MIFT (Move It Forward Theory):

New approach to Manage Catastrophic Downtime in Manufacturing Production Systems and Optimization.

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Abstract

This paper presents research findings on a problem that may help decision makers manage a major breakdown in Manufacturing Production Environments. It will lower or eliminate production and profit losses. We propose a new approach to downtime management. This is study is based on MIFT's (Move It Forward Theory) Operations Management. The proposed method recommends keeping the line moving both upstream and downstream of the failure while repairs are underway. Current practice is to stop the production line completely until the failure is repaired; then operations resume when the repairs are completed.

The research findings area scaled down abstraction of an automotive assembly plant. The results show that using MIFT based operating procedures lead to recovery from a major machine failure with lower loss of production compared to the current practice. The results also show that improvements in performance under MIFT procedure is usable in daily production. MIFT's improvements depend significantly on the location of the failure in relation to the paypoint, bottleneck, and buffer capacities. This paper includes rationale for success of MIFT based operating procedures as well as future extensions.

Keywords

Bottleneck, downtime, industrial application, production management, cost benefit

1. Introduction and Literature Review

One of the researchers discovered the problem during his tenure with a large automotive manufacturer. Application of MIFT based operation is relevant for high volume low variety serial flow line such as automotive assembly line. The prevailing practice among all the OEMs of managing a catastrophic event such as machine failure requiring large repair time is to stop the entire assembly line while the failed machine is under repair. The resulting loss of production was acceptable to management and the practice is consistent with the prevailing best practice of lean manufacturing principles. At the time of MIFT conception, a catastrophic event was consider a machine failure of 30 minutes or more. Current industry practice considers 10 minutes or more of downtime to be catastrophic and production is held in place. Further research revealed that this practice of idling everyone not directly involved in the problem solving is practice used by all OEMs. In this research, we propose the "Move It Forward Theory (MIFT)" of production management during a rare catastrophic downtime. We propose keeping the assembly line moving in all areas where possible. More than just a management of production system in rare event situation – it offers the possibility of alternative management philosophy. The MIFT based operation also shows some promise in potential benefits in other areas of a mass production system, such as quality improvements, improved system recovery, better human resource management, and in some cases leads to complete elimination of production losses as if it didn't happen – saving revenue, profits, and resource utilization.

MIFT is a topic that is a paradigm shift. It departs from the current method large automotive companies manage rare event catastrophic downtime. Hence, in the literature review, my research did not yield a lot of research on the topic. The main author worked with the PhD topic research center in Kresge Library and the research specialist re-iterated the same. There was not much at all in this specific field. Hence, this specific topic of research appears to relatively untraveled and the potential for future research is a great possibility.

2. Research

1) **Researching MIFT Theory:**
MIFT is an operating procedure that is capable of restoring a system to the normal operating state with minimum loss following a major machine breakdown. We will look into the following scenarios:

   A. Minimize production losses via evaluation of a system throughput with and without use of MIFT is to use as the measure of performance.

   B. How does the performance of MIFT depend on the level of content of each buffer at the time of machine failure?

   C. How does the performance of MIFT depend on the location of the failed machine (upstream, closer to the pay point, or its location to the bottleneck)?

   D. How much of an impact on the general applications? Are there other areas in the plant or other manufacturing where MIFT may help?

2) **Investigate the Modeling of MIFT and Machine Downtime.**

A related topic of interest is to explore different ways of modeling machine failure in a Discrete Event Simulation (DES) model. The traditional modeling method uses "Mean Time Between Failures" and "Mean Time To Repair" as random variables. Each model is an appropriate statistical distribution that provides good fit to historical data. It is somewhat simplistic approach to model machine failure and ignores aging of the machine. Each repair is presumes the machine is restored to its original health. This research will address this issue and explore if there is a better way to model machine failure.

   (i) Conventional MTBF and MTTR approach

(ii) Include impact of aging on TBF and TTR

(iii) Use of conditional probability based on the number of cycles completed

(iv) Modeling categories of failure of a machine (high, medium and low repair time). The method (i) serves as the current champion. The results from each of the other methods compared to result from (i).

3. Modeling Experimental Conditions

The system simulates operations with and without use of MIFT. Adequate recovery time allows the system to stabilize following repair of a catastrophic failure. Statistically sufficient data was collected to generate validate results.

The simulation based study is presented to show that "Move It Forward Theory (MIFT)" based operating procedure offers recovery from a catastrophic machine failure with lower loss of production compared to a non-MIFT based operation The simulation study shows that the MIFT based operation performs better under general operating condition.

4. Research and Modeling Experimental Conditions

The theory behind MIFT is to reduce or eliminate losses in catastrophic downtime events and set the production system up to run better when production resumes. The system simulates operations with and without use of MIFT. Adequate recovery time allows the system to stabilize following repair of a catastrophic failure. Statistically sufficient data was collected to generate validate results.

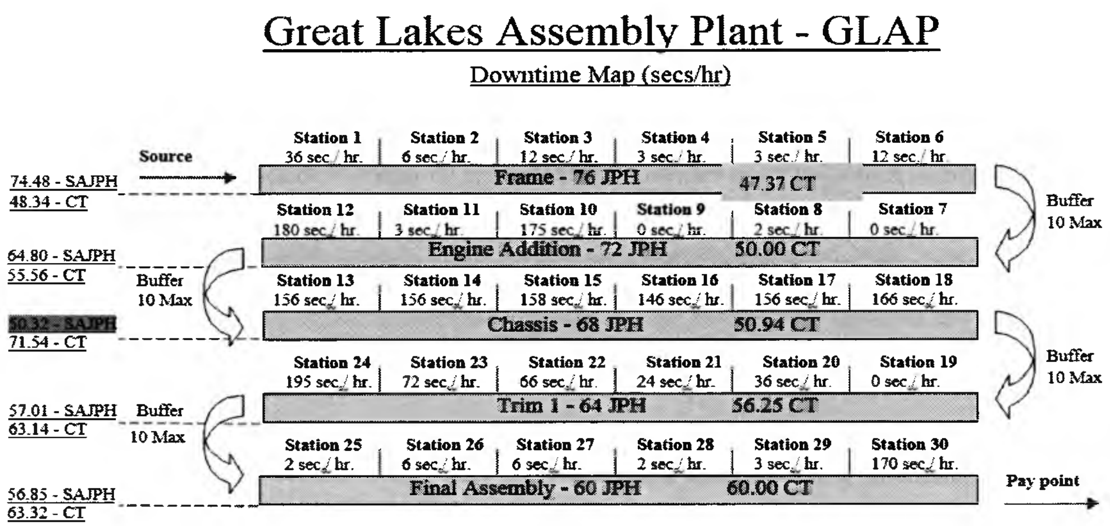

Figure 1: Great Lakes Assembly Plant

The simulation is presents that "Move It Forward Theory (MIFT)" based operating procedure offers recovery from a catastrophic machine failure with lower loss of production compared to a non-MIFT based operation the simulation study shows that the MIFT based operation performs better under general operating condition.

The model resembled a very simple generic assembly plant – See Figure 1. It contained 5 linked serial flow lines, each with 6 synchronized stations. Each station functioned at different Operational Availability (OA). Each feeder line has over-speed to subsequent downstream. Small buffers (accumulators) of 10 maximum units decouple the downtimes between line sections. All the WIP (Work in Process) continues until it leave the end of the assembly plant – the paypoint. Random downtimes appear in the simulation. They are based on the Mean Times Between/To Failure (MTBF/MTTF) and the Mean Times To Repair (MTTR). See Figure 2. Downtime modeling as a whole is on a realistic based model of negative exponential observed from the automotive industry. Figure 1; Simulation on Great Lakes Assembly Plant. The cycle times and Stand Alone Jobs per Hours (SAJPH). We use these values in calculating the bottleneck based on the theory of constraint(s) and the mean net output of the production system is calculated. However, we realize the production systems due not work on nominal values. For example, large downtimes can starve downstream operations and block upstream operations. Hence, mitigating the buffers in these conditions.

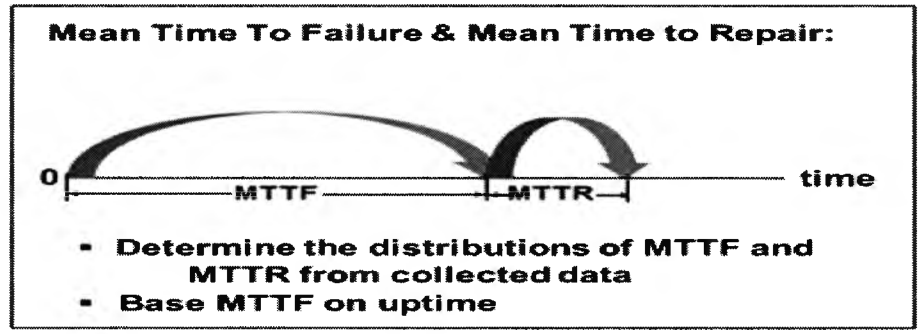

Figure 2; Graph of MTTR and MTTR.

5. MIFT Results & Conclusions

The results of MIFT is always better or the same as running the non-MIFT (conventional methods of management). Table 1 shows the 125 sample runs at each location.

Table 1; Benefits of MIFT vs non-MIFT management

Expected 4 hr Run 201 Vehicles

Expected 3 hr Run (1hr Break Down - nMIFT) 150 Vehicles

BreakDown Location	nMIFT	MIFT	Benefit	Percent Recovered	Simulation Average (125 runs)	Standard Deviation	Median
Source	150	172	22	44%	162	15	165
Line 1	150	172	22	44%	162	4.8	164
Line 2	150	161	11	22%	163	9.6	164
Line 3	150	150	0	0%	153	5.4	154
Line 4	150	160	10	20%	158	5.5	158
Line 5	150	170	20	40%	164	3.3	165

Figure 3 shows a large catastrophic downtime in the Final Line. By continuing to run the line, bottleneck still produces and the product is "spring loaded" into the system via the last two buffers - Ref 1. When production resumes THIS section of the production line actual runs faster than normal production because it is releasing the stored up products and runs at its full SAJPH potential and not at the Bottleneck/Theory of Constraint(TOC) pace of normal production(Ref 1). Hence, this resumed production start-up will run faster that steady state production until the "stored units" in the last two buffers have made it through the paypoint (Ref 1).

For upstream breakdowns; the simulation model and data show the capacity to continue running using the WIP in the system to keep the line producing is greater that the system re-fill to meet production. Said another way; the system may run 54 minute on WIP in the system and it my only take 24 minutes to resume production avoiding 30 minutes of production losses. This first production vehicle to emerge after the breakdown is known as the Genesis 1 vehicle (Ref 1). Further investigations shows the Genesis 1 is never blocked reducing its time to the Paypoint.

The benefits of MIFT depend on many inputs – including where in the system the breakdown occurs. Depending on where, how long, etc, the breakdown is – MIFT production management may eliminate any productions loses – as if it never happened. An outgrowth is MIFT is always the better production management philosophy – regardless of how small the breakdown is.

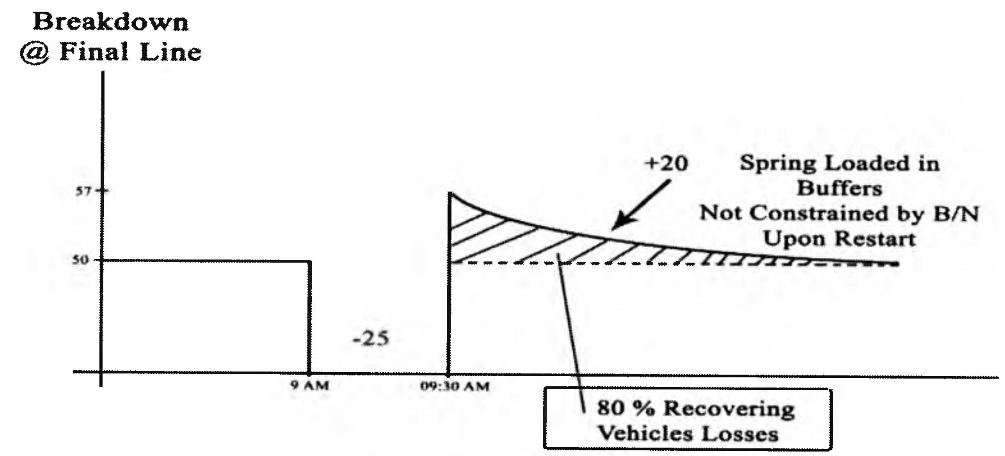

Figure 3; "Spring Loaded" product in final line.

MIFT is a paradigm shift and an innovative way to manage downtime in automotive assembly plants and other production facilities. Of interest, by using MIFT in a breakdown, the quality can actually improve. This is accomplished by the fact the Build Quality In Station (BQIS) is ensured. With the Catastrophic breakdown, the need to continue moving at the same production pace is eliminate. Hence, each vehicle is given ample assembly time in its station. The urgency to pass the vehicle along to a repair station due to the need to perform the task in the normal takt time is not there. Refer to Reference 1.

MIFT is a new approach to downtime management. Future research using this new approach will lead to more studies on production management, human resource utilization, buffers sizes, machine failure, predicting machine failure and other related topics. Not only in today's assembly plant but also in the potential design of future assembly plants to maximize the benefits of using the MIFT approach to catastrophic and daily production in downtime management.

Sample Calculations

Jobs Per Hour to Cycle Time; Chassis Line

Chassis Line; 68 Jobs per hour ➔ $\frac{3600\text{sec/hr}}{68\text{ jph}}$ = 52.94 second Cycle Time

Stand Alone Jobs Per Hour; Final Line

Operational Availability * Gross Line Speed = SAJPH

Operational Availability = [3600sec - Cumulative Downtime (STA 25-30)]/3600sec

SAJPH Final Line;

$\frac{[3600-(2+6+6+2+3+170)\text{sec}]}{3600\text{ sec}} * 60\text{ JPH} = 56.85\text{ SAJPH}$

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