0	1	24.7	
3	92.0	1	25.6	
4	62.0	2	34.4	
5	57.0	1	15.8	
6				
7				
TOTAL		7	150.6	
NEED FOR MINIMUM DECKLE COMPENSATION SIZE			-17	
NEED FOR MAXIMUM DECKLE COMPENSATION SIZE			0	

DECKLE WIDTH	542
Quality	RDP
BW	60
Reel Dia	100

Order Card BY RBLPS TNPL - Microsoft Excel

WINDER SIZE COMBINATION				
SALE ORDER NO	REEL SIZE	NO.OF REELS	CARD QUANTITY	
1	90.0	1	30.0	
2	64.0	1	21.3	
3	92.0	1	30.7	
4	62.0	2	41.3	
5	57.0	3	57.0	
6				
7				
TOTAL		8	180.3	
NEED FOR MINIMUM DECKLE COMPENSATION SIZE			-16	
NEED FOR MAXIMUM DECKLE COMPENSATION SIZE			1	

DECKLE WIDTH	541
Quality	RDP
BW	60
Reel Dia	100

Factor	Deckle	Proportionality
Higher Basis Weight	Higher Deckle	Directly Proportional
Lower Bagasse Pulp	Higher Deckle	Inversely Proportional
Higher HWP	Higher Deckle	Directly Proportional
Lower Profile Metering Rods	Higher Deckle	Inversely Proportional
Higher Jet Speed Difference	Higher Deckle	Directly Proportional

INPUT DATA	PROCESS	MANUAL WORKINGS	AI - ENABLED SOFTWARE OUTPUT DATA
Variety Details With Basis Weight	AI Automated Deckle Matching using Algorithms & Formulas	-NA-	Variety Details With Basis Weight
Reel Size in CMS			Total Nos. of Reels per Combination
Order Quantity in MT			Total Quantity of Combination
Reel Diameter			Reel Diameter
Remarks			Total Deckle Width of Combination
Capable Deckle width in Winder			Alternate Size Combination With Excess production



Order Number	Order Type	Quantity Units	(kg) Required Quantity	(kg) Remain... Quantity	(r) Remaining @ final diameter	-%	+%	(mm) Width	(mm) Length	(kg) Max. Reel Weight	(mm) Min. Diam	(mm) Diameter	(mm) Max. Diam	(mm) Core Size	Core Type	Secondary Machines	TNPL Special
82022002158-6	Must make	kg	800	800	0.7	0.0	5.0	1,055	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022003004-3	Must make	kg	2,600	2,600	4.0	0.0	5.0	585	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022003004-1	Must make	kg	3,000	3,000	2.4	0.0	5.0	1,118	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022003004-4	Must make	kg	3,300	3,300	4.9	0.0	5.0	610	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022003004-8	Must make	kg	3,600	3,600	4.9	0.0	5.0	660	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022003004-10	Must make	kg	4,000	4,000	5.1	0.0	5.0	711	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022003004-6	Must make	kg	4,000	4,000	5.7	0.0	5.0	635	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022002156-7	Must make	kg	4,400	4,400	5.6	0.0	5.0	711	0	9,999	1,500	1,500	1,500	152	FG		KALRA PAPER
82022000908-13	Must make	kg	4,600	4,600	4.6	0.0	5.0	910	0	9,999	1,500	1,500	1,500	152	FG		METRO MERCA
82022000908-10	Must make	kg	5,100	5,100	3.9	0.0	5.0	1,170	0	9,999	1,500	1,500	1,500	152	FG		METRO MERCA
82022002732-1	Must make	kg	7,100	7,100	5.4	0.0	5.0	1,190	0	9,999	1,500	1,500	1,500	152	FG		K C PAPERS PV
82022002278-4	Must make	kg	10,100	10,100	10.0	0.0	5.0	910	0	9,999	1,500	1,500	1,500	152	FG		METRO MERCA
82022002732-4	Must make	kg	10,100	10,100	14.4	0.0	5.0	635	0	9,999	1,500	1,500	1,500	152	FG		K C PAPERS PV
82022002976-2	Must make	kg	10,100	10,100	10.0	0.0	5.0	910	0	9,999	1,500	1,500	1,500	152	FG		METRO MERCA

Σ = 72,800 Σ = 72,800

The screenshot displays the 'Optimisation Parameters' window of the Deckle Matching Process – AI software. The interface includes a toolbar with icons for file operations and optimization, a tabbed menu with 'Optimisation Parameters' selected, and a main settings area with the following sections:

- Algorithm**
 - Solution Method: Full Optimisation
 - Maximum Number of Processor Cores: Max.
- Incremental Production Tolerance**
 - Under Production Increment (%): 0.0
 - Over Production Increment (%): 0.0
- Full Optimisation Parameters**
 - Option: Allow Under Production
 - Cost/Waste Model: Waste Model
 - Market Conditions: N/A
 - Apply Site Constraints to Machines:
 - Radio buttons for diameter types: Variable Diameter, Constant Diameter, Multi-Constant, Metalliser

File Orders Machines Program Solution Tools Window Help

Orders x Trim Order Import x Solution List x Solution - 1 x Solution - 2 x Machines x Solution - 3 x Solution - 4 x Solution - 5 x

Save & Close Add help orders 2nd optimisation Release

BW1 Secondary Machine

KPI	Value
Total Waste (%)	0.230
Run Length (kg)	66,497
Sets	29
Total Waste (kg)	153
Stock Consum...	0
Physical Patterns	10
Predicted (ML)...	11.0
Profit (₹ / T)	0.00
Primary Waste...	153
Primary Waste...	0.230
Knife Changes	34

Primary Machi...	Stock ID	x	(kg) Production	(mm) Wid...	Pattern thumb...	(mm) Diameter	Duration
BM1		5	11,465	3,670		980	000:00:57
BM1		3	6,879	3,670		980	000:00:34
BM1		3	6,879	3,665		980	000:00:34
BM1		2	4,586	3,665		980	000:00:22
BM1		1	2,293	3,660		980	000:00:11
BM1		1	2,293	3,660		980	000:00:11
BM1		2	4,586	3,660		980	000:00:22
BM1		3	6,879	3,660		980	000:00:34
BM1		1	2,293	3,660		980	000:00:11

Display All Orders Load Plan

Order Number	(mm) Width	(mm) Length	(kg) Required Quantity	(kg) (Allo... Quantity	(kg) (+/-) Quantity
82024001505-1	720	0	900	1,799	899
82024000049-4	1,200	0	10,497	10,497	0
82024000861-11	610	0	1,525	1,525	0
82024000861-3	825	0	2,062	2,062	0
82024001021-2	1,050	0	1,312	1,312	0
82024001268-1	800	0	4,998	4,998	0
82024001301-3	1,050	0	15,745	15,745	0
82024001360-1	930	0	5,230	5,230	0
82024001544-10	825	0	1,546	1,546	0
82024001544-11	630	0	1,181	1,181	0
82024001544-4	645	0	1,612	1,612	0
82024001544-5	815	0	1,018	1,018	0

Total Waste = 0.230 % | Run Length = 66,497 kg | Sets = 29 | Total Waste = 153 kg | Stock Consumption = 0 kg | Physical Patterns = 10 | Predicted (ML) Pattern Count = 11.0

Case Example After Increasing 3 CMS Deckle in Parent roll

<u>Sale Order Details</u> RDP 57 GSM 88 CMS REEL 21 MT, RDP 57 GSM 73 CMS REEL 42 MT	Before Parent Roll Deckle – 545	After Parent Roll Deckle - 548
Available Deckle after Minimum Trim of 3 CMS in Parent Roll	539 CMS	542 CMS
Size Combinations	1. 73^6+97^1 2. $88^3+73^2+62^2$	88^2+73^5
Utilized Deckle CMS	535 & 534	541
Excess Quantity	18.1 MT (97 & 62)	1.6 MT
Trim Loss %	1.93	1.28

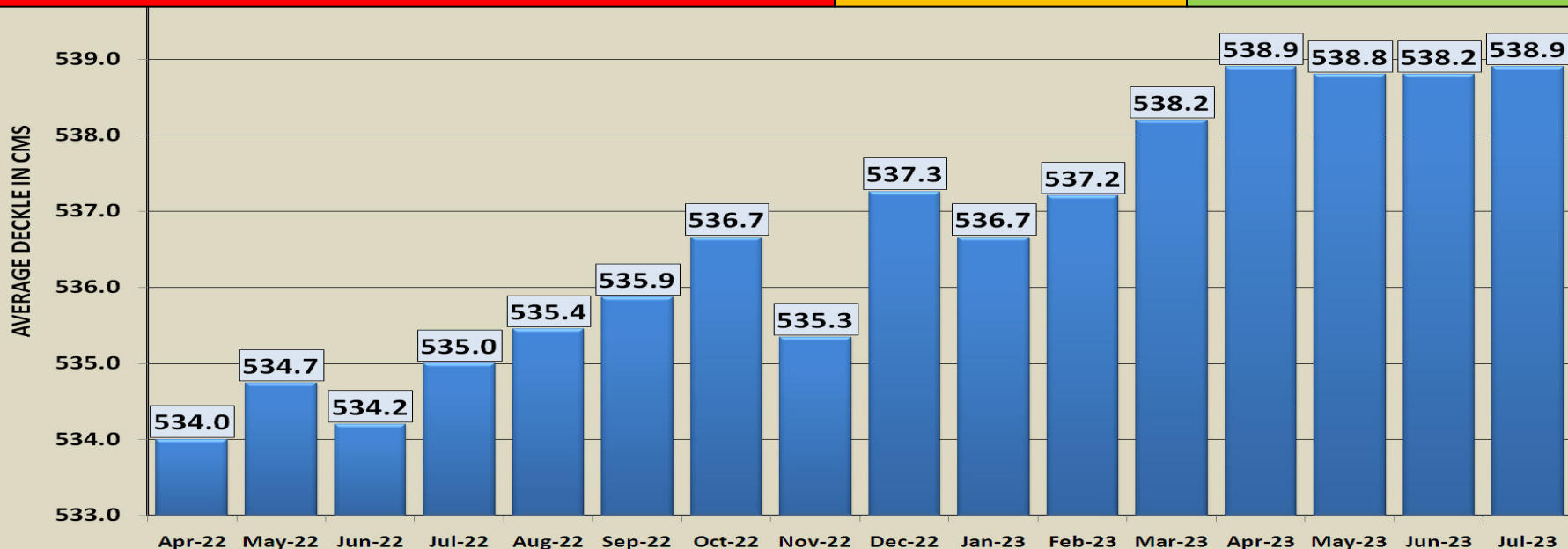
CASE EXAMPLE FOR MANUAL & SOFTWARE WORKINGS COMPARISON

S.NO	ORDER QUANTITY MT	Number of Size Combinations		Average Deckle Utilization CMS	
		MANUAL	AI SOFTWARE	MANUAL	AI SOFTWARE
1	1254	17	22	538	540
2	1127	16	14	537	539
3	88	6	7	533	531
4	581	5	5	537	538
5	687	7	6	538	540

**MANUAL SIZE
COMBINATION
PERIOD**

**PROJECT
TRANSITION
PERIOD**

**MANUAL + AI
SIZE
COMBINATION**

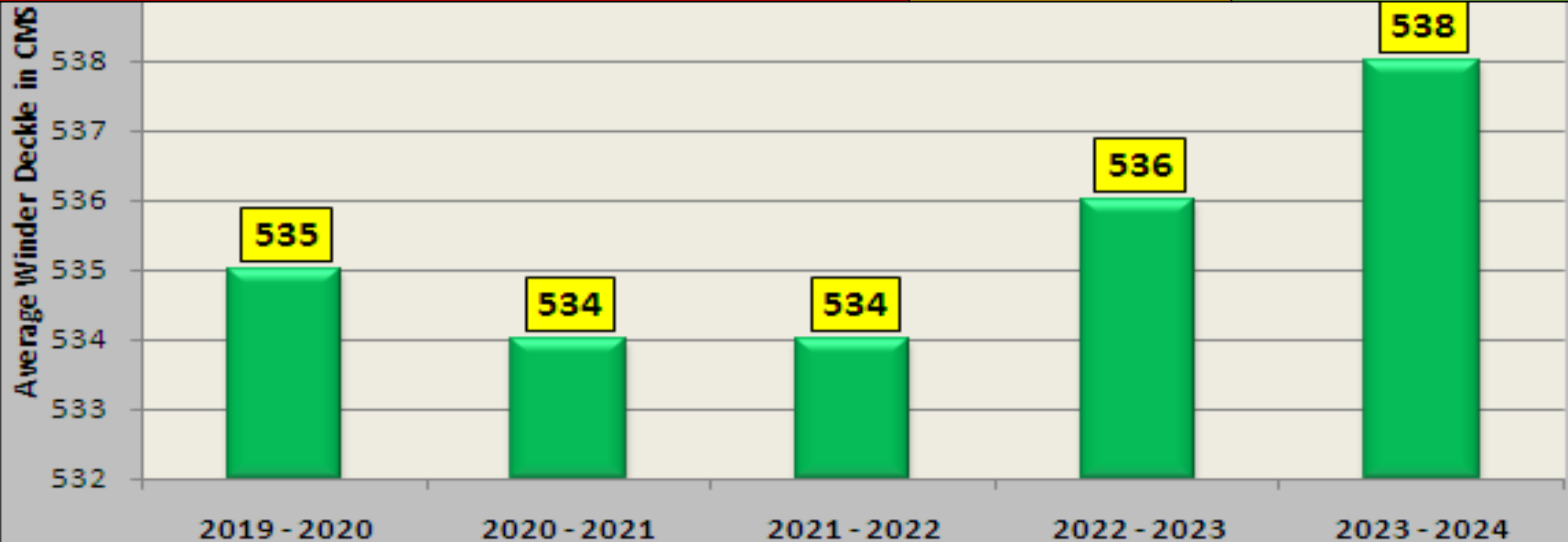


AVERAGE DECKLE UTILIZATION

**MANUAL SIZE
COMBINATION
PERIOD**

**PROJECT
TRANSITION
PERIOD**

**MANUAL + AI
SIZE
COMBINATION**



TANGIBLE BENEFIT

Description	2022-2023	2023-2024	Difference
Avg. Deckle Utilization in Winder-3	535.9 cms	537.8 cms	1.9 cms
Total Machine Production PM#3 (2023-2024)			168789 MT
Projected Utilized Deckle Production	165971 (535.9 CMS)	166559 (537.8 CMS)	588 MT
Total Cost Benefit for the year 2023-2024			2.82 Crores

IN TANGIBLE BENEFITS

- ✓ *Higher Number of Reels Per Combination*
- ✓ *Reduction in Secondary processing of reels*
- ✓ *Elimination of Floor stock reels without order*
- ✓ *Lesser time consuming process*
- ✓ *Avoiding manual errors*

*Facilitation of
Last minute changes
due to change in
Variety / Basis Weight
Size / Quantity*

WAY FORWARD IN IMPLEMENTING AI

*ONLINE PRODUCTION COST
EVALUATION & INDICATION
IN DCS INTERFACE
WITH EXISTING
INFRA STRUCTURE*

CONCLUSION

- ✓ *In early days Paper making was known as an “ART”*
- ✓ *Later it becomes SCIENCE & TECHNOLOGY during Industrial Digitalization era*
- ✓ *Now the complete process of papermaking will be driven by AI & TNPL is fast embracing it through IIOT which is stepping stone of Industry 4.0*