IDENTIFICATION PERFORMANCE AND MACHINE FAILURE OF MANUFACTURING SYSTEM BASED ON OEE AND FMEA METHODS

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ABSTRACT

This paper concerns for identify machines performance and the most dominant failure mode which appears in the PT. APF that causes low levels of quality of the products produced by the machine SDS 700 and SDS 900 in the manufacturing process at the texturizing (TX-1) department of PT. APF. The analysis was done by calculating availability machine 90%, performance rate <95%, and the quality rate <80% of the Overall Equipment Effectiveness (OEE) value of <85%. While the identification of failure modes with FMEA method the highest RPN value is 30 for misthreading failure, which the contribution method and maintenance of machinery by 48% of the processing of the fishbone diagram.

Key words: availability, performance, OEE, FMEA.

1. INTRODUCTION

All of activities within an industry are subjected to gain maximum profit as much as possible, by minimizing the amount of input and maximizing the amount of output (Chand, Shirvan, 2000). Grover (2008) said that from a whole of manufacturing times, only 5% that is used for machining process. About 70% from machining time is used just for loading process, positioning, gagging, etc. Waste elimination within manufacturing process should keep on working for getting an optimal performance from a machine. Overall Equipment Effectiveness (OEE) is one of methods which are commonly used by company which oriented on Total Productive Maintenance (TPM) for machine and equipment performance measurement. This method is used to identify location of the problems on manufacturing tool and machining (Zemestani. et. al., 2011)

The data shows that a number of manufacturing PT. APF year 2011 in machine SDS 700 is only reach 83 % and machine SDS 900 is about 94,5 %. Lack of numbers in this achievement is caused by many things, especially waste activity which occurs in manufacturing activity. Due to the dominant that posed by the problems it then it is the quality, cost and delivery on texturizing (TX-1) department. This paper will identify the OEE performance and failure mode that happened in TX-1departement.

2. THEORETICAL BACKGROUND

2.1. Overall Equipment Effectivenees

Nakajima (1988) introduced quantitative matrix that usually called OEE for measure performance of equipment manufacturing. This concept then was studied and developed in a semiconductor industry on America which done by Giegling, et. al., (1997). OEE is formulated from the function of some interrelated components, such as availability efficiency, performance efficiency, and quality efficiency (Nakajima, 1988). The success value within OEE is appropriate with the international standard (about ≥ 85%), while for each parameter is 90% for availability, 95% efficiency, and 99% for quality rate (Bendaya, et. al., 2009).

According to Muchiri, et al. (2009) 85% industrial world used OEE as an extremely important for knowing the damage that happened within shop floor. The calculation for value availability, performance, quality and OEE can use the equation (1), (2), (3), (4) as shown in Costa and Lima (2002).

$$Availability = \frac{Operating\ Time}{Planed\ Production\ Time} x\ 100\% \quad (1)$$

$$Performance = \frac{Total\ Actual\ Produced}{Total\ Target\ Produced}\ x\ 100\% \quad (2)$$

$$Quality = \frac{Total\ Actual\ Produced - Defect}{Total\ Actual\ Produced} x\ 100\% \quad (3)$$

$$OEE = Availability \times Performance \times Quality \quad (4)$$

In OEE concept there are six big damages that cause reduction labor productivity of the company. The six big damages are Breakdown, Set up and adjustment, Small Stop, Reduced Speed, Startup rejects or reduced yield, production reject (Nakajima, 1988).

2.2 Failure Mode and Effect Analysis (FMEA)

FMEA is a technique that uses for identifying, prioritizing, and reducing problems from system, design, or process before the problems are happened (Kmenta, 2002). Rhee J. et. al. (2003) claims that FMEA is a tool that uses widely in automotive industry, aerospace, and electronic for identifying, prioritizing, and eliminating failure potential, problems, and error system in design before the product is launched. This method counts failure potential, problems with Risk Priority Number (RPN).

$$RPN = S \times O \times D \quad (5)$$

RPN is used by a lot of FMEA procedures for estimating the risk it uses three criteria; Severity (S), Occurrence (O) and Detection (D). The value of RPN itself can be counted by using equation 5.

3. RESEARCH METHOD

This research was conducted in line of manufacturing department TX1 on machine SDS 700 number 24 and 25 and SDS 900A number 4 and SDS 900B number 5 with the normally schedule operation is 24 hour/day It means that there will be no turnover machine operation. The 24 hour/day operation will make the production effective. Texturizing machine consists of 216 positions, where each position is processing a single bobbin of thread. The machine is divided into 2 sides which are side A and side B, where each side has 108 positions which are divided again into 9 blocks. One block consists of 12 positions. It is divided into 3 levels so one level consists of 4 positions.

The object of the research is a whole product (machine 4, 5, 24 and 25) which have begun their production from February 2012 until April 2012 especially DTY product type normal (SDC) by either Single Heater process or Double Heater whether it is using Intermingle (rotto) or non-rotto. Research is begun by gaining data idle position machine as shows in Table 1, the actual manufacturing data shows in Table 2. That data are being analyzed to get the value of OEE. The result is used to identify the failure modes that happened in those machines.

Table 1. A Number of Idle Machine Position

TGL	IDLE – FEBRUARI (posisi)				IDLE – MARET (posisi)				IDLE – APRIL (posisi)			
	M4	M5	M24	M25	M4	M5	M24	M25	M4	M5	M24	M25
1	0	3	3	5	0	1	1	1	3	1	3	3
2	2	1	3	6	0	1	3	2	3	1	3	3
3	1	3	3	4	1	2	3	2	2	1	4	0
4	1	2	3	3	0	4	4	3	2	0	0	7
5	6	2	3	3	0	4	4	3	2	0	0	7
6	6	2	3	3	0	4	4	3	2	2	1	4
7	1	2	3	3	2	7	4	5	2	2	1	4
8	1	2	3	3	2	4	4	5	2	0	0	9
9	1	0	3	3	0	5	4	5	2	0	0	9
10	1	0	6	6	1	5	4	5	0	0	3	7
11	1	0	6	6	1	5	4	5	0	2	1	7
12	1	1	4	5	1	5	4	5	0	0	6	10
13	1	1	4	5	2	0	5	4	0	0	6	0
14	3	1	4	3	1	0	216	4	1	0	4	0
15	1	1	4	1	1	0	2	5	0	2	5	3
16	1	0	4	0	1	1	1	4	0	2	5	3
17	0	3	4	1	1	0	5	0	2	0	0	0
18	0	3	5	1	1	2	5	3	0	1	0	0
19	0	2	6	3	1	2	5	3	0	1	3	5
20	0	2	6	3	1	0	10	2	0	3	0	2
21	0	1	3	1	2	2	3	4	1	5	0	3
22	0	1	4	1	2	2	6	4	0	1	2	5
23	1	1	4	1	2	2	6	4	0	1	2	5
24	1	1	4	1	3	2	0	5	2	3	4	6
25	2	2	0	4	1	0	6	6	0	1	1	10
26	0	4	0	5	1	0	6	6	1	3	1	7
27	0	4	0	5	2	1	4	3	3	1	4	8
28	0	2	1	7	2	2	6	1	1	1	2	8
29	2	3	0	2	2	0	0	3	2	2	3	3
30					3	1	3	3	2	2	3	3
31					3	1	3	3				

Data on Table 1 will be used for calculating value of availability machine, as one of the parameter value OEE.

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Table 2. Target and Actual Manufacturing

TGL	TARGET PRODUKSI (KG)				AKTUAL PRODUKSI (KG)			
	MC 4	MC 5	MC 24	MC 25	MC 4	MC 5	MC 24	MC 25
1	2496	3926	4009	3588	2385	2420	3158	3474
2	1237	3962	4009	2381	1239	3719	3426	2281
3	2485	3926	4009	3605	2472	3741	3441	3423
4	2485	3944	4009	3622	2509	3397	3432	3619
5	2427	3944	4009	2415	2408	3773	3504	2331
6	2427	3944	4009	3622	2476	2530	3370	3466
7	1242	3944	4009	3622	1191	3743	2257	2260
MG 1	14798	27589	28065	22857	14680	23323	22588	20853
8	2485	3944	4009	3622	2505	3673	3356	3385
9	1242	3981	4009	3622	1231	2401	3344	2799
10	2485	3981	2635	2381	1825	2938	2292	1842
11	1242	3981	3953	3571	1113	2478	2988	3352
12	2485	3962	3991	3588	2434	3532	2720	3282
13	2485	3962	3991	3588	2784	3330	3188	2198
14	1231	3962	3991	3622	1223	3716	3354	3376
MG 2	13654	27774	26578	23997	13115	22067	21242	20232
15	2485	3962	3991	3657	2471	3683	2209	2705
16	1242	3981	3991	3674	1249	2561	3376	3071
17	2496	3926	3991	2438	2431	3461	3418	1174
18	2496	1309	3972	3657	1600	1249	3290	3295
19	2496	2629	1318	3622	2066	2518	2243	3016
20	2496	3944	3953	2415	2531	3033	2376	2256
21	1248	3962	4009	3657	1198	4051	3510	3437
MG 3	14960	23713	25223	23118	13545	20554	20422	18954
22	2496	3962	3991	3657	2552	3907	3375	3325
23	1242	3962	3991	3657	790,7	3796	2206	2252
24	2485	3962	3991	3657	2455	2505	3365	3130
25	2473	3944	2711	3605	2363	3726	1266	2680
26	1248	3907	4066	3588	1186	3685	3416	3219
27	2496	3907	4066	3588	2282	3818	3457	3387
28	1248	3944	4047	3554	1256	3828	3404	2247
29	2473	2617	2711	3639	2247	2644	2360	3387
MG 4	18640	31515	29571	28946	15131	27909	22848	23625

Data on Table 2 shows the actual value manufacturing that use for calculating machine performance.

Table 3. Product Quality

MINGGU	MESIN 4					MESIN 5				
	GRADE (BOBBIN)					GRADE (BOBBIN)				
	A	X	B	C	JML	A	X	B	C	JML
01-Feb	1969	404	183	18	2574	3059	841	282	22	4204
02-Feb	1795	720	106	47	2668	2967	979	379	39	4364
03-Feb	1865	453	164	20	2502	2706	701	304	56	3767
04-Feb	2242	784	208	24	3258	3614	726	336	79	4755
01-Mar	2449	520	252	40	3261	2473	530	269	107	3379
02-Mar	2765	1184	497	118	4564	3211	722	277	37	4247
03-Mar	3089	1310	305	31	4735	3095	601	276	22	3994
04-Mar	3875	878	294	20	5067	4328	910	380	66	5684
01-Apr	3217	694	310	67	4288	2670	659	206	11	3546
02-Apr	2773	1112	444	118	4447	2867	731	275	37	3910
03-Apr	3309	697	336	50	4392	2823	823	396	52	4094
04-Apr	3483	912	314	62	4771	3316	1210	441	51	5018

MINGGU	MESIN 24					MESIN 25				
	GRADE (BOBBIN)					GRADE (BOBBIN)				
	A	X	B	C	JML	A	X	B	C	JML
01-Feb	2530	895	359	54	3838	2640	861	410	25	3936
02-Feb	2653	928	600	100	4281	2465	811	319	39	3634
03-Feb	2113	623	826	27	3589	2396	927	349	52	3724
04-Feb	3472	1025	694	128	5319	3195	1133	505	41	4874
01-Mar	2698	804	473	57	4032	2480	783	294	70	3627
02-Mar	2310	882	337	78	3607	2704	767	309	37	3817
03-Mar	2681	985	420	36	4122	2720	834	282	36	3872
04-Mar	3485	1128	511	64	5188	3838	971	404	46	5259
01-Apr	2771	859	302	53	3985	3069	741	301	34	4145
02-Apr	2821	788	294	33	3936	2905	628	257	38	3828
03-Apr	2490	871	388	50	3799	3195	862	282	47	4386
04-Apr	3327	1030	578	46	4981	3709	974	380	68	5131

While the data on Table 3 shows the actual value manufacturing that uses for calculating Quality rate.

4. RESULT AND DISCUSSION

4.1 Availability

Machine SDS 700 & 900 that became the object observation have 216 positions in each machine which operate as cell station manufacturing, so that each position produces one new product in every cycle. Idle is happened on each position and didn't happen in a whole machine. The problem which appears in equation (1) is all of position is still operate entirely. Idle position theoretically will influence the availability of value of the machine. Then a number of idle position and operate position needs to calculate. Calculation by entering factor of idle position obtained by multiply number of available position with total manufacturing times and multiply number of position that operate with total operation times. So that for this approach itself needs adaptation availability equation as follows:

$$A = \frac{(\sum P - \sum Po) \times (T - Dt)}{\sum P \times T} \times 100\% \qquad (6)$$

$\sum P =$ *number of a whole position*
$\sum Po =$ *number of idle position*
$T =$ *total production time*
$Dt =$ *downtime*

From data processing on Table 1 use equation 6. The result of availability machine is shown in graphic on Figure 1.

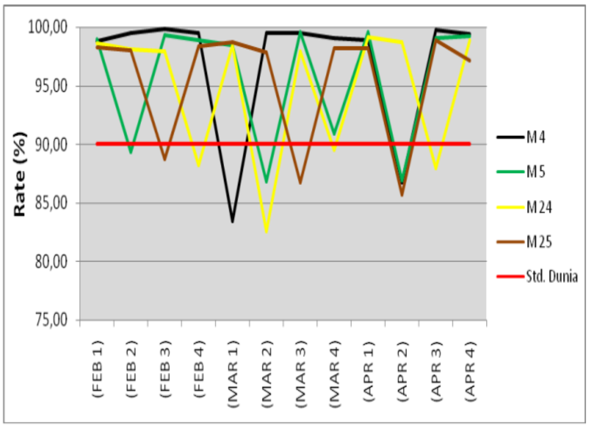

Figure 1. *Availability Rate Machine*

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If we compare the result with international standard of OEE for availability value (90%), some values are below standards.

4.2 Performance

Performance Rate was obtained from comparison between numbers of target manufacturing in one operation time and number of actual manufacturing by using equation 2. The result of calculating performance manufacturing is appropriate with data on Table 2 as it is shown in Figure 2.

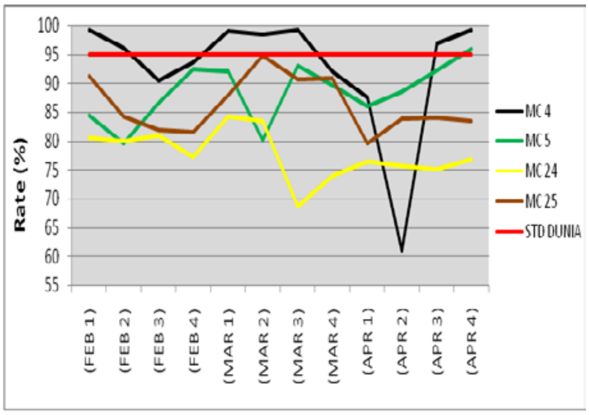

Figure 2. Performance Rate Machine

Figure 2 shows graphic performance rate of international standard (95%). From Figure 2 can be concluded that the lowest performance rate of machine 4 is on the second-week of April (61%) and the highest are on the first-week of February, third-week of March, and fourth-week of April which are 99,2%. The lowest Performance rate of machine 5 is on the second-week of February (79,5%) and the highest on the fourth-week of April (96%). The lowest machine 24 performance rate is on the third-week of March (68,7%), while the highest value on the first-week of March (84,2%). The lowest *Performance rate of* machine 25 is on the first-week of April (79,5%), while the highest value is on the second-week of March (94,8%). Those results are so far below the international standard of OEE (95%).

4.3 Quality Rate

Quality rate is calculation between good product numbers and actual total product. The data is quality product in units (bobbin). The standard reference is product Grade A, so that the calculation can use the equation 7.

$$Q = \frac{\sum Produk\ Grade\ A}{\sum Produksi} \times 100\% \qquad (7)$$

Result from calculation of quality rate shows on Figure 3.

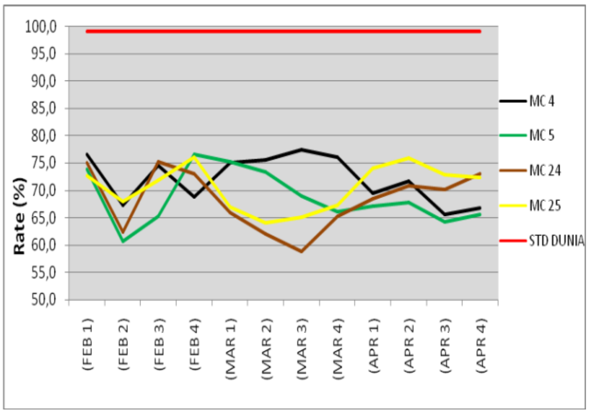

Figure 3. Quality Rate Machine

From figure 4.7 that shows quality rate machine it can be seen that the lowest quality (65,5%) and the highest is on the third-week of March (77,5%). The lowest Quality rate of machine 5 is on the second-week of February (60,6%) and the highest is on the fourth-week of February (76,5%). The lowest Quality rate of machine 24 is on the third-week of March (58,9%) and the highest is on the third-week of February (75,3%). The lowest Quality rate of machine 25 is on the second-week of March that is 64% and the highest is on the fourth-week of February that is 76%. If it's compare with the international standard of quality rate OEE that is 99% then a whole of quality rate machine 4, 5, 24 and 25 is below the international standard, because all of them are under 80%.

4.4 Overall Equipment Effectiveness Rate

The calculation value of OEE rate can use equation 4 to identify the effectiveness of a manufacturing machine or generally can be used for measuring manufacturing performance from PT. APF. Result calculation of OEE rate is shown on Table 4:

Table 4. OEE Rate

BLN	MGGU	OEE RATE (%)			
		M 4	M 5	M 24	M 25
FEBRUARI	MG 1	75	61,8	59,6	65,2
	MG 2	64,3	43,1	48,9	56,2
	MG 3	67,3	56,1	59,7	52,2
	MG 4	64,1	69,9	49,8	61
MARET	MG 1	60,5	68,3	54,6	58,1
	MG 2	74,1	51,1	42,8	59,3
	MG 3	76,5	64	39,6	51,2
	MG 4	69,4	54	43,2	60
APRIL	MG 1	60,2	57,5	51,8	57,8
	MG 2	37,9	52,2	52,8	54,5
	MG 3	63,4	58,8	46,4	60,5
	MG 4	65,9	62,5	55,4	58,6

Table 4 shows that the value of OEE rate of the whole machine is below the international standards 85%.

4.4 Failure Mode and Effect Analysis (FMEA)

After it's known that the height number of grade X because of the medium thread, so in this level, the FMEA method is used to identify the influence factor of the broken threads. The reason for that problem is because of the material reception, loading material, continuation process, and start/ threading and texturizing machine process.

The calculation number of occurrences is performed by using the approach numbers of break each ton that occurred. It's known that average number of break each ton is about 33 breaks each ton of every machine. It means that in 1.000 kg each machine uses 216 position, the average of break product is about 33 break product.

Table 5. Number of Failure Occurrence

Potensi kegagalan	Jml. Kejadian	Probabilitas Kejadian (jml kejadian/5000)
Gagal sambung	312	0,06
Misthreading (salah jalur)	24	0,005
Fly waste mesin	48	0,009
Putus merambat	48	0,009
Tail material tidak ada	24	0,005
Fly waste di POY	48	0,009
Tail material rusak/pecah	48	0,009
Ribbon material	72	0,014
Posisi material tidak benar	96	0,02
Run cover cacat	72	0,014

From these event we can identify RPN for knowing the most often failure mode that happened, as shows on Table 6.

Table 6. RPN FMEA Value

Item	Moda Kegagalan	S	O	D	RPN (S x O x D)
Penerimaan Material	Kondisi material tidak sesuai standar	1	2	4	8
		2	2	5	20
		1	2	1	2
		2	2	5	20
Loading	Bottom Layer	2	3	4	24
	Laju benang terhambat	2	2	2	8
Penyambungan	Gagal sambung	1	3	3	9
Start/ Threading	*Misthreading*	5	2	3	30
Proses mesin *Texturizing*	*Fly waste* mesin	2	2	2	8
	Putus merambat	2	2	3	12

From Table 6 we can conclude that the highest value of RPN is 30 that is misthreading, where the lane entry of the thread is misallocation or detached. The highest rank of severity (5) because misthreading can cause lapping that makes machine performance becomes heavy and it will stop. Some failure detection of misthreading is figure out in fishbone diagram that shows on Figure 4.

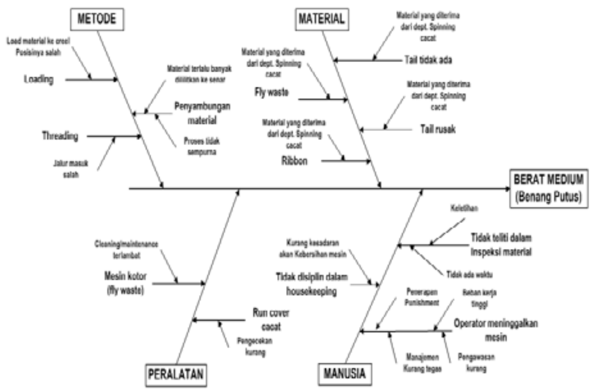

Figure 4. Fishbone Diagram Cause Medium Weight (Broken Thread)

Number of this percentage was obtained from number of occurrence in FMEA, which was distributing in fishbone diagram. Percentage factor in fishbone sequentially are method (48,5%), material (21,2%), equipment (21,2%) and human (9,1%). Occurrence with the highest value is misthreading with percentage 39,4% from percentage method 48,5%.

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5. CONCLUSION

Based on identification by OEE method, quality problem become the main of problem of performance productivity. Dept. TX 1. Generally, the value of OEE rate machine 4, 5, 24 and 25 are still in the range of 35% to 75 % which means it is far from international standard OEE (99%). Data shows that low value of quality rate on OEE is caused by the medium weight because the broken thread which happened in process. The results of the data processing show that misthreading FMEA RPN has the highest value (30), so it should be a priority of improvement.

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