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# Harnessing Artificial Intelligence (AI) in TNPL Paper Conversion Process


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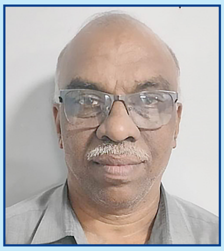

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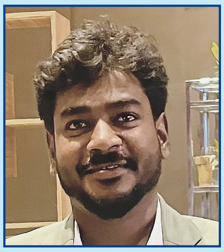

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**Abstract:**

*Paper industry is at critical inflection point in the history. Mills are feeling the weight of changing demand trends, rising energy and raw material prices besides increasingly stringent environmental pressures. To thrive in this evolving landscape, rapid implementation of cost-effective solutions that enhance agility in production is crucial. Swift adoption of Artificial Intelligence can help to control costs, improve production and meet the sustainable goals. It can also help the industry pivot to different products more rapidly. AI revolutionized various aspects of Process Optimization to enhance product quality, Waste reduction etc.*

*Paper industries today focus on waste reduction in every stage of paper manufacturing. Conversation of Jumbo rolls into reels is one major area everyone focuses on. Operating with minimum trim in the Winder & Rewinder during conversion of parent reels to child reels becomes a great challenge while accommodating various customer requirements. Reducing trim also contributes to reduced resource usage and effluent discharge, thereby helping the industry to perform more effectively & economically sustainable.*

*This article delves & explores the challenges and opportunities utilizing AI technology for Trim optimization during Paper conversion process by following Manufacturing Excellence – A tailor made manufacturing concept embracing basic statistical tools used to drive Six Sigma projects. This article explains our journey in successful incorporation of AI in Trim optimization along with functional expertise and shows how we reaped the benefits of improved efficiency & cost savings.*


**Keywords:** *Trim Optimization, Manufacturing Excellence, Six Sigma*

## 1. INTRODUCTION TO ARTIFICIAL INTELLIGENCE IN PAPER INDUSTRY

Artificial Intelligence, abbreviated as AI is engineered to acquire knowledge through exposure, Adapt to novel inputs, and accomplish tasks without explicit pre-programming. The pulp and paper industry has undergone significant technological advancements in recent years, with the introduction of digital technologies and automation improving efficiency and reducing costs. With the help of AI, companies can continue to improve efficiency, reduce waste, and meet the demands of a changing market while also prioritizing sustainability and social responsibility. By analyzing data from production processes, AI can identify areas where opportunities for optimizing resource usage like Waste reduction and provide recommendations for it. In spite of the potential advantages of AI in the paper industry, there exist numerous hurdles that necessitate attention. Despite these challenges, many manufacturers in the pulp and paper industry are already exploring the use of AI to improve their operations and reduce their environmental impact.

## 2. TRIM OPTIMIZATION FOR REDUCTION OF WASTAGE

It is essential to recognize that waste is an inherent part of the process. No matter how well waste is minimized but it needs to be noticed amidst the optimization efforts in the facility. The primary focus for conversion process is to produce required reel widths with minimum trim and with minimum number of cutting patterns or the knife-set up actions. Trim loss is an inevitable outcome of the trimming process. The trim-loss problem for any paper machine/ winder is solved as an integrated part of production planning before the jumbo reels are actually being produced. In case of any quality deviations, the predetermined cutting plan may be far from optimal. However, the available time for doing manual changes to the cutting patterns of a large number of jumbo-reels operations is often very limited.

Reduction of trim loss by increasing Deckle Utilization through AI & workforce expertise has been taken as a task oriented project by our team using Six Sigma tool DMAIC (Define, Measure, Analyze, Improve and Control)

**Define Phase:** Winder#3 was designed for a maximum deckle of 544 CMS. But, this deckle could not be achieved every time due to operational constraints, due to which the average Deckle utilization on a monthly basis was limited to 534 CMS. It was also found that better increasing the deckle utilization would be possible if a systematic problem solving technique is used. Based on this the problem was defined as below:

| Problem Statement | Goal Statement | Business Case |
|---|---|---|
| Lesser Deckle Utilization of **534 CMS** in Winder against capacity of **544 CMS** | Increasing Deckle Utilization by **5 CMS** (534 CMS to 539 CMS) | **1 CM** increase in Deckle Utilization will incur **1 MT** of paper per day which intern **Rs. 10 millions per annum** |

**Measure Phase:** Measuring the deckle for each jumbo manually is a tedious task and cannot be done with accuracy every time. But modern digitalization enables this activity through a simple photo cell which is mounted in Scanners equipped with encoder. It can be called also as "Auto Edge off Sheet" (Figure: 1) sensor used to map CD profile of Basis weight & Caliper. The sensor helps to detect both edges (Front & Drive side) of paper online and by comparing the scanner encoder value the Sheet Width is measured & indicated in DCS graphics. The trends of Sheet Width from both Scanners (Before Sizer & after Sizer) were configured to analyze further in depth.

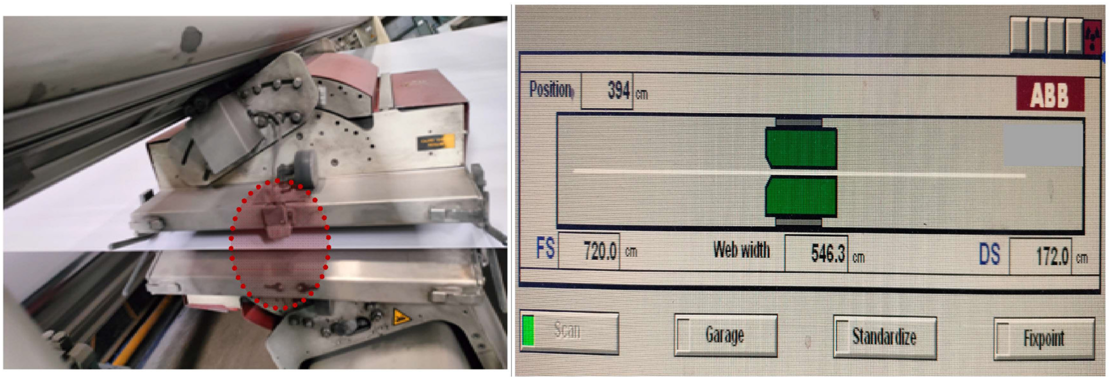


*Figure: 1 Auto Edge OFF Sheet Sensor in Scanner & Sheet Width display in DCS Graphics*

Analyze Phase: An acute discussion with officers & brain storming sessions with workmen were out to find variable factors which may influence higher trim loss. All the factors were listed out, and a cause & effect (Fish bone) diagram prepared (Figure: 2). Then as per procedure all the suitable factors were evaluated using risk priority numbering system. RPN system was followed with Severity, Occurrence & Detection (SOD) score. The top most factors were identified as follows

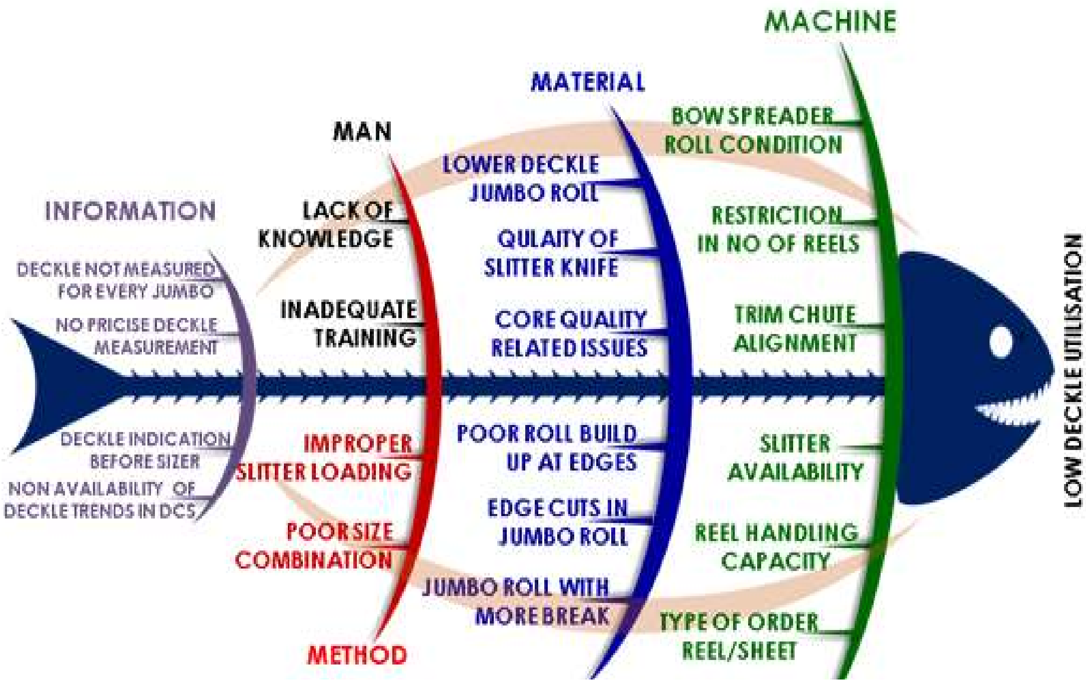


*Figure: 2 Cause & Effect Diagram for Lower Deckle Utilization*

a. Lower deckle Jumbo roll which could not be accommodated in winder to operate with lesser trim since it leads to defective reels

b. Poor Size combinations, which could not utilize the entire jumbo deckle with minimum trim loss

**Improve Phase:**

a. Lower Deckle Parent Roll:

In continuation of the analyze phase deckle variations in parent roll was closely monitored through digital signal obtained from scanner photo cell. Various factors were observed which influences much on deckle like, Furnish, Basis Weight, Jet/Wire Speed difference, Sizer metering rod profile etc. Each factor was evaluated with the available data and the same has been represented below Table No.1, 2, 3, 4 &Figure No.3.

| Table: 1 – Comparison between Furnish & Deckle | | | |
|---|---|---|---|
| HWP % | CBP % | DIP % | DECKLE MTS |
| 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 IN 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 IN METERS |
| 25 | 5.495 |
| 15 | 5.490 |
| 5 | 5.485 |
| -15 | 5.480 |
| -25 | 5.475 |

With the help of digitalization the reason and correlation between various factors with deckle were identified and the same has been tabulated in Table: 5. based on the analysis best possible process parameters were identified for a higher sheet width for different varieties.

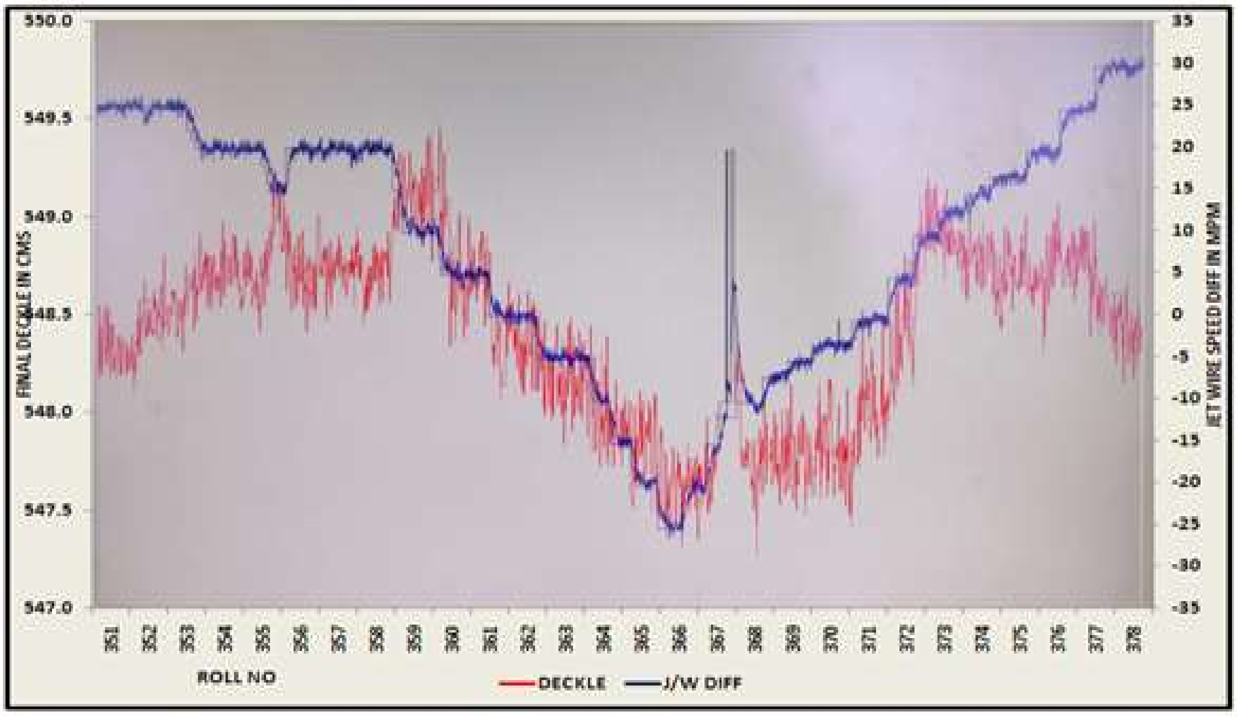


*Figure: 3 Trend of Sheet Width and Jet Wire Speed Difference*

| Table: 5 – Correlation between Factor & Deckle | | |
|---|---|---|
| **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 |

As a result sheet width has been increased by 3 CMS in parent roll itself which enables winder to operate at higher deckle utilization with sufficient trim. It can be explained with the following example as per Table No: 6.

| Table: 6 – Case Example for Higher Deckle Utilization | | |
|---|---|---|
| **Sale Order Details** RDP 57 GSM 88 CMS REEL 21 MT, RDP 57 GSM 73 CMS REEL 42 MT | **Description** | |
| | **Parent Roll Deckle - 545** | **Parent Roll Deckle - 548** |
| **Available Deckle after Minimum Trim of 3 CMS in Parent Roll** | 539 CMS | 542 CMS |
| **Size Combinations** | 1. $73^6+97^1$<br>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 |

**b. Poor size combination:**

Deckle matching is a complex process that can save millions if it is carried out efficiently. Deckle matching was done by manual matching of orders through spreadsheets which is a time-consuming process. The prepared deckle match solution is not guaranteed to be the most optimal solution. It became a very difficult task to manage order fulfillment as we are unable to plan deckle matching for more than 2-3 days ahead resulting in a last-minute scramble to fulfill orders. As there were many specifications from the customers, in the orders, we were not able to hold an inventory of products for standard sizes. Order quantity also frequently changes at the customer site, resulting in increased combinations for deckle matching. Difficulties in managing unfulfilled order items for deckle matching as their quantity varies significantly resulting in high trim losses and more combinations for the solution.

To optimize the process of deckle matching and to ensure the maximum utilization of deckle from parent roll with minimum number of size combination TNPL collaborated with software provider. The AI based Deckle matching software has been introduced in production planning process along with manual deckle matching using spreadsheets. The steps involved in Deckle matching software graphics and manual deckle matching spread sheet are illustrated in the below figures 4 & 5.

In manual deckle matching spread sheet, size combinations is carried out on trial & error basis by considering reel width, Order quantity & maximum possible utilization of deckle. The number of size combinations depends upon the skill set of the person who works on it. Deviations in deckle utilization & quantity will be differing, from person to person, whereas in deckle matching software the repeatability of the size combination & order quantity remains same.

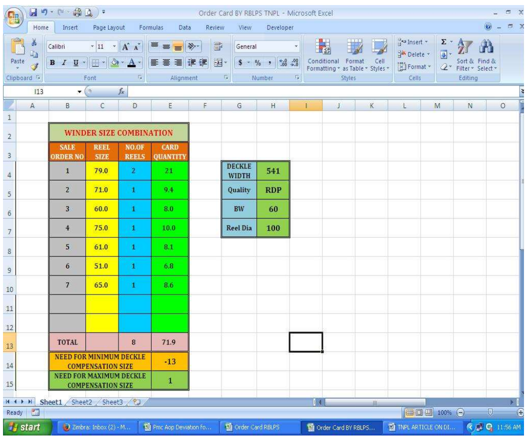


Figure:4 Manual Deckle Combination Sheet

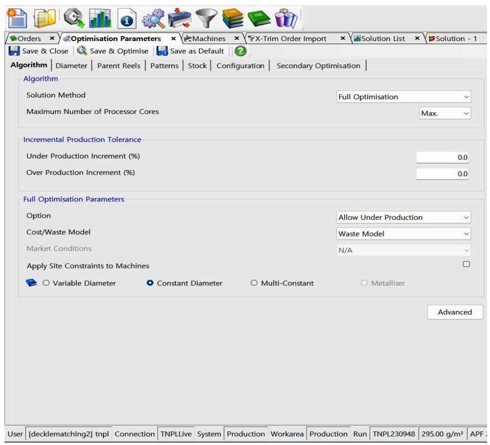


Figure: 5 Entries for Optimizing Parameters

This Deckle optimization software allows last minute corrections in order quantity with minimum time frame compared to manual work. The limitations like deckle width, Number of reels per set, tolerance level of order quantity & reel diameter were incorporated in this software. Some of the graphics in software are shown in Figure No: 6 & 7. Final size combinations are then fixed by comparing both the results of manual & software based workings. Some of the case examples are tabulated in Table No: 7.

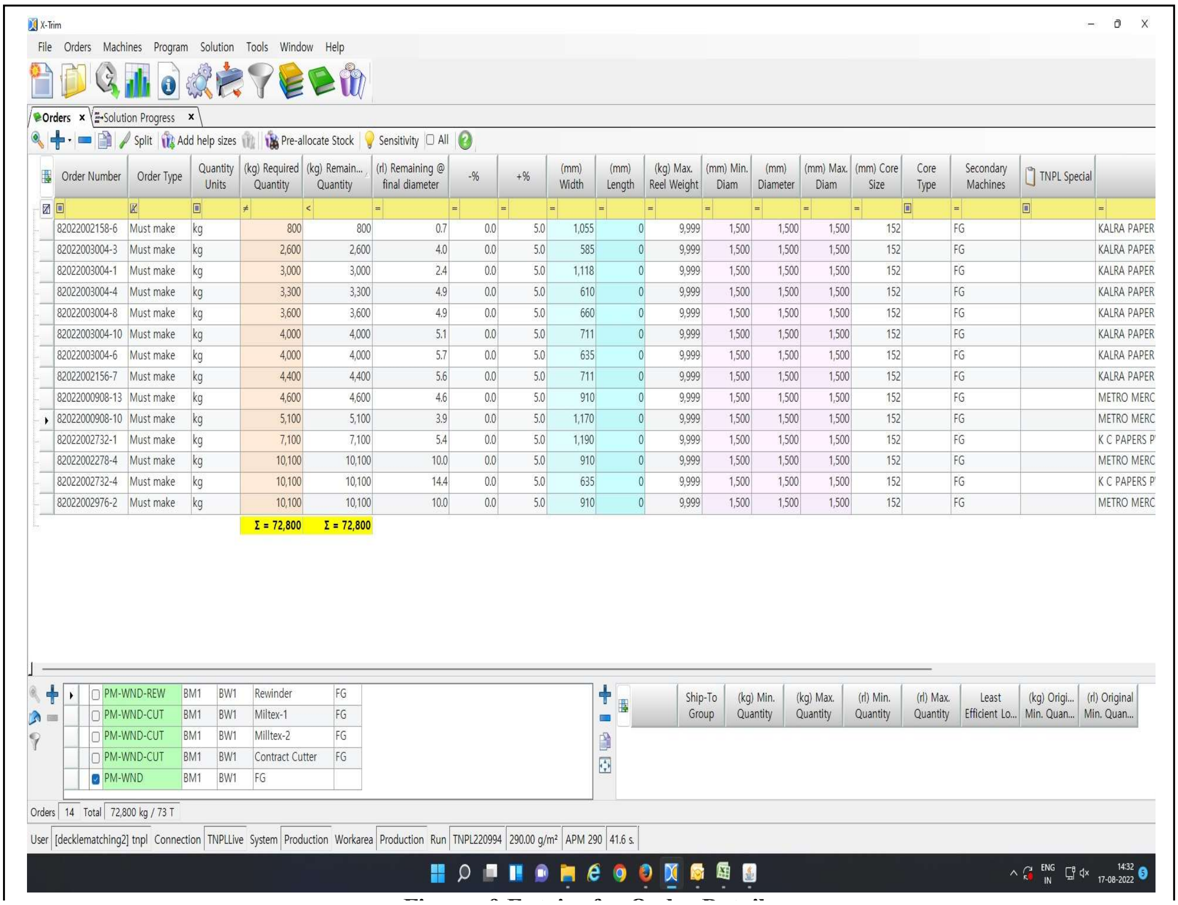

*Figure: 6 Entries for Order Details*

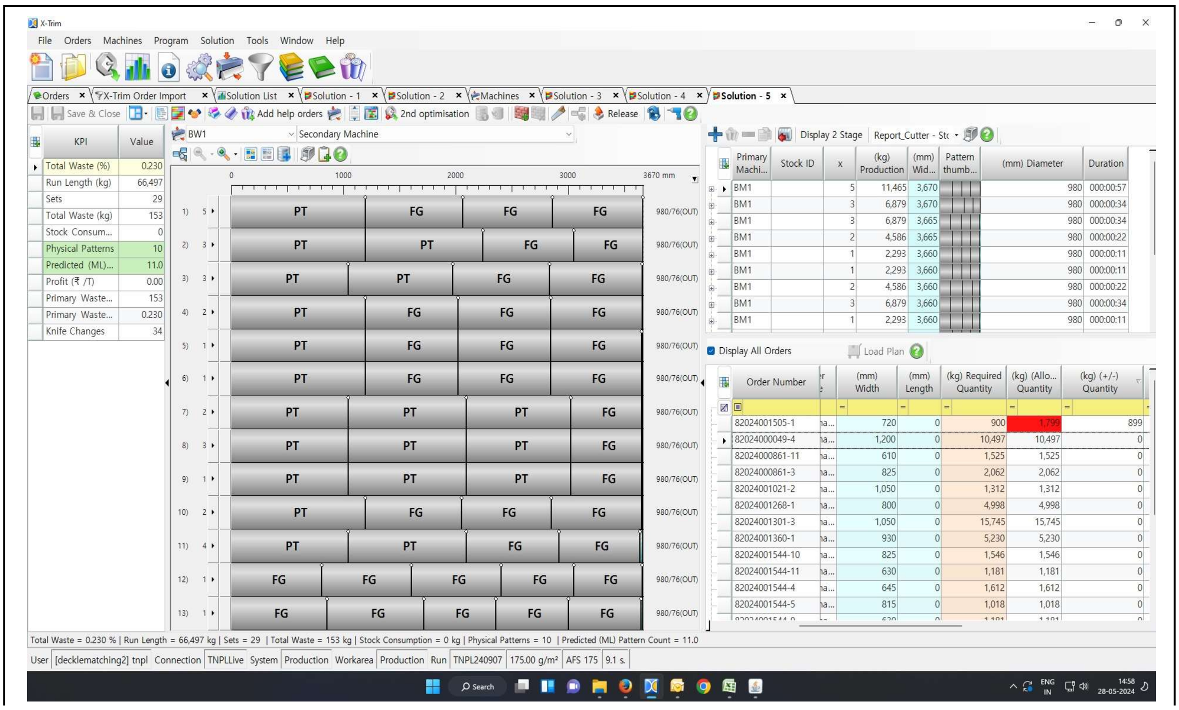

*Figure: 7 Deckle Matching Solutions*

| Table: 7 – Case Example for Manual & Software workings comparison | | | | | |
|---|---|---|---|---|---|
| S.NO | Oder Quantity MT | Number of Size Combinations | | Average Deckle Utilization CMS | |
| | | Manual | AI Based Software | Manual | AI Based 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 |

**Control Phase:** A comparison system has been incorporated in existing Production planning process to extract the best possible combinations from both AI based Deckle matching software & Workforce expertise. After increasing the Parent roll deckle & using the trim Optimization software, average winder deckle utilization has been increased by around 5 CMS (Figure: 8) with lesser size combinations.


*Figure: 8 Winder Average Deckle Utilization*

| TABLE NO: 8 - COST IMPACT ON WINDER DECKLE UTILIZATION | | | |
|---|---|---|---|
| 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** |

## 4. CONCLUSION

Cost cutting is no longer the solution to sustainable profitability. The key to success is finding creative ways to prevent waste. The mix of people, process & technology is a recipe for success when used strategically. Leveraging AI technologies effectively is a boon for those who are ready to increase their bottom line with new business opportunities. The complete process of papermaking and eco-system will be driven by AI in current industrial revolution & TNPL is fast embracing it through IIOT which is stepping stone of Industry 4.0.

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