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An Effort to Increase the Assembling Process Outputs of Superstar Model Shoes by Reducing Cycle Time Based on Quantification of Fuzzy Failure Mode and Effect Analysis (Fuzzy Fmea)

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Abstract: Based on observations at PT. Parkland World Indonesia, 17C assembling line is known to never reach the production target compared to other lines with the same process, this is the lowest of the 13 lines in Building 2. To analyze the assembling process, Fuzzy Failure Mode and Effect Analysis (Fuzzy FMEA) tools are used to obtain the highest risk priority number (RPN) and Fuzzy risk priority number (FRPN) as a reference for priority improvements. 8 assembling sub-processes are known to be in the not ideal category, so that the severity, occurrence, and detection must be assessed and processed into FRPN output using the matlab application. Corrective action is carried out by the Process Activity Mapping method to be able to classify each activity so that the type VA (value added), NVA (non value added), and NVAN (non value added but necessary) can be identified. Every NVA activity will be removed to reduce CT. After repairs, the total CT of the assembling process was successfully reduced. On the first day of repairs, the output produced increased by 57pairs/ day. In addition, the results of the recalculation show that the FRPN value of the repaired process has decreased, which indicates that the process has undergone improvement.

Keywords: Fuzzy Failure Mode and Effect Analysis, Lean Manufacturing, Process Activity Mapping

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1. Introduction

Since 2011, Indonesia has entered the Industry 4.0 Revolution [17]. In order to meet the industrial revolution 4.0, PT. Parkland World Indonesia (PT. PWI) seeks to increase the use of robots and automation in the shoe production process to increase the productivity. The use of machines and robots has been set automatically in order to meet the expected output target. But in fact, there are still some obstacles that cause nonoptimal productivity. There are four main processes in the production process of Superstar model shoes including the cutting process, preparation, sewing, and assembling process. In the assembling process, the line 17C's output is the lowest of the 13 lines in Building 2, this assembling line never reaches the target compared to other lines that work on the

same process. This is due to the actual cycle time exceeds takt time due to waste in the production process carried out by the operator. Waste that is carried out includes waste of movement and waste due to excessive processes. These kind of wastes cause the processing time becomes longer. Waste is an activity that absorbs, or wastes resources such as expense or additional time but does not add any value to the activity [38]. Problems in the production process such as waste must be immediately eliminated because it will cause the production process flow to be hampered. In the assembling process there were 21 sub-processes involving 38 operators. Therefore, an analysis tool is needed so that the improvement of cycle time for the assembling process can be done effectively and efficiently. The use of FMEA helps companies find the most dominant mistakes that will be given a solution / improvement. FMEA is a research method to determine how a product, process or system might fail and the possible effects of the failure mode [35]. Fuzzy FMEA is a development model of the conventional FMEA method, adding Fuzzy concepts to the FMEA algorithm allows linguistic data [28] and the numerical data used has a membership value for each attribute [20]. By using fuzzy FMEA and lean manufacturing, we do analysis and improvements in this assembling process. This study aims to increase production output through cycle time reduction by improving based on FMEA, in the assembling sub-process with the highest FRPN value or the highest ranking process.

2. Materials and Methods

FMEA's tool with fuzzy logic as a form of conventional FMEA development, is used to prioritize improvements in sub-processes that have a cycle time value that exceeds takt time, by rating the process with the highest RPN value in the production department of Building 2. To get the RPN value, we need to determine the severity, occurrence and detection. Observation data was collected on March 25, 2019 to April 5 2019. Data collected were primary data obtained directly from the object of research at PT. PWI through interviews, direct observation, output data, targets per day of the assembling process, machinery data, tools, and components used, and actual data cycle time using time studies.

Determination of severity is based on the amount of cycle time deviation from takt time. PT. PWI sets a 15% allowance, so that, cycle times with values less than equal to takt time are reduced by 15% takt time (CT≤85% TT). Occurrence is determined based on the chance of a process experiencing excessive cycle time. Opportunities for occurrence have values between 0 and 1. While, to determine detection, depends on how much the process requires control. Manual processes tend to require greater control than the process that is done with the machine.

Severity, occurence, and detection are determined in 8 assembling sub-processes which are considered to have inappropriate cycle time, by distributing questionnaires to 6 correspondents who get involved in the brainstorming process, including production manager, line manager, and 4 administrative staff in Building 2. The assessment results of the 6 correspondents are averaged and processed for ranking based on FRPN using the matlab application. The values for each severity, occurence, and detection are entered as input data and processed into FRPN output. The process with the highest FRPN value or with the highest ranking is analyzed using Process Activity Mapping (PAM), by classifying value added activities (VA), non value added activities (NVA), and non value added but necessary activities (NVAN).

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The NVA activities are then improved by turning them into more efficient activities, or even eliminating them if possible. Activities that include wastage of excess process must also be eliminated to shorten the steps, so that the processing time becomes more effective. The Improvements can be done by improving movements, steps, and other improvements related to efforts to eliminate waste of movement and excessive processes.

3. Results

Based on the study's results, the production target set was 1.200 pairs / day for each line. Below is the output data from the assembling process in Building 2, three days before the research is carried out based on the production report.

Table 1. *Output of Building 2 assembling process*

Line	Working Hours	Day 1	Working Hours	Day 2	Working Hours	Day 3
13A	10	1.240	10	1.235	10	1.245
13B	10	1.221	10	1.218	10	1.234
14A	10	1.210	10	1.220	10	1.230
14B	10	1.215	10	1.220	10	1.220
15A	10	1.220	10	1.233	10	1.225
15B	10	1.240	10	1.228	10	1.230
16A	8	968	10	1.210	10	1.208
16B	8	980	10	1.216	10	1.210
17A	10	1.210	10	1.215	10	1.208
17B	10	1.204	10	1.200	10	1.198
17C	8	877	10	1.108	10	1.100
18A	10	1.198	10	1.201	10	1.205
18B	10	1.180	10	1.190	10	1.185

Source: Production Department PT. PWI

Based on the above data, it can be concluded that the output of the 17C assembling line is the lowest compared to the others. There are several sub-processes in the assembling process having an excessive cycle time. The cycle time data of the assembling sub-process is presented in Table 2 as follow:

Table 2. Data cycle time assembling process line 17C

No	Process Name	Day 1 (sec)	CT/TT (%)	Day 2 (sec)	CT/TT (%)	Max (%)
1	Hotmelt heel counter	26,64	89%	27,08	90%	90%
2	Press back part molding 1	27,37	91%	28,82	96%	96%
3	Strobel stitching	20,55	68%	22,12	74%	74%
4	Laste insert on the upper	20,92	70%	22,08	74%	74%
5	Gauge marking laste	22,84	76%	22,32	74%	76%
6	Hand grinding	25,51	85%	26,17	87%	87%

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No	Process Name	Day 1 (sec)	CT/TT (%)	Day 2 (sec)	CT/TT (%)	Max (%)
7	Transfer 1	23,42	78%	22,17	74%	78%
8	Primary upper	36,08	120%	34,79	116%	120%
9	Cement upper	36,50	122%	32,76	109%	122%
10	Embed toe cap and outsole and universal press	24,89	83%	24,42	81%	83%
11	Wire brush shoes	26,78	89%	30,53	102%	102%
12	Open the rope and open laste	31,85	106%	32,54	108%	108%
13	Ariance stitching	23,67	79%	21,82	73%	79%
14	Checking bonding	16,77	56%	15,32	51%	56%
15	Attach the sockliner	21,14	70%	23,60	79%	79%
16	Attach the rope	24,59	82%	24,99	83%	83%
17	Clean shoes and repairing	28,34	94%	18,32	61%	94%
18	TQC finishing	16,23	54%	17,14	57%	57%
19	Folding inner box	21,54	72%	21,19	71%	72%
20	Attach the inner box label and the hangtag	17,35	58%	20,49	68%	68%
21	Final QC and packing	16,68	56%	18,35	61%	61%
	Total	509,6		507		

Source: Production Department Building 2, PT. PWI

Based on the review and brainstorming results, it was decided that based on the two day cycle time calculation, the process that is categorized as having a risk of failure is a process that has a cycle time value of more than 25.5 seconds, or if it is percentage in the cycle time/takt time ratio more than 85%. From Table 2, it can be concluded that there are 8 processes that fall into the criteria of the failure process, including:

Table 3. Process with high risk of failure

No	Process Name	Day 1	Day 2	Median	Maximum
1	Hotmelt heel counter	89%	90%	88%	90%
2	Press back part molding	91%	96%	95%	96%
3	Hand grinding	85%	87%	86%	87%
4	Primary upper	120%	116%	115%	120%
5	Cement upper	122%	109%	115%	122%
6	Wire brush shoes	89%	102%	96%	102%
7	Open the rope and open laste	106%	108%	107%	108%
8	Clean shoes and repairing	94%	61%	79%	94%

Source: Production Department Building 2, PT. PWI

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From the 8 processes above, assessment, ranking and categories are carried out using RPN based on the formula RPN = S (Severity) × O (Occurrence) × D (Detection) and FRPN (Fuzzy Risk Priority Number) using the matlab application with the following results:

Table 4. Comparison of values, categories, and ratings between RPN and FRPN

No	Process Name	Average			RPN	Rank	Cat.	FRPN	Rank	Cat.
		S	O	D						
1	Hotmelt heel counter	1	4,7	8	37,6	9	VL	45,7	9	VL
2	Press back part molding	3	4,5	8	108	7	L	214,8	6	L-M
3	Hand grinding	1	5,7	8	45,6	9	VL	45,7	9	VL
4	Primary upper	8,5	8,8	5	374	4	M-H	525,9	3	H
5	Cement upper	8,7	8,8	5	382,8	4	M-H	525,4	3	H
6	Wire brush shoes	3,7	4,2	5	77,7	8	VL-L	141,1	7	L
7	Open the rope and open laste	6,7	6,7	9	402	4	M-H	495,4	3	H
8	Clean shoes and repairing	1	4,2	9	37,5	9	VL	50,2	8	VL-L

Source: PT. PWI

Remarks: Cat. (Categories)

In the table above, it can be concluded that the top rank for the failure process is in the primary upper, cement upper, and open rope and open laste. The three processes are ranked 4 based on the calculation of RPN with the M-H category (moderate to high) while based on FRPN calculations are ranked 3 with the category H (High). Then, these three processes were mapped using PAM to analyze VA, NVA, and NVAN, therefore, types of activities that did not provide added value could be identified and then eliminated. The results of mapping before and after repairs are as follows:

Table 5. PAM of primary upper process

No	Component Task	Component Task Time (sec)	Type of Activity	Point Observed Before (sec)	Point Observed After (sec)
1	Take shoes	2,56	VA	1,40	0,78
				1,16	1,36
2	Primary upper smearing	61,41	VA	27,71	23,74
				33,70	24,18
3	Put down the shoes	1,87	VA	0,82	0,45
				1,05	0,51
4	Clean the brush	0,69	NVA	41,18	
				41,81	
5	Open the shoes, check the size	0,16	NVA	11,2	
				8,34	
6	Insert the rope	0,14	NVA	5,68	
				10,78	
		66,83	sec/pair		51,02
		65,84	VA		51,02
		0,99	NVA		0
		0	NVAN		0
Time for 1 Cycle (sec)		**33,42**	**CT**		**25,51**

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Source: PT. PWI

*Remarks, at the observed point of activity number 4,5,6 were observed in 1 hour, so it needs to be divided by 120 (target 120/hour) to get the task time.

Based on the results of the PAM mapping of the primary upper process, it can be seen that there are three activities categorized as the type of NVA activity, they are cleaning the brush, opening shoes to check the size and inserting the rope/ shoelace. After monitoring the operator by eliminating all NVA activities and improve the smearing movement, re-mapping using PAM is done with the cycle time results decreasing. The cycle time process before improvement was 33.42 seconds, while after improvement, has been reduced to 25.51 seconds. These three types of NVA consume a portion of 1.5% of the primary upper activity, so that it does not have a large effect.

Table 6. PAM of cement upper process

No	*Component Task*	*Component Task Time* (detik)	Type of Activity	*Point Observed* Before (sec)	*Point Observed* After (sec)
1	Take shoes	2,37	VA	1,12 1,25	1,15 1,35
2	Primary upper smearing	65,11	VA	29,33 35,78	23,76 28,43
3	Put down the shoes	2,27	VA	0,82 1,45	0,77 1,25
4	Clean the brush	0,17	NVA	64,52 70,62	
5	Open the shoes, check the size	1,13	NVA	11,57 9,00	
		71,05	sec/pair		56,71
		69,75	VA		56,71
		1,30	NVA		0
		0	NVAN		0
***Time for* 1 *Cycle* (sec)**		**35,525**	**CT**		**28,355**

Source: PT PWI

*Remarks, at the observed point of activity number 4,5 were observed in 1 hour, so it needs to be divided by 120 (target 120/hour) to get the task time.

NVA activity of cement upper process is 1.86%. The improvement process was done by eliminating all the NVA activity. The cycle time of cement upper process after improvement is 28,355 seconds. Much better than before improvement, 35.525 seconds.

Table 7. PAM of open the rope and open laste process

No	Component Task	Component Task Time (sec)	Type of Activity	Point Observed Before (sec)	Point Observed After (sec)
1	Take shoes	3,15	VA	3,15 0	2,67 0
2	Open the rope	14,23	VA	7,10 7,13	7,38 7,80

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No	Component Task	Component Task Time (sec)	Type of Activity	Point Observed Before (sec)	Point Observed After (sec)
3	Pull the rope	4,59	VA	2,52	2,17
				2,07	2,47
4	Put down the rope	2,88	VA	1,54	1,12
			VA	1,34	Put down the rope &tongue
5	Put down the tongue	2,41		1,03	
				1,38	1
6	Put down the shoes	1,00	VA	1,00	0,83
				0	0
7	Check the size	0,14	NVA	16,55	0
				0	0
8	Tidy up the lorry	1,28	NVA	154	0
				0	0
9	Returns an incorrect size	0,48	NVA	57	0
				0	0
		30,16	sec/pair		25,44
		28,26	VA		25,44
		1,90	NVA		0
		0	NVAN		0
Time for 1 Cycle (sec)		**30,16**	**CT**		**25,44**

Source: PT PWI

*Remarks, at the observed point of activity number 7,8,9 were observed in 1 hour, so it needs to be divided by 120 (target 120/hour) to get the task time.

Based on the observations results, 6.72% of activities in the process of opening the rope and opening laste were NVA activities. After the NVA activity removed and there is an improvement in movement, the cycle time is successfully reduced to 25.44 seconds which is initially 30.16 seconds.

After the improvement process, cycle time is checked again to make sure that the improvement results are succeed. Cycle time data after improvements on the primary upper process, cement upper, and open the rope and open laste are presented in the following table:

Table 8. *Cycle time* after improvements

No	Process Name	Day 1 (sec)	CT/TT (%)	Day 2 (sec)	CT/TT (%)	Max (%)
1	Hotmelt heel counter	24,52	82%	28,45	95%	95%
2	Press back part molding 1	27,63	92%	25,05	84%	92%
3	Strobel stitching	21,80	73%	22,24	74%	74%
4	Laste insert on the upper	21,12	70%	22,23	74%	74%
5	Gauge marking laste	22,07	74%	22,83	76%	76%
6	Hand grinding	25,83	86%	26,75	89%	89%
7	Transfer 1	22,13	74%	21,73	72%	74%

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No	Process Name	Day 1 (sec)	CT/TT (%)	Day 2 (sec)	CT/TT (%)	Max (%)
8	Primary upper	24,96	83%	25,81	86%	86%
9	Cement upper	26,54	88%	27,82	93%	93%
10	Embed toe cap and outsole and universal press	25,34	84%	26,07	87%	87%
11	Wire brush shoes	25,37	85%	31,53	105%	105%
12	Open the rope and open laste	26,45	88%	29,66	99%	99%
13	Ariance stitching	23,22	77%	21,78	73%	77%
14	Checking bonding	15,33	51%	15,78	53%	53%
15	Attach the sockliner	21,42	71%	20,30	68%	71%
16	Attach the rope	22,57	75%	23,82	79%	79%
17	Clean shoes and repairing	24,17	81%	24,61	82%	82%
18	TQC finishing	19,54	65%	15,83	53%	65%
19	Folding inner box	22,23	74%	20,68	69%	74%
20	Attach the inner box label and the hangtag	16,31	54%	31,78	106%	106%
21	Final QC and packing	18,89	63%	17,23	57%	63%
	Total	**477,4**		**502**		

Source: Production Department Building 2, PT. PWI

Based on Table 2 and Table 8, it can be seen the cycle time differences for the three processes that have been improved. The initial cycle time for the primary upper process was 36.06 seconds and 34.79 seconds, after improvements becomes 24.96 seconds and 25.81 seconds, for the cement upper cycle time process from 36.50 seconds and 32.76 seconds to 26.54 seconds and 27.82 seconds, while the process of opening the rope and opening the laste, initial cycle time was 31.85 seconds and 32.54 seconds becomes 26.45 seconds and 29.66 seconds. The total cycle time of the assembling process was also successfully reduced, the total cycle time before improvements was 509.6 seconds and 507 seconds was successfully reduced to 477.4 seconds. In addition, the output also increased on the first day after the improvement process. Output per day which was initially 1,100 pairs on the first and second day before improvements, managed to rise to 1,157 pairs on the first day after improvements.

After the cycle time data is re-collected, then the process is eliminated with a cycle time ≥ 85% TT as a process that is considered to have a risk of failure. There are 9 processes that fall into the category for the assessment of the new S, O, D. Then the assessment of RPN and FRPN was carried out by distributing questionnaires to the same correspondent. RPN and FRPN calculations are carried out again to ensure that the improved process has decreased RPN and FRPN. Later, the value of FRPN can be used as a reference for future action.

Table 9. Process with high risk of failure

No	Process Name	Day 1	Day 2	Median	Maximum
1	Hotmelt heel counter	82%	95%	86%	95%
2	Press back part molding	92%	84%	90%	92%
3	Hand grinding	86%	89%	91%	89%
4	Primary upper	83%	86%	86%	86%

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No	Process Name	Day 1	Day 2	Median	Maximum
5	Cement upper	88%	93%	90%	93%
6	Embed toe cap and outsole and universal press	84%	87%	84%	87%
7	Wire brush shoe	85%	105%	87%	105%
8	Open the rope and open the laste	88%	99%	98%	99%
9	Attach inner box label and attach hangtag	54%	106%	58%	106%

Source: Production Department Building 2, PT. PWI

Table 10. Values, categories, and ratings of RPN and FRPN for future action

No	Process Name	Average			RPN	Rank	Categories	FRPN	Rank	Categories
		S	O	D						
1	Hotmelt heel counter and upper and attach try counter to upper	1,2	4,7	8	45,12	9	VL	90,7	8	VL-L
2	Press back part molding	2	4,5	8	72	8	VL-L	130,4	7	L
3	Hand grinding	1,8	5,7	8	82,08	8	VL-L	126,9	7	L
4	Primary upper	1	8,8	5	44	9	VL	50	8	VL-L
5	Cement upper	2	8,8	5	88	8	VL-L	143,9	7	L
6	Embed toe cap and outsole and universal press	1	7	8	56	8	VL-L	52,3	8	VL-L
7	Wire brush shoe	4,7	4,2	5	98,7	8	VL-L	150,2	6	L-M
8	Open the rope and open laste	3	6,7	9	180,9	6	L-M	299,9	5	M
9	Attach inner box label and attach hangtag	4,8	5	9	216	6	L-M	279,1	5	M

Source: Production Department Building 2, PT. PWI

Comparison of RPN and FRPN values based on Tables 4 and 9 are, in Table 4 the primary upper process, cement upper, and open the rope and open laste shows that the ranking of the three processes is ranked 4 based on the calculation of the RPN with medium to high category, FRPN is ranked 3 in the high category. While after the results of the improvement, it can be seen that the ranking for each process has decreased based on FRPN calculations. The primary upper process drops to rank 8 with the category VL-L (very low to low, while the cement upper process is ranked 7 with the category L (low). For the process of opening the rope and opening laste, although it does not experience a deep downgrade, as in the primary upper and cement upper processes, it still shows a decrease in rating, which is ranked 5 in category M (moderate). A rating downgrade indicates that the improvement process was declared successful based on the Fuzzy FMEA method. The calculation of FRPN in Table 10 can be used as a reference for future improvement.

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4. Discussion

The results of the S, O, D assessment involving six correspondents through the questionnaire obtained three processes with the highest ranking, and it is important to immediately take corrective actions to these three processes, so that the cycle time can be reduced. Based on the results of the PAM mapping in the primary upper process, there are three NVA activities, they are: cleaning the brush, opening shoes to check the size and inserting the shoelace. Cleaning the brush is not the operator's job, there should be a laboratory person that replaces the brush which is full of dry glue with a new brush every hour. The operator also does not need to check the size of the shoe because it can be seen directly on laste. The process of inserting a shoelace is also not the primary upper operator's job, but, it was the responsibility of the operator in the laste insert process, several processes before the upper primary process. Then, during the primary upper smearing process, both operators have excess time, especially the second operator, which is 27.71 seconds and 33.70 seconds. The duration of the smearing process is caused by the ineffective operator movement, so that we do the improvement by pulling the brush and keeps the pressure in order to make sure the glue is smeared properly. With this improvement, cycle time was successfully decreased, which initially 33.42 seconds was successfully reduced to 25.51 seconds.

Furthermore, for the cement upper, this process is the same as the primary upper, except for the type of the glue used. Problems found in the cement upper process are also almost the same as the primary upper process, so the improvement process is not much different. The cycle time of cement upper process after improvement is 28,355 seconds. Much better than before improvement, 35.525 seconds.

The third process is opening the rope and opening laste, this process is only carried out by an operator, different with the primary upper and cement upper which done by two operators. In the primary upper and cement upper process, the material is flowed by a conveyor, so that the process control is easier. While, the tool used to open laste is kabogi with the pry tool, and opening the rope is a manual by hand. 6.72% of the activity in this process is NVA, including checking size, tidying the lorry, and returning the wrong size shoes. To ensure that the open rope and open laste's operator does not need to check the size and return shoes with different size/ wrong size, it is necessary for the wire brush operator, which is the process before the rope opening and open laste process to do the task. The open rope and open laste's operator also has the habit of tidying up the lorry that has piled up with laste, even though this task is one of the laste insert's operator responsibility. Meanwhile for the activity of putting a rope and putting a tongue, it should be done together, the right hand after pulling the rope is continued to put the rope together with the left hand that was previously used to hold the shoe, now used to put the tongue. After NVA activity is eliminated and there is an improvement in right and left hand movements in the process of opening the rope and opening laste, the cycle time is reduced to 25.44 seconds.

After some of improvements and supervision conducted, the total cycle time before improvements was 509.6 seconds and 507 seconds, now has been reduced to 477.4 seconds. Moreover the output on the first day after the improvement process increased, which initially 1,100 pairs on the first and second day before improvements managed to rise to 1,157 pairs on the first day after improvements. But on the second day after improvements, output dropped to 1,100 pairs. This is due

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to operators returning to do some NVA activities because they are not familiar with the processes after improvements, and lack of supervision. For this reason, it is necessary to do supervision and further analyze to the causes of the decreasing output.

This study focuses on increasing production output by reducing cycle times in the assembling process based on the results of fuzzy quantification of FMEA. We combine FMEA with lean manufacturing, FMEA as a tool to identify potential failures, the effects that arise on the operation of the product and identify actions to overcome these problems, while lean as a solution by applying wasteless concept manufacturing by eliminating activities that have no value add on.

The assembling process is the process of combining several shoe components into complete shoes. The 17C assembling line has 38 operators with various types of machines, tools, and components used. Operator line 17C itself is a combination of operators taken from various lines in various buildings at PT. PWI and formed less than half a year.

Determination of S, O, D, is based on cycle time deviations from takt time, but that does not mean the cycle time value must be the same as takt time, because in fact, the operator requires an allowance to carry out activities needed for the operator, such as drinking, toilet, prayer and other needs. Therefore ideally cycle time cannot be the same as takt time, but it must be less than takt time, if the company wants to reach the production target. PT. PWI sets a 15% allowance, so that the ideal cycle time is less than equal to takt time minus 15% takt time (CT≤85% TT). So that, with a production target 1,200pairs per day or 120pairs for each hour, the takt time or standard time to make one pair of shoes is 30 seconds. If we use 15% allowance, then:

$$CT = TT - 15\%TT$$
$$= 85\%TT$$
$$= 25.5 \text{ seconds/pair.}$$

The cycle time is calculated for two days, and it was decided that the process which is categorized as having a risk of failure is a process that has a cycle time value of more than 25.5 seconds, or if it is percentage in the cycle time/takt time ratio more than 85%. Because there are two data from cycle time observations, the data with a maximum cycle time value is used as a reference as data that having a risk of failure.

The criteria for each severity, occurrence, and detection are also determined. The severity criteria based on the percentage of the ratio of cycle time divided by takt time, to facilitate the correspondent in assessing severity. Severity criteria are based on the comparison of cycle time divided by takt time, to help the correspondent in measuring the severity. The occurence criteria are determined based on the occurrence of un-ideal cycle time, therefore the chosen correspondents are those who have worked for a long time in the production department, so that they are considered to know more about the occurrence of failure in the processes of observation's objects. While for detection criteria refers to the type of sub-process in the assembling process. The process that is done using machine tools will certainly be easier to control, so it is considered more reliable than the manual process.

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