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Improvement of the Reliability of Automatic Manufacture Systems by Using FTA Technique

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ABSTRACT

In recent years, Many manufacturing industries for promoting their efficiency have tended to use the automatic manufacturing systems. Expanding automatic systems and to increase their complexity are representing the necessity of studying a proper functional quality and using reliable equipment in such systems more than ever. In this direction, the technique of fault tree analysis (FTA), along with using other techniques such as failure mode and effect analysis (FMEA) reveals the incorrect performance states (modes) in system in order to know these modes exactly may prevent their occurance and increase their function quality. In this study, the approaches may increase the reliability of performance in an industrial robot are studied by FTA technique as a case study to show improvement in performance of equipments on automatic systems to reduce their destruction (fault) during the work, and finally access to an automatic manufacturing systems with high reliability.

1. Introduction

In the competitional world of manufacturing products, various factories utilize automatic equipment: and systems to promote the competitiveness and immediate responding to the needs of customers, in recent years. In following the increase of using automatic systems, the problem of performance reliability in such equipment and regarding to it, some indexes such accessibility, rate of fault and etc are suggested.

Since the most automatic systems are designed for continuous missions and the destruction during the mission, can make high expenses for utilizers, so evaluating the assurance on equipment must be considered in different steps and also in the phase of planning, to prevent such unwanted destructions (faults) during the work[1].

In this field. Kovarium and et.al. have promoted the reliability and improvement of robot 3P and robot 6R by tools FMEA and QFD[2]. To obtain a desired reliability level, we study the potential fault and the reasons of destruction(fault) in a four free-degree robot as a sample of automatic manufacturing equipment, in this essay. Three tools of FBD, FMEA and FTA have been used on the base of designing algorithm. This algorithm is shown in fig[1].

For correct modeling of performance in this robot, the tool FBD has been used in primitive phase to show the system inputs, treated process and outputs of system clearly and briefly.

In the neat phase, the fault tree analysis (FTA) has been engaged, that we by FTA as a logical model of up

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to down, to detect the error routes from an undesirable position.
These detected routes are starting of a top event. The top event has been obtained by analysing treated processes and in the primitive step.
After detecting the error routes, the top event is as a potential fault and its reasons are recognized and then are investigated to analyse destructions (faults) in the tables FMEA. Finally, the preventive acts are suggested to control occurance of destructions. Thus, reducing the fault in the result of preventive acts, the reliability R(t) will be improved.

2. FBD Sketch to Four- Free Degree Robot

Determining the potential modes of destruction is required to know and analyse the system perfectly. Here, there is the system of cannibalization having four free- degree that has been designed in order to move spares in the weight of maximum 500 gr [3].
In this robot have been used strong steel arms and seven serves of dc motor with the moment about 30 kg and many other electronic hardware's [4]. The plan FBD for the robot is according to fig.2.
With a complete plan FBD, the potential fault modes are determined by studying treated processes. We find that disablement in the whole process, not moving the joints or clamps, not sending message from sensor or not sending the orders from CPU, can be undesirable modes in present processes that may influence the output of process. By knowing such modes, we start to study the reasons.

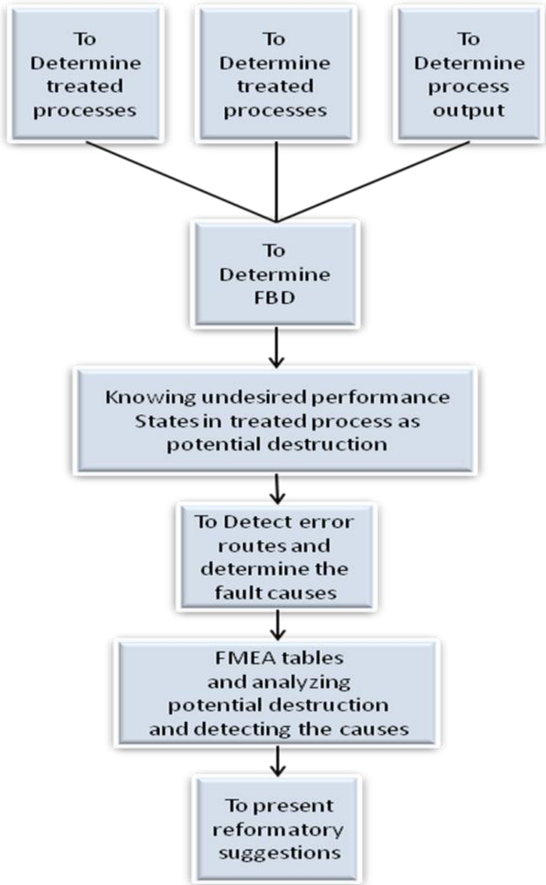

Fig. 1. A Diagram of fault analysis

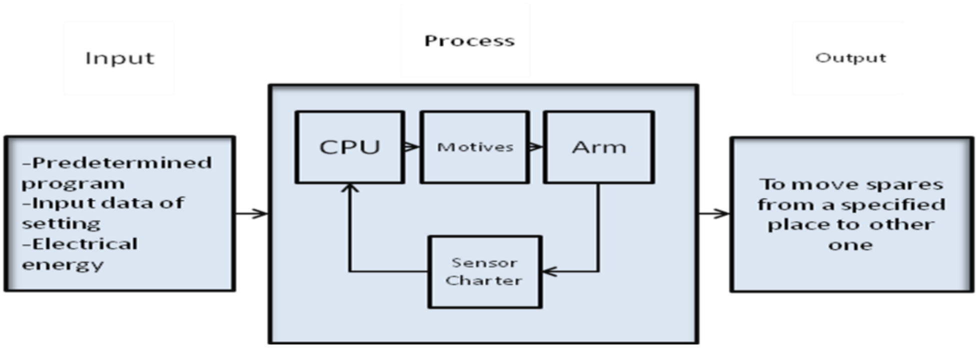

Fig. 2. Plan FBD for designated robot

3. FTA Plan

A rooty conflict with maker elements of undesirable modes in the phase of planning will cause to promote the performance level in system. After recognition errors by FTA as a logical model from up to down such as designing assistant, the system analysing may be considered, and possible destruction of system is evaluated. This analysis is followed by using three procedures:
1- To draw the fault tree.
2- To determine the possibility of fault
3- To know and estimating critical sets resulted in the occurrence of top event.

Forming the fault tree in a up to down process from the final error which is defined as the event of fault in the robot system, is started and expanded to the basis event. It means that the possibility of median faults in terms of the possibility of basis event and finally the possibility of final event in terms of the possibility of median and basis events are calculated [5].
Regard to this limitation, the FTA technique considers only one undesirable situation or event which must be predicted by analyzer. At first, outlining the FTA for the total fault in system is considered, and then possibility modes of faults in median events are investigated. Fig .3. shows the outlined FTA for the event of error in the whole robot system.

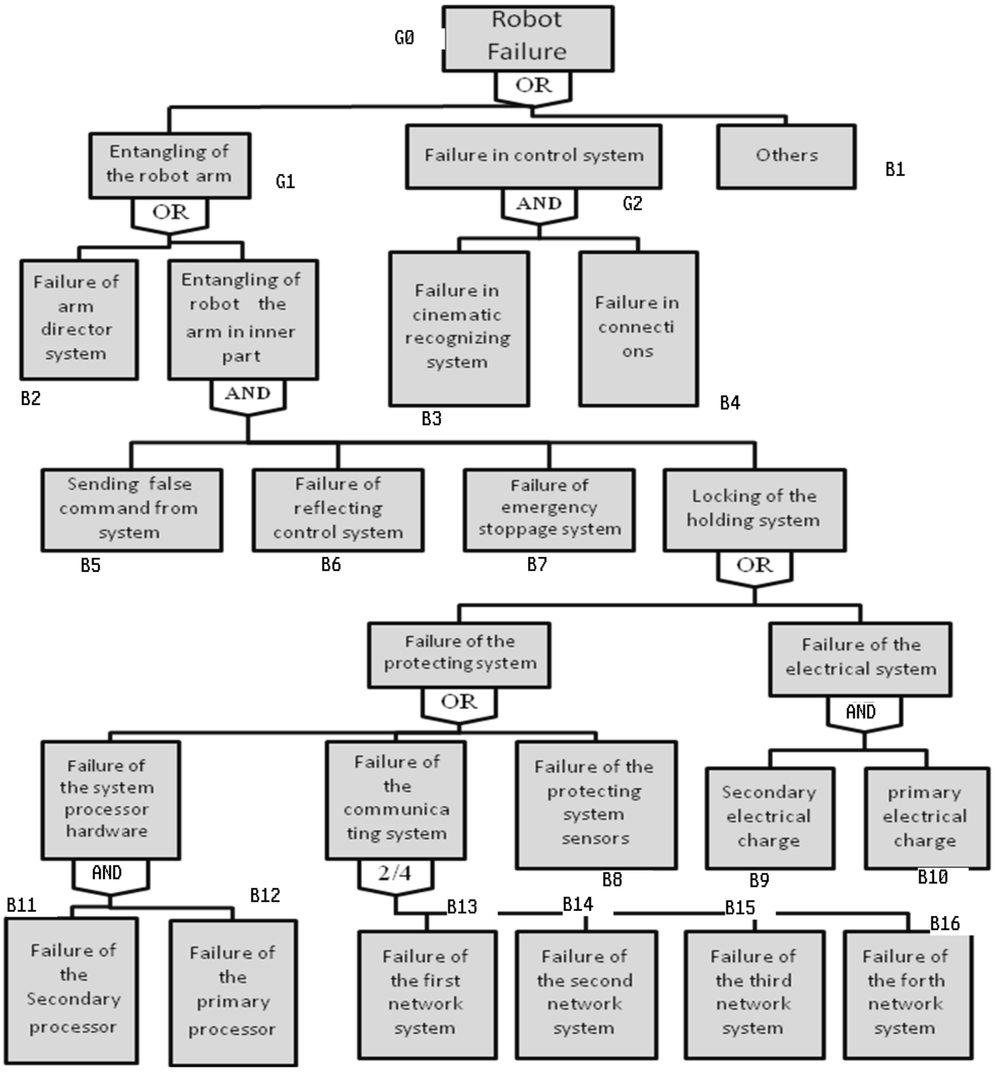

Fig. 3. Fault tree analyze of robot all error events

4. Drawing Reliability Block Diagram of System

In this stage, RBD is as figure 4 based on FTA drawn in preceding stage:

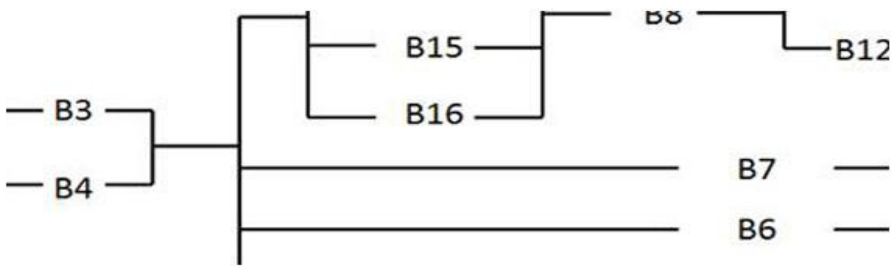

Fig. 4. RBD of system based on FTA

By surveying RBD, we compute total reliability of system. Moreover, it is purposed to increase reliability of B1 and B2 components with respect to it is as series in system. But for computing reliability of electronic components, Mil – HDBK – 217 standard is used, and Mech Rel software is used for estimating reliability of mechanical pieces. The results of these computation based of failure rate are in table 1.

Tab. 1. failure rate of components.

No.	Component	Failure Rate	Reliability(t=3000h)
1	B1	2E-06	0.994017964
2	B2	.000003	0.991040379
3	B3	.000007	0.979218965
4	B4	.000006	0.982161032
5	B5	.000007	0.979218965
6	B6	.000009	0.973361242
7	B7	.000009	0.973361242
8	B8	.000001	0.973361242
9	B9	.000008	0.997004496
10	B10	.000007	0.97628571
11	B11	.000006	0.979218965
12	B12	.000007	0.982161032
13	B13	.000008	0.979218965
14	B14	.000006	0.97628571
15	B15	.000005	0.982161032
16	B16	.000007	0.98511194

Based on failure rate computed for components and using this relation, total system reliability is computed. This reliability is equal 0.998754

5. The FMEA Plan to Present Proposed Measures

After finding potential fault modes, to prioritize and knowing the causes, are the next step. For this, the FMEA technique is used. This method is a systematic method of recognizing, and prioritizing the fault in a system or product. It acts according to the prevention law.

One of the success elements in this technique is the time of its performance and has been planned it, that would be a measure before event, not an exercise after being revealed the difficulties.

Regarding to the nature of this technique and its flexibility in all steps of planning and manufacturing the product, utilizing such technique at the first steps of planning is very useful.

In this technique, the most important obtained index is RPN that potential modes are prioritized according to this index. And the risk of default is estimated by this parameter. The risk and loss in default and the effects are depended to three factors:

1- Intensity; to evaluate the default consequence.

2- Occurrence; the possibility or counting the number of defaults.

In order to determine the intensity rate of the potential fault modes about the robot, the table 1, has been presented.

This table has been set on the base of top event in previous step.

Table 2. To determine intensity rate

Influence rate	Description
7-10	Disablement that for restarting needs long-term repairments
4-7	Disablement that restarting with immediate repairments and short- term
1-4	Disablement that requires reseting the system

The best method to measure the default rate is using processed data which show the process ability in a form of information table. In order to determine the default rate, regarding that this assessment is done in primitives planning steps, there is no access to the number of the future defaults, so the other process data are used, including the fault occurance rate.

The notion of fault or fault rate, is an obvious sense which determines the occurance rate.

Regarding to the essence of spares, one can devote a proper h(t) to them, and estimate the occurance rate. In the case of the robot for electronic segments, we can obtain the intensity rate by a proper estimation from the exponential distribution. h(t) of this distribution is expressed by equation 1.

$$h(t) = \delta \tag{1}$$

Therefore, the occurance rate is determined in relation to obtained δ. Also, we can consider the historical repairs in other segments,to estimate their distribution function. By simulating one of robot segments, we may obtain a fairly right estimation from their distribution function.

According to the historical repairs, this procedure shows following of the pattern of viable distribution function, that is defined by α and β parameters. Thus, the occurance rate is determined in relation to obtained α and β [6].

To specify the priority seals RPN, we may multiply the intensity rate and the yielded occurance rate together:

RPN=S*O

The organized FMEA on the base of potential faults and yielded RPN_s are shown in Table.2. Regarding the dynamism FMEA after offered reformatory measures in initial steps, we must review FMEA and search for improvement indications among different indexes, including the reliability index, R(t).

Tab. 3. FMEA for top event fault

Potential fault	Possibility causes of fault	0	Fault effects	S	RPN
Disablement of robot	1- Disablement in control system	7		9	
	2- Clamping robot arm	7	Clamping arm	9	
	3- Disablement monitoring arm system	5	Clamping arm	9	
	4- Disablement monitoring arm system				
	5- Disablement in distinction system of cinematic and disablement in joints	6	Failure in control system of clamping	8	
	6- Sending wrong command from system and disablement response control system and disablement urgent stop system and locking	7	arm Protection system fault	9	
	the protector system	7		9	
	7- Disablement the sensors in protection system		Processor hardware fault		
	8- Disablement of the first processor				
	9- Disablement of the second processor	7	Communication	6	
	10-Disablement of all the 4 control networks		system fault		
		7		9	
		7		9	
		7		7	

6. Conclusion

By using the planned algorithm on the base of FBD, FTA and FMEA tools, The below results can be achieved:

1) Recognizing the potential fault roots in the first levels of planning.
2) Determining the cause of potential faults
3) Priorizing of the faults for corrective actions
4) Performing of necessary actions in order to reduce or delete the potential Failure

Achieving the mentioned aims will cause to increase reliability of the systems and decrease the costs. With increasing of the reliability and eliminating or decreasing errors by using systematic detecting and preventing its occurance, a system with minimum stoppage can be achieved. The minimum stoppage or continuous operation is very important part in automatic systems. Therefor minimizing the stoppages lead to improving of the automatic production systems and also reducing the costs.

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