IDENTIFICATION PERFORMANCE AND MACHINE FAILURE OF MANUFACTURING SYSTEM BASED ON OEE AND FMEA METHODS (Case Study on PT. APF)

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ABSTRACT

This paper concern for identification machines performance and the most dominant failure mode 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 subjected to gain maximum profit as much as possible, with minimize the amount of *input* and maximize the amount of *output* (Chand, Shirvan, 2000). Grover (2001) said that from a whole of manufacturing times, only 5% times that used for machining process. About 70% from machining time 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 are common used within company which oriented on *Total Productive Maintenance* (TPM) for machine and equipment performance measurement. This method used to identify location of the problems on manufacturing tool and machining (Zemestani. et. al., 2011)

The topical data a number of manufacturing PT. APF year 2011 shows that machine SDS 700 only reach 83 % and machine SDS 900 about 94,5 %. Lack of numbers this achievement is caused by many things, especially waste activity which occurs in manufacturing activity. Due to the dominant that posed by the problems itself is its influence in *quality, cost* and *delivery* on *texturizing* (TX-1) department. This Paper will identify 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 with the function from some interrelated components, that is *availability efficiency, performance efficiency, and quality efficiency* (Nakajima, 1988). The success value within OEE appropriate with the international standard is 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 availability value, performance, quality and OEE can used the equation (1), (2), (3),

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(4) such as being delivered by 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 is known six big damages that cause reduction labor productivity of the company. The six big damages are *Breakdown, Set up and adjusement, Small Stop, Reduced Speed, Startup rejects or reduced yield, Manufacturing reject (Nakajima, 1988).*

2.2 Failure Mode and Effect Analysis (FMEA)

FMEA is a technical that use for identifying, prioritizing, and reducing problems from system, design, or process before the problems are happened (Kmenta, 2002). While J. Rhee (2003) claims that FMEA is a tool that use 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 use three criteries; *Severity (S), Occurrence (O)* and *Detection (D).* The value of RPN itself can be count 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 there's no turnover this machine operation that will cause schedule a very high breakdown machine. *Texturizing* machine consist of 216 positions, where each position is processing a single bobbin of thread. A machine is divided into 2 *sides* they are *side* A and *side* B, where each *side* has 108 positions which divide again become 9 blocks. In one block consist of 12 positions which divide into 3 levels so that one level consists from 4 positions.

Products that became the object of the research are a whole product that was produced from machine 4, 5, 24 and 25 began from February 2012 until April 2012 especially DTY product type normal (SDC) by either *Single Heater* process or *Double Heater* whether using *Intermingle* (*rotto*) and *non-rotto*. Research began by gaining data *idle* position machine such as being shown in Table 1, actual manufacturing data in Table 2, *quality rate.* That data are being analyse to get the value of OEE, the result is used for identifying 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 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 data on Table 3 shows the actual value manufacturing that use for calculating Quality rate.

4. RESULT AND DISCUSSION

4.1 Availability

Machine SDS 700 & 900 that became the object observation have 216 positions in one machine which operate as *cell station manufacturing*, so that each position produce one new product in every time cycle. *Idle* that happened on machine is in each position and didn't happen in a whole machine. Problem that appears is total times operation in equation (1) was defined that whole positions that available operate entirely. *Idle position* theoretically will influence *availability value* 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 position available with total manufacturing times and multiply number of position that operate with total operation times. So that for approachment 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 by using equation 6 then be obtained the result availability machine such as being shown in graphic on Figure 1.

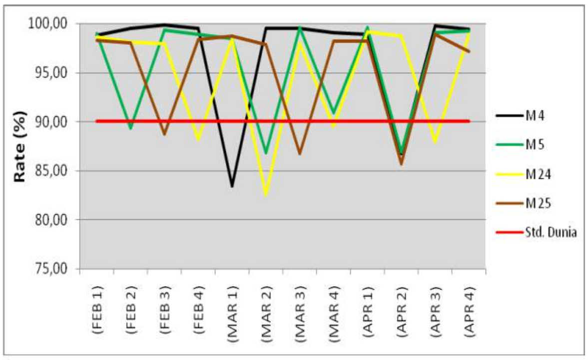

Figure 1. *Availability Rate Machine*

If we compare with international standard of OEE for *availability value*, that is 90%, then there's some value that place under the standard.

4.2 Performance

Performance Rate was obtained from comparation between numbers of target manufacturing in one operation time with number of actual manufacturing by using equation 2. Result of calculating performance manufacturing appropriate with data on Table 2 was obtained result such as being shown on Figure 2.

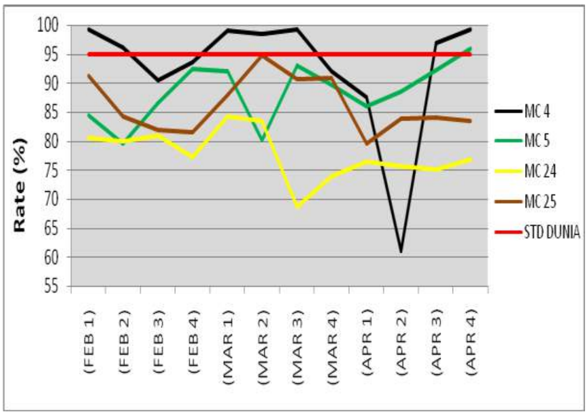

Figure 2. Performance Rate Machine

Figure 2 shows graphic *performance rate* than international standard (95%). From Figure 2 can be concluded that the lowest *performance rate* machine 4 is on the second-week of April (61%) and the highest on the first-week of February, third-week of March, and fourth-week of April that is 99,2%. The lowest *Performance rate* machine 5 is on the second-week of February (79,5) and the highest on the fourth-week of April (96%). The lowest *Performance rate* machine 24 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* 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 under the international standard of OEE that is 95%.

4.3 Quality Rate

Quality rate is calculate from comparation between number of *good product*, that is product which has quality *grade* A with produced total actual product. Data that use is data of quality product in units (*bobbin*). As the standard reference is product Grade A, so that the calculation can use the equation 7.

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

Result from calculation of quality rate shows on Figure 3.

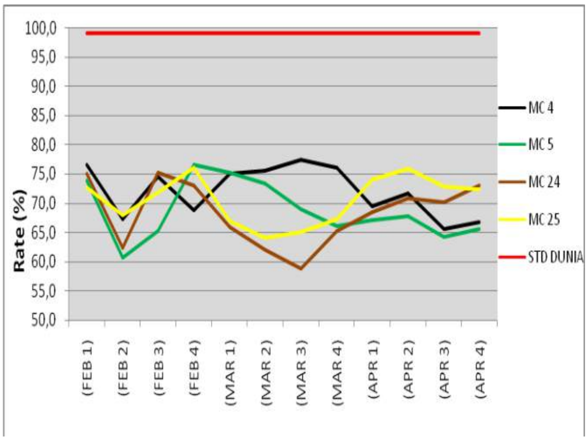

Figure 3. Quality Rate Machine

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* 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* machine 24 is on the the third-week of March (58,9%) and the highest is on the third-week of February (75,3%). The lowest *Quality rate* 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 intenational standard of *quality rate* OEE that is 99% then a whole of *quality* rate machine 4, 5, 24 and 25 is on under theinternational standard, even all of them are under range 80%.

4.4 Overall Equipment Effectiveness Rate

Calculation value of OEE rate can use equation 4, for identifying effectiveness from a manufacturing machine or commonly can be used for measuring manufacturing performance from PT. APF. Result calculation of OEE rate shows 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 value of OEE *rate* a whole machine if they are compare with international standard of OEE *rate* is on under the standard that is 85%.

4.4 Failure Mode and Effect Analysis (FMEA)

After it's known that height number of *grade* X is because the medium thread, in this step will it's used FMEA method for knowing factor that being effect of the broken threads that appear with medium weight thread. Problem that cause the broken thread appear in material reception, *loading* material, continuation process, *start/ threading* and *texturizing* machine process.

Calculation number of *occurrences* performed by using the approach number of *break* each ton that occurred. It's known that average number of *break* each ton is about 33 *break* each ton of every machine, it means that in 1.000 kg each machine use 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 Occurrence that can be identified RPN for knowing the most often failure mode happened, such as being shown 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 mislocation or detached. The highest rank of severity (5) because *misthreading* can cause *lapping* that make machine performance become weight until stop. Some failure detection of misthreading is figure out in fishbone diagram that shows on Figure 4.

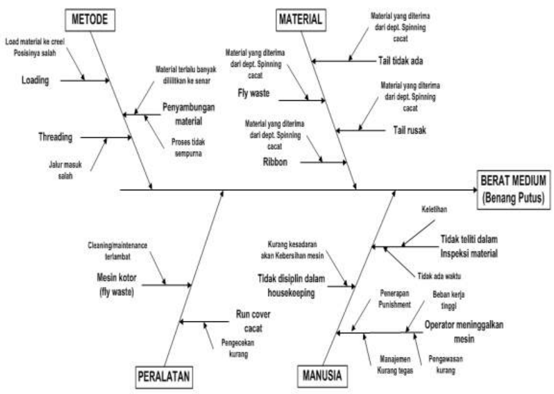

Figure 4. Fishbone Diagram Cause Medium Weight (Broken Thread)

Number of this percentage was obtained from number of occurrence in FMEA, that was distribute to the factor 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 presentation 39,4% from presentation method 48,5%.

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5. CONCLUSION

Based on identification by OEE method, quality problem become the main problem factor of performance productivity. Dept. TX 1. Generally, value of OEE *rate* machine 4, 5, 24 and 25 still in the range of 35% to 75 % which means still far from international standard OEE (99%). Data shows that low value of *quality rate* on OEE is caused by medium weight because the broken thread 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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