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Implementation of Min-Max Stock Insert Components to Prevent Lost Opportunity Tooling Case Study: Automotive Component Company

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A B S T R A C T

Inadequate or delayed supply of raw materials or components needed for production can lead to line stoppages. Reducing the frequency and duration of line stoppages is crucial for maintaining efficiency and meeting production targets. It can happen due to logistics problemsThis research was conducted in the logistics department of an automotive component company. One of the causes is the procurement of tooling, which needs to be improved for production needs. The tooling factor is part of the logistics scope and is the highest factor causing lost opportunities and line stoppages. To minimize the impact of line production stoppages, manufacturers often implement strategies like implementing a minimum stock of insert components. The problem-solving methodology includes a five whys analysis, conducting a Pareto diagram, determining the service level of the stock level, and calculating the maximum-minimum stock level. Based on the result, 17 types of inserts must apply stock levels to avoid stock shortages.

1. INTRODUCTION

Most of the manufacturing operations are related to the supply of goods, starting from raw materials, goods in process, and finished goods. Inventory is the number of goods provided to facilitate the next process. For example, raw materials are provided to expedite production, and finished goods are provided to meet consumer demand. Inventory is unique because its existence is very necessary, but if the quantity is too much, it will be a waste (Imansuri et al., 2024). Moreover, if the quantity is too little, it cannot meet consumer demand, so consumers will be disappointed because what they expect is not fulfilled. It will cause big losses for the company because consumers will give a less good image of its services. Besides that, the company will lose the opportunity to gain profits already in sight. So, the role of inventory in the company is so big that inventory must be controlled as best as possible (Basuki, 2019). A production system is a combined series of interconnected elements that support each other to complete the production process and produce a product. Common problems in the production system are problems controlling inventory, inefficient production processes, and failure to achieve production targets. One of the problems that occurs is that production targets are not achieved, which can reduce productivity competitiveness and be detrimental to the company. This problem was caused by the production line stopping with factors including damaged machines, running out of materials, and empty tooling supplies so that production could not run (Albrecht, 2014).

DI, Ltd is a company engaged in manufacturing automotive mechanical parts and components, especially those related to machining, forging, heat treatment and aluminum casting. This problem also occurs at DI, Ltd, where production line stop problems often occur. This problem resulted in losses for company. Therefore, DI, Ltd made a production stop report which provides information on the factors causing production to stop. One of the causes is the procurement of tooling, which needs to be improved for production needs. The tooling factor is part of the logistics scope and is the highest factor causing lost opportunities with a duration of 190,753 hours during January, 2021-March, 2023. The type of tooling that experiences procurement problems is inserts because these items are only used once, requiring repeated procurement. Therefore, it is necessary to apply stock levels to prevent stock shortages.

Some research on inventory is as follows: the problem of placing safety stock over a logistics network in the automotive industry using dynamic programming to solve the placing safety stock problem under guaranteed-service time models so that these improvements reduce inventory (Funaki, 2012; Moncayo-Martínez et al., 2014). Cost control in the inventory management process by conducting a Reorder Point (ROP) analysis to determine the right reorder time, Economic Order Quantity (EOQ) to determine economic order volume and frequency, and Safety Stock to determine the quantity of safety inventory that must be owned for smooth running. Demand spikes do not disrupt the production process at any time (Katiandagho & Trisyanto, 2022; Kushartini, Dinni, 2015). As a result, the company could save Total Inventory Costs for it's twelve raw materials up to Rp2,290,219 with the EOQ Method (Katiandagho & Trisyanto, 2022).

Research related to determining stock levels by building a model of the problem as a multi-item, single-echelon inventory policy where items can be stored in stocking locations supplied by an indoor vendor (i.e., the main warehouse) with infinite capacity (Ekren & Ornek, 2015). Determining safety stock is based on forecasting the number of defective products so that the recommended amount of safety stock is obtained to anticipate the presence of defective products (Imansuri et al., 2025). Further research determines the ideal stock level in the tire manufacturing industry. The problem is that the old inventory model cannot optimize production. So, the proposed model uses mathematical programming (Keskin et al., 2015). Based on the problems above, this research will determine the minimum and maximum stock of insert components to prevent lost tooling opportunities.

2. LITERATURE REVIEW

Inventories are material deposits in the form of raw materials, goods in process, and finished goods. Inventory control is a system that companies use as a report for top management and inventory managers as a tool for measuring inventory performance. It can also be used to help create inventory policies (Hasan & Pulansari, 2023; Murti et al., 2019). The maximum and minimum inventory quantities determine the concept of maximum and minimum inventory. If the inventory has reached the minimum quantity, then immediately purchase raw materials until the quantity reaches the maximum inventory. If the raw material inventory has reached maximum, then purchases are stopped. When raw materials in inventory are used continuously, the inventory will reach a minimum point again. This concept was developed based on the idea that to maintain the continuity of operations of a company or other facility, certain types of raw material in minimum quantities should be available in inventory so that they can be used immediately at any time they are needed, but too many raw material are not allowed to be stored so that there is the maximum value (Rachmawati & Lentari, 2022).

3. RESEARCH METHOD

The object of study for this research is the insert tooling part, which functions in the initial machining process up to the finishing stage. The data used in this research is data on the need and availability of insert components. Apart from that, interviews were also conducted with related parties, such as the procurement department, regarding the assumed service level and lead time for each type of part insert. Next, data processing using the maximum-minimum inventory concept follows the research method steps as follows:

1. Five whys Analysis

Five whys Analysis is a method or formula concept used to solve a problem. This method can be a helpful tool in identifying the root of the problem or cause of non-conformities in a process. The analysis is carried out by asking five questions starting with the question sentence "Why," with specified steps in finding the root of the problem such as defining the problem, collecting data, identifying possible causes, identifying the root cause and propose and implement solutions to the root of the problems that occur (Sumasto et al., 2023).

2. Pareto diagram

The Pareto chart determines the relative frequency and order of importance of a problem or the factors causing the problems. Pareto also focuses on critical and important issues by ranking the problems that occur (Ducharme et al., 2021; Helia & Suyoto, 2018).

3. Determining the service levels

Determining the service level desired by the company, or the level of possibility of meeting the company's desired insert component needs, is usually expressed in percentage form (Piranti & Sofiana, 2021):

$$Z = \text{service level} = \text{safety stock} = \frac{\text{Total company production hours in a month}}{\text{Total hours in a month}} \times 100\% \quad (1)$$

4. Determining the level stock

Safety stock, or what is known as safety stock, is inventory used to anticipate the occurrence of stockouts (inventory shortages) or delays in the arrival of ordered goods. This stock can keep production running smoothly without being hampered by insufficient stock. Determining level stock using several formula below (Amin Kadafi & Delvina, 2021):

a. Calculate average

$$\text{Average} = \frac{\text{Total Requirement}}{\text{Total Period}} \quad (2)$$

b. Calculate standard deviation (Chandra & Sunarni, 2019)

$$\text{Stdev} = \sqrt{\frac{\sum(\text{requirement} - \text{average})^2}{\text{total period -1}}} \quad (3)$$

c. Usage during lead time

Usage during lead time = lead time × average (4)

d. Safety Stock

Safety stock = safety factor × stdev (5)

5. Calculation of minimum-maximum stock level

Determining minimum stock is how reordering must be done based on average yearly demand. Meanwhile, the maximum stock is the maximum amount of material allowed to be stored as inventory. The following is the maximum and minimum stock calculation formula (Rachmawati & Lentari, 2022):

a. Minimum level

= Usage during lead time + Safety Stock (6)

b. Maximum level

= 2 x Usage during lead time + Safety Stock(7)

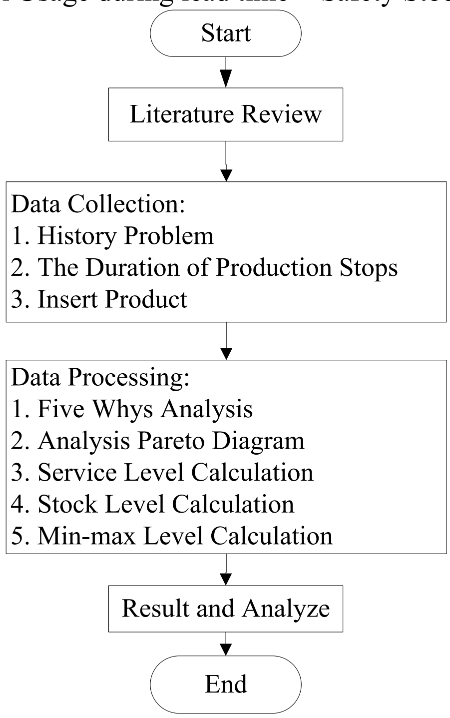

Figure 1. Research framework

4. RESULT AND DISCUSSION

Data Collection

DI, Ltd, an industrial company in the manufacturing sector producing automotive component products, needs help meeting the company's needs and production targets. One of the problems faced is productivity performance that does not run optimally because the production line often stops, wasting a lot of time in the production process. The impact is that production targets must match planning, resulting in very high lost opportunities for the company. Lost opportunity data obtained from the results of the production stop report, which explains the information on the duration of production stops due to several factors, can be seen in Table 1.

Table 1. The Duration of Production Stops

Factors Causing The Production Line To Stop	Duration (Minute)	%
Planning master production schedule	17,647	0.02%
Process	28,575	0.04%
Others	96,290	0.13%
Childpart	162,251	0.23%
Jig & Fix	575,741	0.80%
Setting	689,269	0.95%
Consumable	1,238,055	1.72%
Sub-countract	2,902,837	4.04%
Material	3,908,535	5.44%
Operator	8,564,315	11.92%
Tooling	11,445,188	15.92%
Machine	42,247,470	58.78%
Total	**71,873,173**	**100%**

Based on Table 1, in the ranking list of factors causing production to stop at DI, Ltd from January 2021 to March 2023, the first rank that forces production to stop is machines caused by repair or maintenance of machines that experience problems or damage. The second cause is tooling, namely production equipment such as inserts and drills that do not have stock or stock is empty so that machining processes for production cannot be carried out. And the third biggest factor is the people factor, which is because some operators are on leave or are sick. The procurement department should be able to fulfill user requests, especially the production department. Therefore, procurement planning must have a plan for providing stock of goods to avoid empty stock and minimize lost opportunities for tooling to increase company productivity.

The production stop report is a database that contains the history of lost opportunities in the company, containing data based on time duration and the causal factors that led to the stop line. The data in the production stop report is then processed as a bar chart to know the lost opportunity development graph. So you can see the comparison before and after making improvements in procuring goods to meet production needs. Figure 2 shows a production report graph from January 2021 to March 2023 showing lost opportunity tooling of 15.92% with a duration of 11,445,188 minutes in the first position.

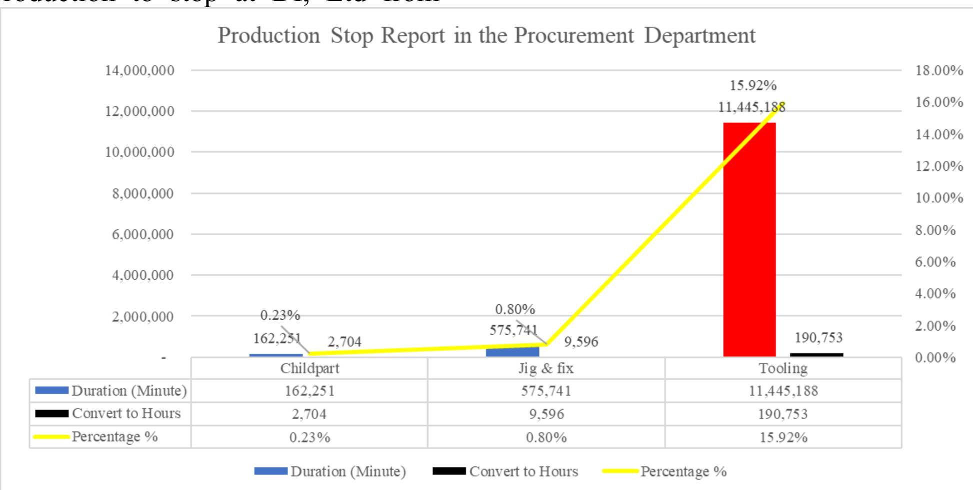

Figure 2. Graphic of production stop report in the procurement department

Based on Figure 3. it can be processed again by looking at the graphic diagram according to lost opportunity tooling over three years from 2021 to 2023. The total duration of lost opportunity tooling is graphed by displaying the durations per year. In 2021, the whole time was 2,492,281 minutes ago. There was an increase in 2022, with a total duration of 7,028,230. In the current year, 2023, lost opportunity tooling has experienced an entire time of 1,924,677 in the first three months from January to March.

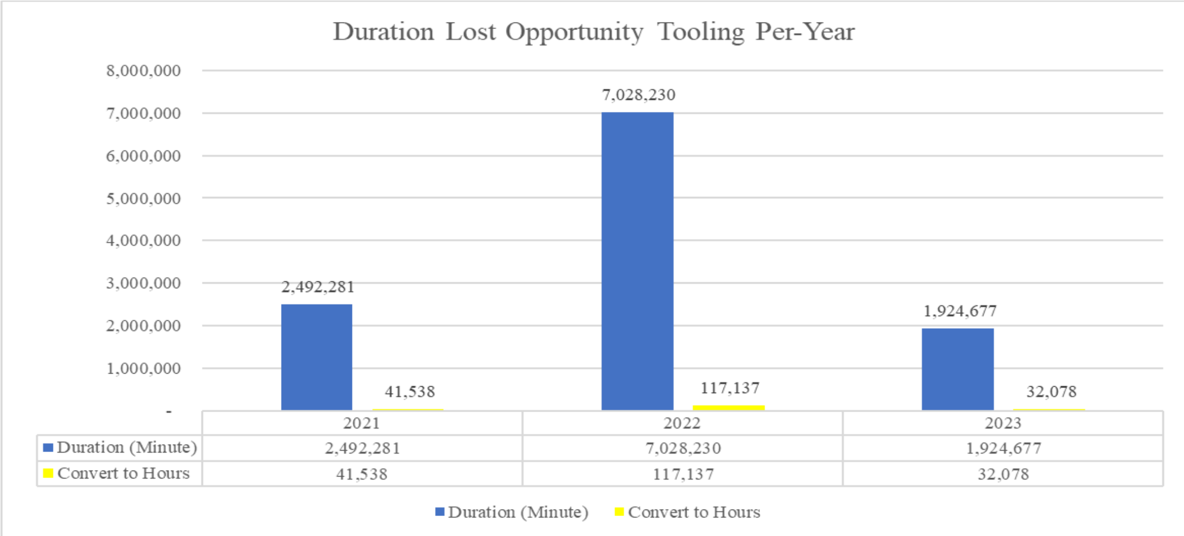

Figure 3. Duration lost opportunity tooling per year

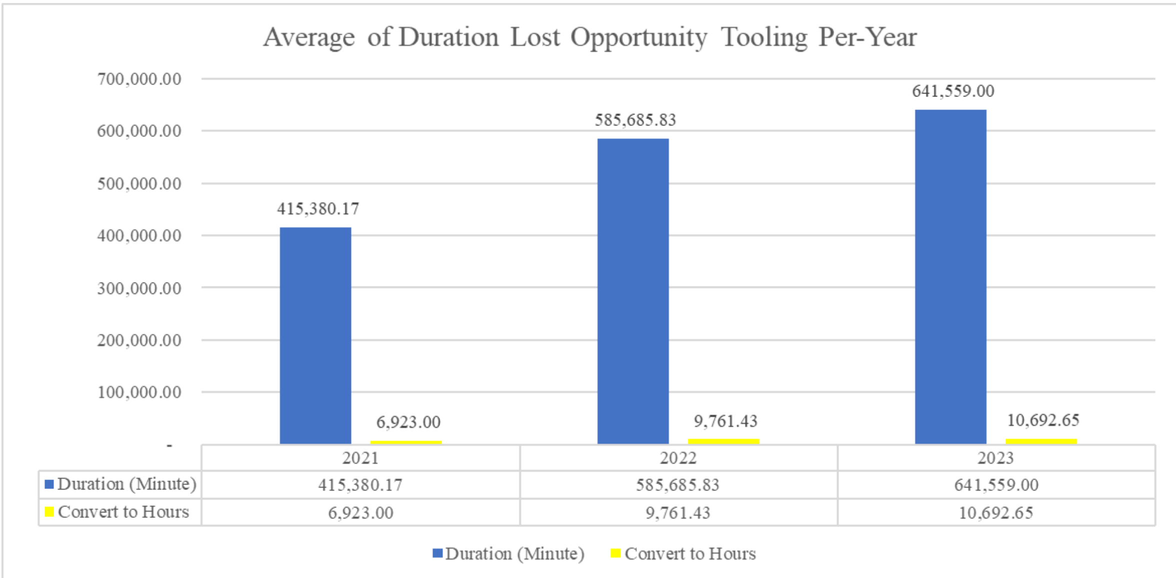

Figure 4. Average of duration lost opportunity tooling per year

After knowing the data on the number of lost opportunity tooling durations per year, the data must be processed again to see the average per year. So that you can see the duration of the stop line and whether the graphic results are decreasing or increasing compared to the previous year. In 2023, the graph shows an upward trend, so it can be concluded that there are problems with the stock of goods caused by lost opportunity tooling in procuring goods.

Before making improvements to overcome the occurrence of lost opportunity tooling, calculate the number of stop line durations per month from January to March 2023, which can be seen in Figure 5. Based on Figure 4, there is an increasing trend in the length of time the stop line occurs.

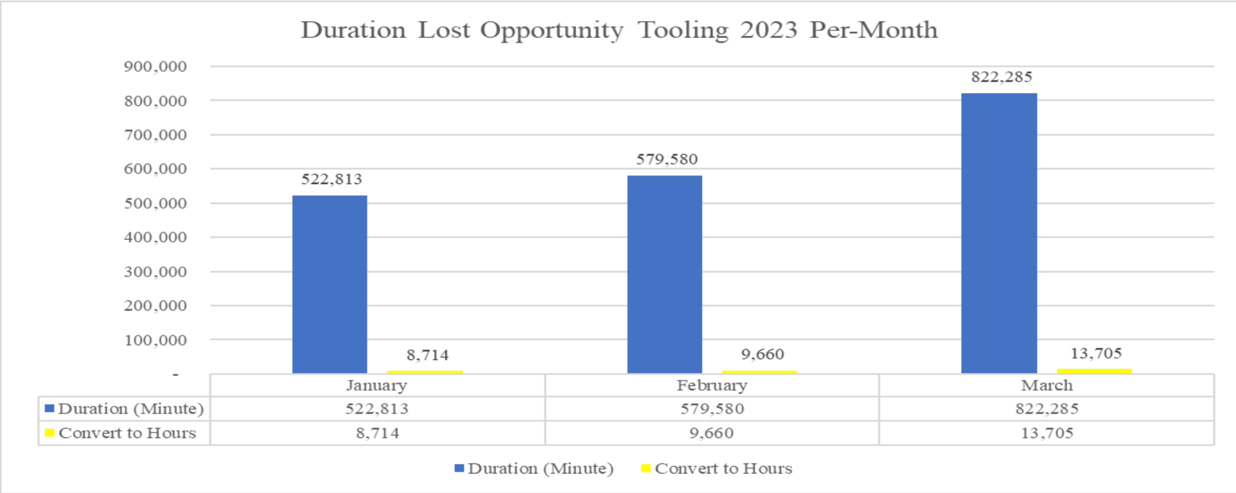

Figure 5. Duration lost opportunity tooling per month 2023

Logistics data is goods in stock during procurement, which are classified according to item groups and the types of goods provided in logistics. One of the item groups is inserts. Insert components are goods or equipment that play an important role in the production process, especially for components requiring large production processes.

Figure 6. Insert product

The function of the insert tool is as an initial process or step in machining to the final finishing stage with processes such as scraping and smoothing items. Inserts have many types and shapes according to specifications. The advantage of the insert tool is that it is more precise because when it becomes blunt, it can be replaced with a new one without changing other tooling. Moreover, this company can use various brands, especially ISO-standardized ones. Many manufacturers make inserts with many sizes and blade shapes. There is data on 132 types of insert items, which are stock items in logistics.

Data Processing

The data collected during the research will then be processed by determining the stock of goods, calculating tooling insert stock levels, and determining the minimum-maximum levels required for procuring stock of goods in logistics. The five whys analysis method identifies the root of the problem or cause of non-conformities in a process. Based on Table 1, the tooling factor is the second biggest cause of line stops. This research will discuss solving problems that cause line stops from tooling factors. The five whys analysis method (seen in Table 2) is a tool to identify the root of the problem or cause of non-conformities in a process. Based on Table 1, the tooling factor is the second biggest cause of line stops. This research will discuss solving problems that cause line stops from tooling factors.

Table 2. Whys analysis method

Stage	Description
Why 1	Lost opportunities in tooling are in second place as a cause of production line stops.

	Production can only carry out the machining process if the required tooling insert is present.
Why 2	Logistics cannot provide the appropriate insert tooling required by production.
Why 3	The stock of insert items often needs to be more in logistics tooling supplies.
Why 4	The company does not have safety stock for insert-type tooling in logistics stock.
Why 5	There is no minimum - maximum limit on the stock of tooling inserts in logistics stock.

From January to March 2023, there is data on tooling inserts for 102 out of 132 insert types. Based on data on insert usage from January to March 2023, it was found that insert components were out of stock or did not meet requirements, so they did not meet user demand in the production department, which resulted in production line stops. Next, create a Pareto diagram to determine the highest percentage of empty stock and determine the type of insert that must be applied to stock levels so that the implementation does not result in overstock of certain types of inserts, which can be seen in Figure 5.

Based on Figure 7, there are 17 types of inserts with the highest number of empty stocks of 15 to 10 pcs, which greatly influence the occurrence of stop lines. So, this type of insert needs to implement stock levels to maintain stock availability when needed and minimize lost opportunities.

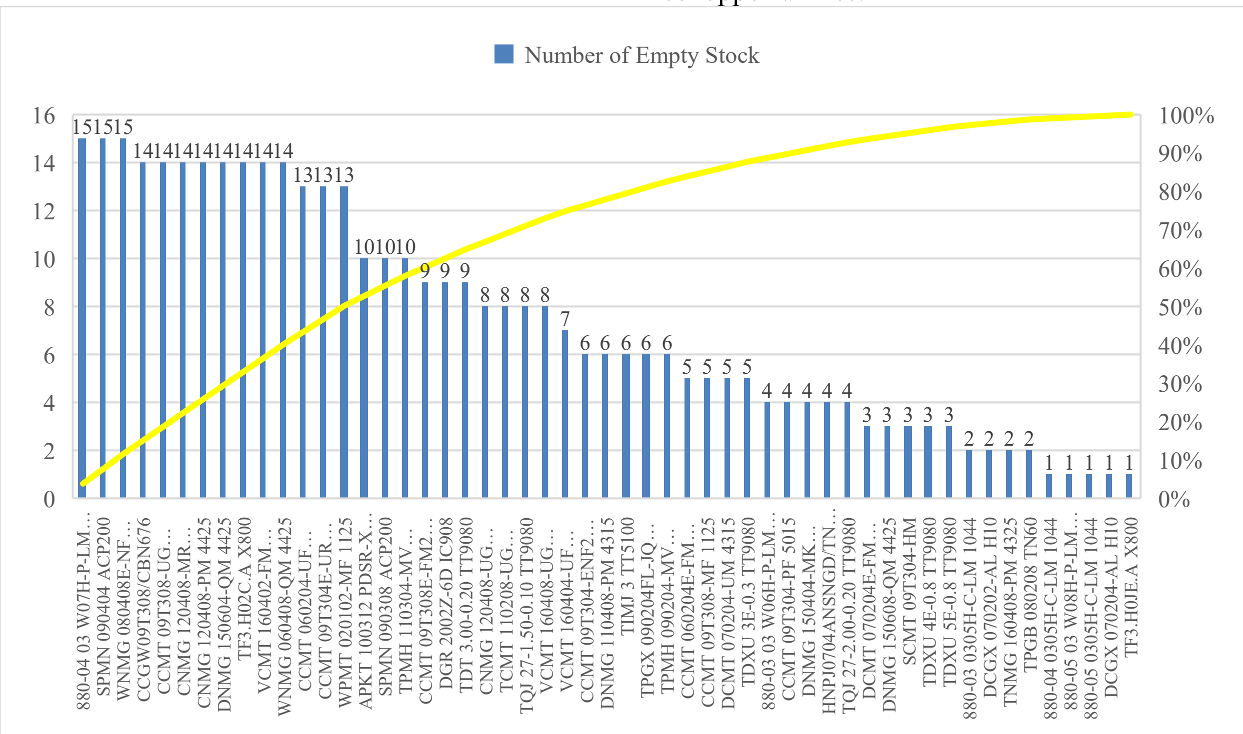

Figure 7. Pareto diagram for empty stock tool insert january-march 2023

A company's service level can influence determining the safety stock level of inventory to achieve a predetermined service level can be seen in Table 3.

Table 3. Service level and service factor data

Service Level	Safety Factor	Service Level	Safety Factor
50.00	0.00	97.72	2.00
75.00	0.67	98.00	2.05
80.00	0.84	98.61	2.20
84.13	1.00	99.00	2.33
85.00	1.04	99.18	2.40
89.44	1.25	99.38	2.50
90.00	1.28	99.60	2.65
91.00	1.34	99.70	2.75
93.32	1.50	99.80	2.88
94.52	1.60	99.86	3.00
95.00	1.65	99.90	3.09
96.00	1.75	99.93	3.20
97.00	1.88	99.99	4.00

Description and conditions:
1. z = Service Level = Safety Factor
2. 24 hours x Total days in one month = Service Level 100%
3. 24 hours x 31 days = 744 hours (100%)
4. Down-time tolerance from the company = 1% = 7 hours 44 minutes
5. 744 hours – 7 hours 44 minutes = 736 hours 27 minutes = 99% = 4.00

Calculate Company Level Service using formula (1):
Total company production hours = 22 hours
z = 22 hours x 31 days
z = 682 hours
z = 682 hours/744 hours X 100%
z = 92%
Downtime tolerance of 1% = 92% - 1% = 91%
So, z = Service Level = Safety Factor = 1.34

The stock level is determined by z (service level) and standard deviation (σ) of the usage period. Next is the stock level calculation for the 17 insert types, as shown in the following Table 4:

Table 4. Insert tooling usage data January – March 2023

Insert Type	Usage (Pcs)			Total usage
	January	February	March	
880-04 03 W07H-P-LM 4334	33	21	26	80
APKT 100312 PDSR-X PH6930	30	20	30	80
CCGW09T308/CBN676	52	47	53	152
CCMT 060204-UF YG3020	298	443	431	1.172
CCMT 09T304E-UR T8330	83	89	175	347
CCMT 09T308-UG YG3020	167	181	152	500
CNMG 120408-MR YG211	82	80	110	272
CNMG 120408-PM 4425	664	841	921	2.426
DNMG 150604-QM 4425	290	298	364	952
SPMN 090308 ACP200	20	10	10	40
SPMN 090404 ACP200	90	95	105	290
TF3.H02C.A X800	20	63	65	148
TPMH 110304-MV MC6025	256	260	224	740
VCMT 160402-FM PHH910	125	81	105	311
WNMG 060408-QM 4425	50	20	30	100
WNMG 080408E-NF T8315	167	95	129	391
WPMT 020102-MF 1125	24	19	14	57

Next, calculate the stock level for one of the insert components 880-04 03 W07H-P-LM 4334. Table 5 shows the calculation of the average requirement for the insert component. Table 5. Stock Insert Level Calculation Type 880-04 03 W07H-P-LM 4334.

Table 5. Determining the average demand for the insert component

Period	Month	Requirement	Average	(Average)²
1	January	33	6.34	40.20
2	February	21	-5.66	32.04
3	March	26	-0.66	0.44
Amount		**80**	**0.02**	**72.67**

a. Calculate average requirements for each period using formula (2)

- Average = $\frac{\text{Total Requirement}}{\text{Total Period}} = \frac{80}{3}$ = 26,66

b. Calculate standard deviation (σ) using formula (3)

-Standard deviation =

$$\sqrt{\frac{\sum(\text{requirement - average})^2}{\text{total period -1}}} = \sqrt{\frac{72.67}{3-1}} = 6.02$$

c. Calculate usage during lead time using formula (4)

Usage during lead time
= Lead Time x Average = 3 x 26.66 = 79.98

d. Calculate safety stock using formula (5)

Safety Stock
= Safety Factor x Standard deviation = 1.34 x 6.02 = 8.06 = 8

The stock level values for other insert types are also calculated so that the calculation results for 17 insert types are obtained, as shown in the following Table 6:

Table 6. Stock tooling level calculation results for 17 types of insert type

Insert Type	Average	Standard Deviation	Usage During Lead Time	Safety Stock
880-04 03 W07H-P-LM 4334	26.66	6.02	79.98	8
APKT 100312 PDSR-X PH6930	26.66	5.78	79.98	8
CCGW09T308/CBN676	50.67	3.21	152.01	4
CCMT 060204-UF YG3020	390.67	80.47	1.172.01	108
CCMT 09T304E-UR T8330	115.67	51.47	347.01	69
CCMT 09T308-UG YG3020	166.67	14.5	500.01	19
CNMG 120408-MR YG211	90.67	16.22	272.01	22
CNMG 120408-PM 4425	808.67	131.51	2.426.01	176
DNMG 150604-QM 4425	317.33	40.61	951.99	54
SPMN 090308 ACP200	13.33	5.77	39.99	8
SPMN 090404 ACP200	96.67	7.63	290.01	10
TF3.H02C.A X800	49.33	25.42	147.99	34
TPMH 110304-MV MC6025	246.67	19.73	740.01	26
VCMT 160402-FM PHH910	103.67	22.03	311.01	30
WNMG 060408-QM 4425	33.33	15.27	99.99	20
WNMG 080408E-NF T8315	130.33	36.01	390.99	48
WPMT 020102-MF 1125	19	5	57	7

By calculating the minimum-maximum stock, the stock level method functions as a threshold for an inventory of goods. It aims to maintain a minimum limit for restocking goods and a maximum limit for stock of goods so that there is no overstock in inventory. The usage value determines the minimum-maximum stock level during the lead time. The calculation of the minimum-maximum stock level for one type of Insert 880-04 03 W07H-P-LM 4334 is as follows:

- Calculate minimum level using formula (6) :

Minimum level = Usage during lead time + *Safety Stock* = 79.98 + 8 = 87.98 = 88

- Calculate maximum level using formula (7) :

Maximum level = 2 x Usage during lead time + *Safety Stock* = 2 x 79.98 + 8 = 167.96 = 168

The minimum-maximum stock level values for other insert types are also calculated so that the calculation results for 17 insert types are obtained, as shown in the following Table 7:

Table 7. Result of minimum-maximum tooling calculation for 17 types of insert types

Insert Type	Usage Total	*Safety Stock*	Minimum Level	Maximum Level
880-04 03 W07H-P-LM 4334	80	8	88	168
APKT 100312 PDSR-X PH6930	80	8	88	168
CCGW09T308/CBN676	152	4	156	308
CCMT 060204-UF YG3020	1,172	108	1,280	2,452
CCMT 09T304E-UR T8330	347	69	416	763
CCMT 09T308-UG YG3020	500	19	519	1.019
CNMG 120408-MR YG211	272	22	294	566
CNMG 120408-PM 4425	2,426	176	2.602	5,028
DNMG 150604-QM 4425	952	54	1,006	1,958
SPMN 090308 ACP200	40	8	48	88
SPMN 090404 ACP200	290	10	300	590
TF3.H02C.A X800	148	34	182	330
TPMH 110304-MV MC6025	740	26	766	1,506
VCMT 160402-FM PHH910	311	30	341	652
WNMG 060408-QM 4425	100	20	120	220
WNMG 080408E-NF T8315	391	48	439	830
WPMT 020102-MF 1125	57	7	64	121

5. CONCLUSION

The production process at DI, Ltd implements a batch production system, which is included in repetitive production activities with the number or volume to be produced being larger and repeated. The material flow process used in production is a straight-line material flow type, so the process is shorter in large-quantity production. The logistics sector is a part of procurement with a work process for managing goods the company needs to support activities such as machining processes in the production section. The problem that occurs at company is high levels of lost opportunities due to stop lines occurring in the production process, which is caused by several factors, such as the logistics sector experiencing shortages of goods in the form of tooling which results in the production process not being able to run. The application that can be made to the problem of empty stock in logistics is by implementing safety stock using the minimum-maximum stock level method, which can help maintain the availability of stock quantities of goods. Insert-type tooling is an important item in the production process, which often experiences stock shortages or does not meet demand requirements. Based on the Pareto diagram, 17 types of inserts must apply stock levels to avoid stock shortages.

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