Enhancement of Throughput Simulation Accuracy Using AI

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Abstract*: This research article study and analyze the feasibility of deploying the time study analysis, which has been created by using Artificial Intelligence (AI). Artificial Intelligence is used to reach accurate results by a throughput simulation study and which is also used to reduce the percentage of variability in the pre-production study versus the physical implementation. The modern manufacturing facility is very keen in implementing the optimized production system to avoid the unwanted cost investment and smooth running without stoppage like starving and blocking prior to the physical implementation. But the level of output accuracy differs in Throughput study when we use the designed cycle time instead of the real physical time studies. Deriving the physical time study is possible only when the facility is implemented in the manufacturing area. In this study, the correlation between the AI and physical time would be validated and Throughput simulation result will be compared to improve the accuracy and difference. Usual data usage for the Throughput study are designed to cycle time, Mean Time To Repair (MTTR), Mean Time Between Failures (MTBF). This feasibility study will replace the designed cycle time by Artificial Intelligence (AI) time. Expected results from this study are to find the benefits by using the AI time studies from the Throughput simulation when compared to the designed cycle time.

Index Terms: Artificial Intelligence, Automod, MTBF, Simulation,

I. INTRODUCTION

Throughput Simulation is a method to verify the capability of production lines and logistics before the implementation or procurement facility equipment's to maximize the efficiency and find the bottleneck. As present the preprogram analysis team is using the designed cycle time based on the expected volume from the facility. The major inputs for the Throughput simulation study are cycle time, Mean Time To Repair (MTTR), Mean Time Between Failures (MTBF). The output from the assembly throughput study is potential Jobs Per Hour (JPH), Bottleneck Analysis and Pallet optimization. The simulation usually considers the running period of 30 production day to get the probable failures on the occurrence base. The number of running time can be vary based on the customer need also..

A large number of industrial organizations in developing countries use simulation in their manufacturing systems so that practical production problems relating to their daily operations would be solved. There is an obvious growing increase in the use of simulation for the analysis of manufacturing systems. This is strengthened by a reduction in computing costs, improvements in simulation software and a greater emphasis on developing and using automated manufacturing systems to improve productivity and reduce costs. The tool used to run the simulation is Automod for this study. The Automod software can be used in almost any area of manufacturing and material handling. It has been used widely in the following applications, categorized by industry Automated material handling systems (AMHS), Automotive and Warehousing/distribution centers

II. LITERATURE STUDY

Junfeng Wang and Qing Chang have developed a data-driven simulation methodology to automatically model a production system and rapidly modify the model corresponding to dynamic requirements and real-time information. The generic simulation model was developed considering the processing as well as the logistics aspects of assembly manufacturing systems.

Jerry banks have outlined general simulation principles and provide step-by-step instructions for building, running, and analyzing models using the AutoMod software. The book teaches core AutoMod concepts, including how to write model logic that simulates real-world processes and how to simulate automated material handling systems, including conveyor and vehicle systems.

Juyoun Wy and Sangwon jeong have introduced a generic simulation modeling framework to reduce the simulation build time. The framework consists of layout modeling software and data-driven generic simulation model

III. PROBLEM STATEMENT

Currently, we are facing the concern in the facility that the derived results from the existing Throughput simulation study is not matching with after the facility physical implementation. Due to this,

- Defined Bottleneck operations getting change
- Number of required pallets are not matching with the real requirements
- The estimated jobs per hour is varying

Because of this change the facility Process or Industrial Engineering work iteration getting high.

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IV. ROOT CAUSE ANALYSIS

Currently, we are using the designed cycle time for the Throughput simulation study as recommended by the program team. Since getting real-time data is possible only after the tool tries out in the manufacturing unit. Also, we are getting a data from the supplier for the MTTR (Mean Time to repair) and the MTBF (Mean time between failures) or based on the existing facility the data has been pulled from the plant operating system monitoring. The physical study and the designed cycle time comparison for the manual stations are plotted below and there is no correlation between the cycle times is shown in Fig.1.

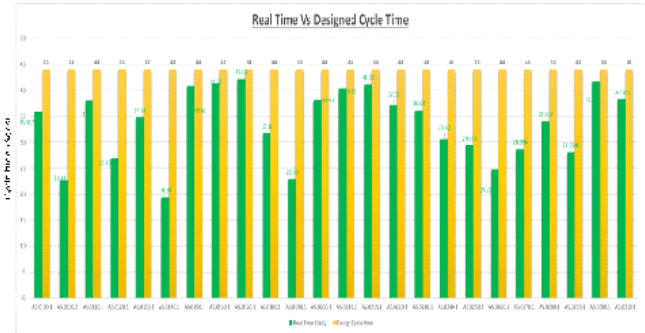

Fig. 1 Cycle time Comparison of Real Time Vs Design Time

V. PROPOSED METHOD

Currently, we have the processing deck to get the operator workload before the program approval itself using the standard verbs in the process elements. This process deck is used to estimate the part, tool usages and to estimate the manufacturing costing prior to the launch confirmation through the Planning tool. But the correlation between the time studies is not done. How we are getting the AI generated Time studies before the facility implementation!

VI. INTRODUCTION TO PROCESS AND PLANNING TOOL

This tool to have been created to find the manufacturing costing prior to the launch confirmation considering various data. It Consist of Process Deck, Planning tool, Process Sheet which is shown in fig.2.

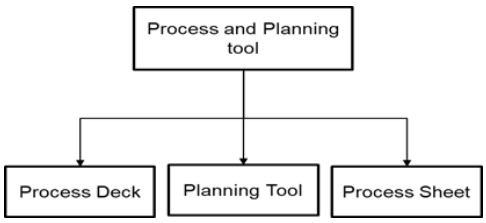

Fig.2. components of Process Planning Toll

A. Process Deck

Process Deck is a subsystem within the larger process and planning tool to facilitate all facets of product process and study creation management. The purpose of the processing deck is to allow users to:

View the Product and process related information with the existing deck and the facility process owner can edit the process content according to the requirements. The Standard language in this Process Deck,

- Restrict the syntax and grammar
- Information's about tools, parts, and work required to manufacture the product
- Predefined over 5000 words, 1600 abbreviations are can be used by the process owner
- All requirements are controlled by Artificial Intelligence

B. Planning Tool

This tool is developed and implemented to manage the operations, workstations, Line balancing, Ergo analysis, operator work instruction, and workplace safety analysis. The workstation owner can easily swap the process between the stations according to the requirements in the earlier stage of the pre-program stage.

C. Process Sheet

Process sheet is the advanced system than the classic Process System in the manufacturing line. The major components of Process sheet are Operator instruction, workplace safety analysis, and Work instruction. All these elements are developed to ensure standardized work and to create a safe work environment in the manufacturing lines.

VII. FEASIBILITY STUDY

In order to find the correlation study between Artificial Intelligence time and the physical time study, in this listed three different time studies in the current process.

AI - Artificial Intelligence time created from the Process Deck process allocation in the Process planning (includes pre-defined N/C) which is shown in fig. 3.

AI(C) - Corrected Artificial Intelligence time (i.e., internal, SIMO opportunities, N/C removal) which is shown in fig. 4.

Real-time Study - Extracted from the Process Planning time studies (Physical MODAPTS study) which is shown in fig. 5.

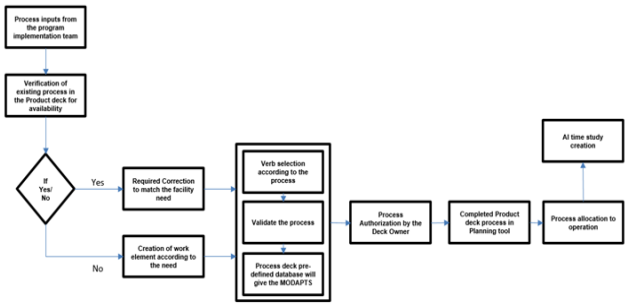

Fig.3. Components of AI Time

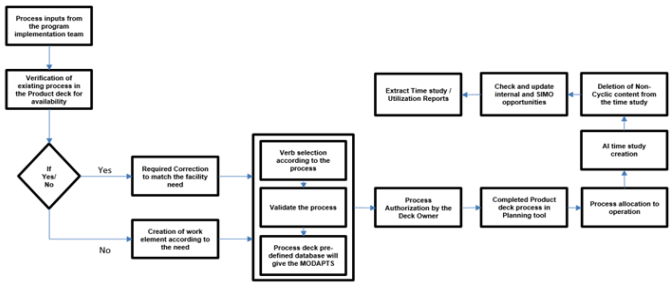

Fig.4. Components of AI Time Corrected

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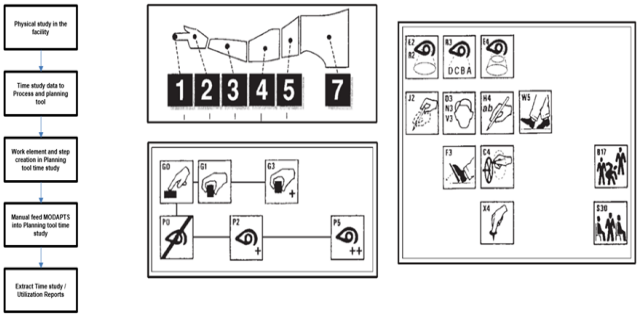

Fig.5. components of Physical Study

MODAPTS

The MODAPTS (Modular Arrangement of Predetermined Time Standards) system is used to analyze work performance by monitoring the operator's movements in the workplace. MODAPTS records the workplace or monitors the operator's movements in the workplace in order to simplify and facilitate work in the workplace, detect and eliminate idle motions, analyze the performance of the MODAPTS method.

In MODAPTS there are three main classes of elements:

- Movement
- Terminal
- Auxiliary

VIII. PHYSICAL STUDY RESULTS

To find the correlation between all these different scenario time studies, we have chosen the existing facility and did the correlation study with designed cycle time, AI, AI corrected and the physical study. And the results are plotted in the fig. 6.

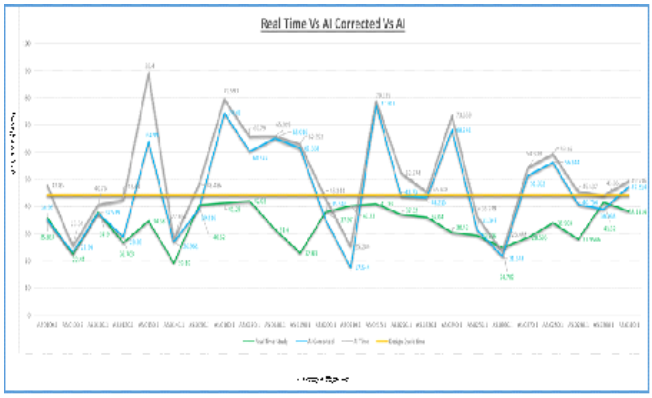

Fig 6. Cycle time Comparison of Real Time Vs AI Systems

From this study, If was found there is no correlation between any of these time studies and we found some common issues like wrong verb usage, wrong code generation and some walk distance differences in the planning tool and the processing deck. When it is assigned to the Process planning tool, the predefined MODAPTS code making more difference in the total timings. One sample mentioned below,

The work element has been broken down into one step for analysis, Obtain (4) washers

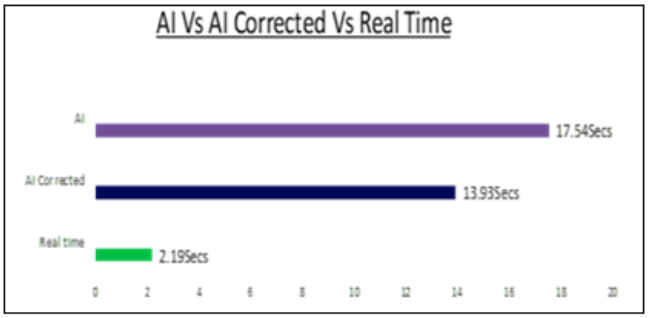

Fig 7. Comparison of AI Corrected Vs Real Time

Here the difference between the Real-time and AI corrected is around 85%. The difference in the time is because of the verb used during the process of writing by the engineers. Usually "SELECT'' is the verb should be in the use when there are two or more variants in the manufacturing line to give the required time to the operator to perform verify and decide for the part complexity. This kind of complexity usually manages through the pick to light in the manufacturing facility. The predefined MODAPTS for verb ''SELECT'' are check (E2), decide (D3), walk to the object (2W5), grasp the object (M4G3) and return to the work station (2W5). ''OBTAIN'' is the verb will be in the use where the operator required to walk to grasp the object. For ''OBTAIN'' the predefined MODAPTS is similar to ''SELECT'' except verify and decide (E2D3). The ''GRASP" is the verb to be used when only the operator can take control of the object very simply.

Study Probability

A. *Phase -1*

Correlation study between Real-time study without non-cyclic Vs AI Corrected

The first probable study is between the physical study in the facility without non-cyclic and the AI corrected. Reason for selecting the physical time study without non-cyclic is to match the AI corrected conditions. Since the AI corrected is the next process level of AI time studies which have been automatically created from the processing deck through the planning tool Non-cyclic is the process of handling the dunnage's, tool change over setup change over.

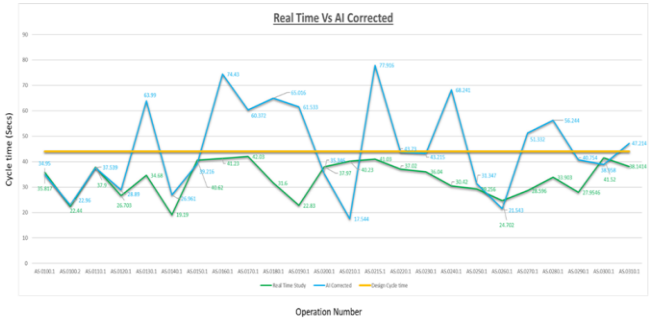

Fig. 8 Comparison of Real Time Vs AI Corrected

From this study, it is observed that 10 stations are higher than the designed cycle time out of 25 stations

B. *Phase – 2*

Correlation study between Real-time study with non-cyclic Vs AI

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The second probability of the study had been carried out between the physical study in the facility with non-cyclic and the AI. The reason for selecting the physical study with Non-cyclic is to match the AI contents. Usually, the AI time consists of predefine non-cyclic activities based on the part size (VSML, SML, LRG, VLRG). The fig. 9 shows that No correlation observed in this study and the level of mismatch is too high from the designed cycle time

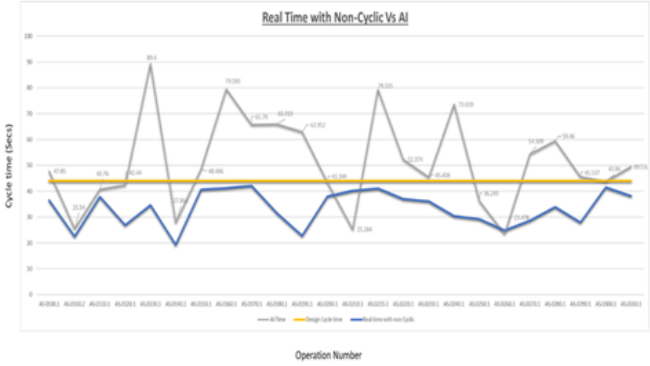

Fig. 9. Comparison of real time with Non-Cyclic Vs AI

IX. NEWLY PROPOSED METHOD

In order to have the correlation between the real-time studies and the AI corrected, there is the set of the standard defined to the team like; refer the 2D layout, process layout to confirm the distance and the variants. The proposed method is named as AI correct (proposed) for understanding. The recommended standards can be modified in the planning tool manually and few are direct to be changed in the processing deck, where we have the predefined MODAPTS using AI based on the verb usage. The fig. 10 shows the Comparison of Real time Vs AI Corrected and proposed AI Corrected

The few examples are discussed here, SELECT / OBTAIN / GRASP

- Recommended to use the layout to refer the distance and the variants prior to the process writing

OBTAIN BOLT FROM THE RACK

- Any grasp after the walk must be M2 except M7

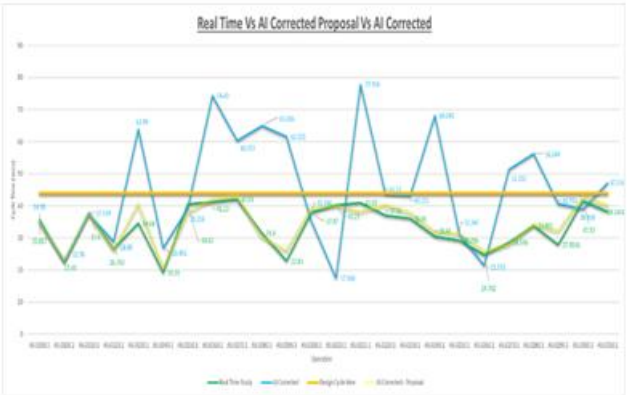

Fig. 10 Comparison of Real time Vs AI Corrected and proposed AI Corrected

X. RESULTS AND DISCUSSION

A. Throughput simulation (Design Vs AI Corrected Proposed)

In order to verify the variable output from the design cycle time and the AI corrected cycle time through the simulation study the tool used to simulate Automod. The major inputs to the Automod are the conveyor length, conveyor speed, pallet length, Meantime Time To Repair {MTTR), Meantime Between Failure {MTBF), machine availability and the station cycle time. The expected result from the simulation is the variations of bottleneck stations, potential Jobs Per Hour (JPH), variation the pallet sensitivity.

Below are the common inputs to the Automod,

Pallet length	- 1500mm
Conveyor pitch	- 1600mm
Conveyor speed	- 15m / min
Conveyor length	- 154.56m

Number of days considered for simulation is 30 working days.

B. Automod Module

The Fig. 11 shows the Sample window of Automod module program environment.

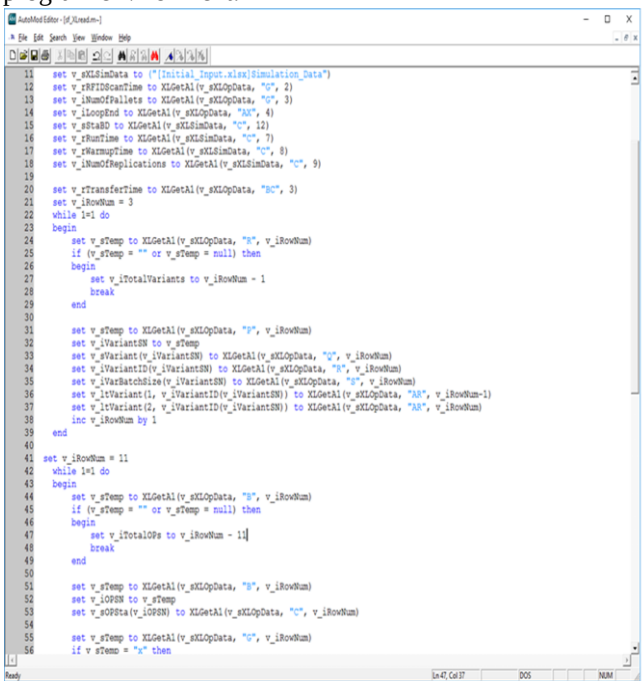

Fig. 11 Sample window of Automod program module

C. Automod runtime screen

The Fig. 12 shows the Sample window of A simulation model of Automod runtime environment.

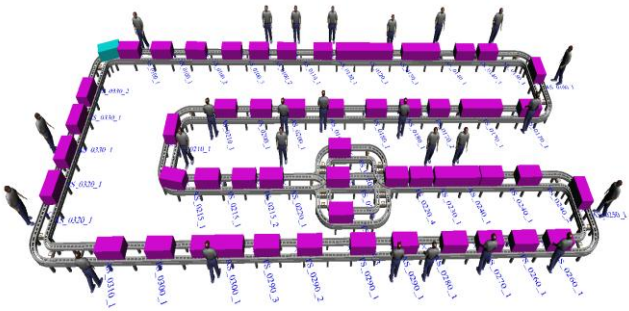

Fig. 12 A simulation model of Automod runtime

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D. Results from the designed cycle time

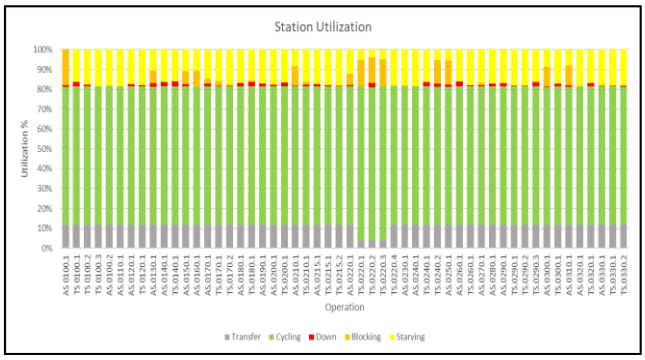

Fig. 13 Station utilization % of designed cycle time

The operator utilization there is no changes between the operations since the considered cycle time is common throughout the line. Also identifying the opportunity is not possible for the work sequence optimization or the process improvements at this point in time by the industrial engineers.

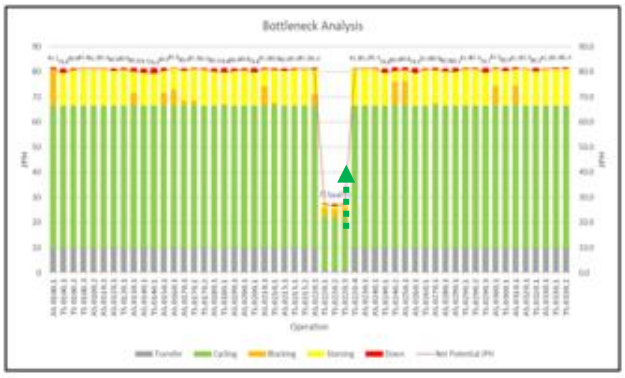

Fig. 14 Bottleneck analysis designed cycle time

The identified bottleneck station from the above study is not exactly matching with the physical facility. Since the used time study for the simulation study is designed to cycle time. The operating time for all the stations are remaining same, so the bottleneck will vary only depends on the breakdown occurrences.

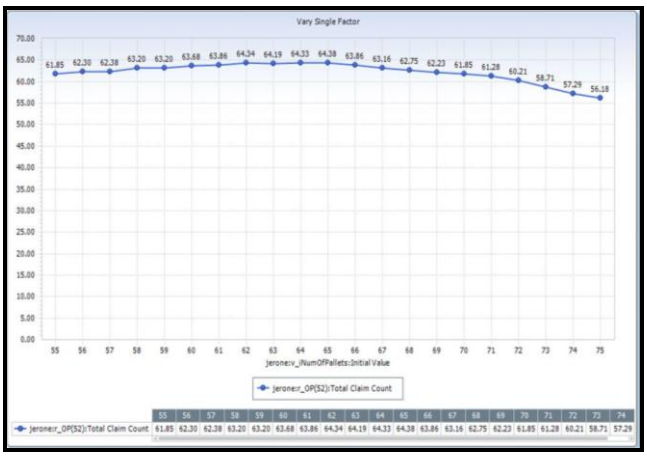

Fig. 15 Pallet utilization of total claim count in present

The identified pallet requirements may higher than the actual requirements since the machine availability is the reason majorly give the impact in the number of pallets in the Throughput study.

E. The result from AI corrected proposed time

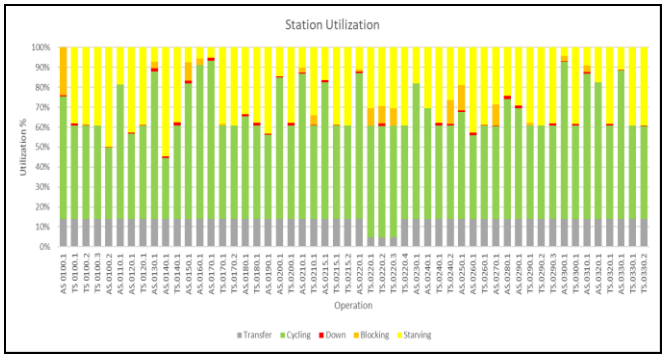

Fig. 16 Station utilization % of AI corrected proposed time

The identified utilization is clearly varying from the actual what we identified from the designed cycle time for the Throughput study. Since the used time for this study is AI corrected and has a good correlation with the physical study.

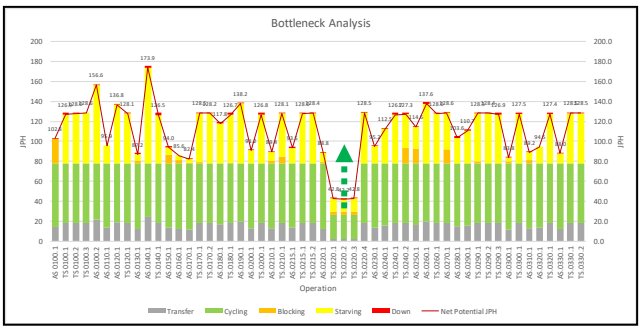

Fig. 17 Bottleneck analysis designed cycle time

Bottleneck station is changed from the old study which we have using the designed cycle time output, now the bottleneck station is AS.0170.1. The number of iteration is not necessary on the process swap since this date will exactly match with the real-time data.

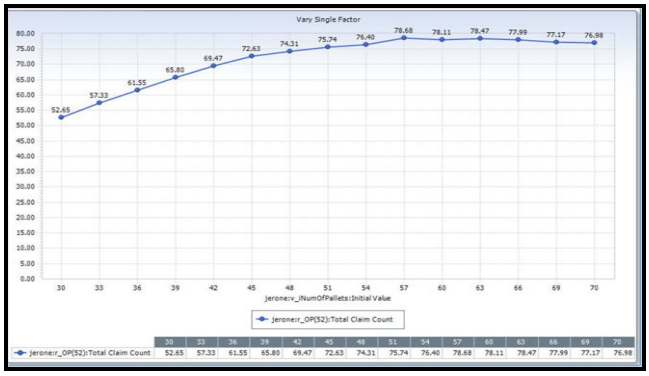

Fig. 18 Real pallet requirement of the design cycle time

The earlier study data from the design cycle time requires 65 pallets to get the desired output. But when we used the newly proposed method it came to 57 pallets to get the output.

From the Throughput simulation study using designed cycle time and AI correct cycle time gave the significant changes in all the outputs,

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- Operator utilization – Change in percentage
- Bottleneck station – Station changes
- Pallet sensitivity – Quantity changes

The results of Design cycle time and AI correct cycle time usage in the Throughput simulation study as below,

Design CT Vs AI Corrected CT (Proposed)		
Parameter	Designed Cycle Time	AI Corrected Cycle Time (Proposed)
Operator utilization	69.36	54.6
Bottleneck Station	TS.0140.1	AS.0170.1
Pallet Sensitivity	65	57

Based on the study, the usage of AI corrected cycle time in the Throughput study will give the benefits to the facility are,

An approximate cost avoidance of 6000000 INR on pallet procurement.

- ✓ Found exact Bottleneck is avoided for unwanted process swaps in the optimization process.
- ✓ Accurate operator utilization was identified.

XI. CONCLUSION

This study provides the feasibility of deploy in AI corrected time with proposal came very finely with the run time data in the manufacturing line. In bottleneck was identified exactly matching with the physical validation and also identified the number of pallets available in the current line is not required and cost can be easily avoided if by using the AI corrected proposal method. Currently, the feasibility is achieved to used the AI corrected proposed cycle time along with EH existing mean time to repair (MTTR) data and Mean time between failure (MTBF).

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