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Time and Motion Study of Cutting Tool Production: Process Charts and Layouts (I)

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***Abstract*— A manufacturing company should use its resources (i.e., manpower, machinery, and so on) in *an efficient manner* to improve productivity and minimize cost. The purpose of the present study was to recommend improvement methodologies for production in a company that designed a cutting tool to be installed on the bottom of a boring machine. To produce the cutting tool, the company has used traditional technology that has resulted in a lengthy processing time and a delay in supplying the finished goods to the vendors. This article 1) described how the process was adopted by the organization.**

***Index Terms*— Time, motion, lean, layout, idle**

I. INTRODUCTION

The manufacturing company produced cutting tool bits. Cast iron E18 was recommended for the design of this tool bit. This cast iron E18 was to pass through various stages before being molded into a finished product (cutting piece). Lathe, milling, computer numerical controlled (CNC), and drilling machines were employed for manufacturing the finished product. The finished product would be installed on the bottom surface of the boring machine that would be used to dig mud.

Currently, the company faced a major problem in not producing the end product at an appropriate rate and, as a result, the company was not able to deliver it to the vendor on time. In this competitive market, to withstand the competitions from its counterparts, the company must deliver the product in a timely manner. To accomplish this goal, the company must adopt modern techniques and methods to enhance the production rate and to meet customer demand with little or no waste (Genaidy and Karwowski, 2003; Koufteros et al., 1998; Plonka, 1997; Shah and Ward, 2003).

The worker and machine process chart allows analysts to observe the exact time relationship between the working cycle of the operator and the operating cycle of the machine (Freivalds, 2009, Meller and Gau, 1996; Phillips, 1997).

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This chart illustrates occupied and idle time for both the operator and the machine within the cycle, resulting in a fuller utilization of the cycle time. Adopting these methods would lead to a significant reduction in idle time of worker or machine (Aft, 2000; Alsyouf, 2007). The present study described how the process was adopted by the organization and provided the worker-machine relationship chart and block layout prior to improvements performed by the company.

II. PROCEDURE AND PROCESS

As shown in Figure 1, upon completion of phase (9) in Figure 2, the finished goods were moved to the storage room. The remainder of this section details the phases in Figure 2. The complete work flow prior to improvements is shown in Figure 2.

In phase (1), the raw material was subjected to the cutting operation on milling machines. In this initial phase, a long bar of raw material was milled in order to cut the work piece to the required length. The operator took two minutes to unload the previously loaded work piece and to load another work piece. The machining operation to adjust the cutting tool took one minute.

Fig 1: The process layout prior to any improvements
* find the figure 1 in page no. 30

Fig 2: Process operations prior to improvements
* find the figure 2 in page no. 31

Then, the machine took three minutes to cut the work piece. The complete cycle time was six minutes. The operator was *idle while the machining process was carried out by the machine*. Figure 3 showed the worker-machine relationship for this operation. In all figures, W represents the worker and M/C represents the machine (phase 1).

In phase (2), the work piece was subjected to the turning operation on lathe machines. In this phase, the turning operation was carried out on the outer surface of the work piece. For a faster rate of production, the company used two lathe machines and two workers. The tasks performed by both operators were identical. The operators took four minutes to unload the previously loaded work piece and to load another work piece and, then, adjusted the cutting tool for the turning operation for one minute. The machine performed the initial turning operation for eight minutes. Next, the operators set dimension for the turning operation

for the lower diameter on the work piece. Then, another turning operation was carried out for eight minutes. The worker-machine relationship for this operation was shown in Figure 4. Each operator was *idle for sixteen minutes*.

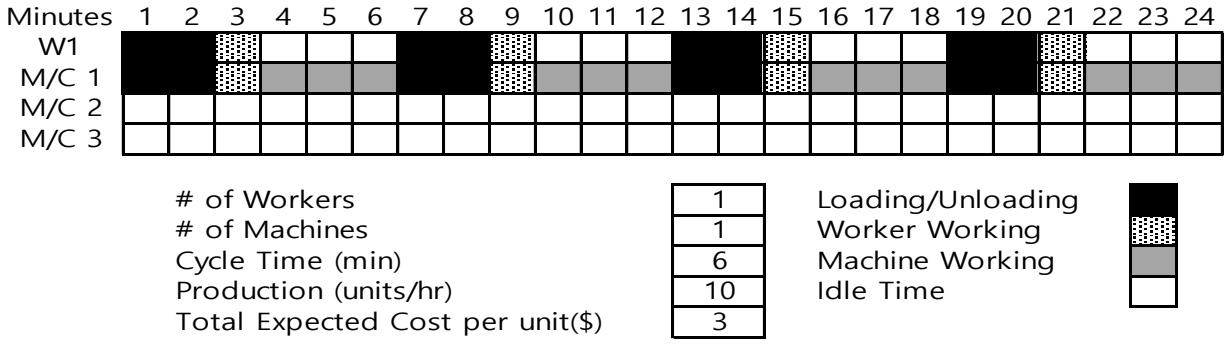

Fig 3: The worker-machine relationship in phase (1),(3),(5), or (7)

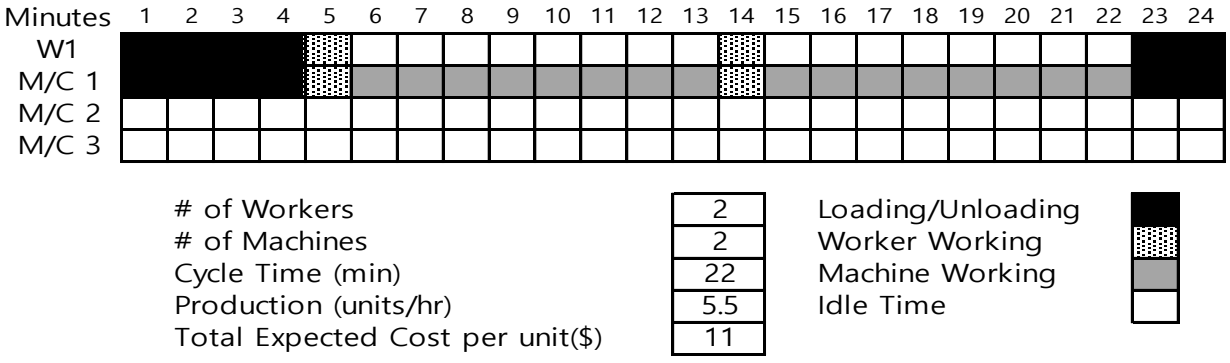

Fig 4: The worker-machine relationship in phase (2)

In phase (3), the work piece was subjected to the turning operation on a CNC machine. The operator used the CNC machine to perform accurate and high-quality finishing on the work piece. The operator took two minutes to unload the previously loaded work piece and to load another work piece. It took one minute to adjust the cutting tool before machine operated. Next, the machine took three minutes to cut the work piece. For this cycle of operation (Figure 3), the complete cycle time was six minutes and the operator was *idle for three minutes* during the machining process.

In phase (4), the work piece was subjected to a drilling operation on a drilling machine. First, the work piece collected from CNC machine was loaded to the drilling machine. The drilling machine drilled a long hole at the center of the work piece starting from the lower diameter of the work piece eccentric to the lower diameter of the work piece. The operator took four minutes to unload the previously loaded work piece and to load another work piece. The machining time to adjust the tool bit was about one minute, afterward, the drilling operation started. Since a long hole on the work piece was to be drilled, the mode of operation was slow. The machine performed drilling operation for four minutes. The complete cycle was nine minutes and the operator was *idle for four minutes* during one cycle. Figure 5 illustrates the worker-machine relationship for this cycle of operation.

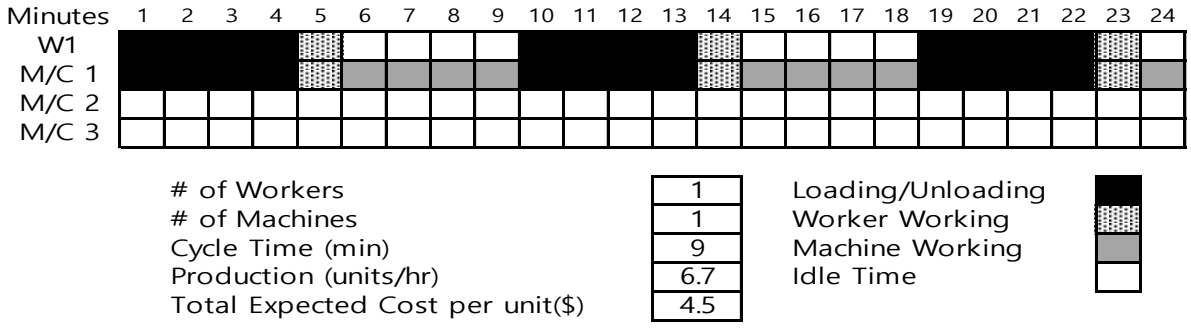

Fig 5: The worker-machine relationship for phase (4) or (8)

In phase (5), the work piece was subjected to the drilling operation on a CNC machine. The operator enlarged the hole made in the previous operation. The CNC machine was used for accuracy. The operator took two minutes to unload the previously loaded work piece and to load another work piece. It took one minute to adjust the cutting tool. Then, the machine operated for three minutes. The complete cycle time was six minutes and the operator was *idle for three minutes*. Figure 3 illustrates the worker-machine relationship for this cycle of operation.

In phase (6), the dimensions of the work piece were inspected and a work piece with accurate dimension was transferred to the next level of operation. The operator took one minute to inspect the work piece. The defective work pieces were checked for compatibility for other lower configurations or were scrapped.

In phase (7), the drilling machine was used to create three holes at an inclined angle intersecting the long hole drilled from the other end of the work piece. The operator took two minutes to unload the previously loaded work piece and to load another piece. For each operation, it took one minute to adjust the cutting tool. Next, the machine operation to make a hole in the piece lasted three minutes. For this operation, the complete cycle time was six minutes and the operator was *idle for three minutes*. Figure 3 illustrates the worker-machine relationship for this cycle of operation.

In phase (8), a drilling machine was used to drill eight cylindrical holes on the circular surface area of the work piece. The operator took four minutes to unload the previously loaded work piece and to load another piece in addition to the three holes created in phase (7). It took approximately one minute to adjust the tool bit before the drilling operation started. The machine was operated for four minutes. The complete cycle of operation was nine minutes and the operator was *idle for four minutes* during each cycle. The worker-machine relationship is shown in Figure 5.

In phase 9, the final work piece was inspected for accuracy at the inspection table. The same worker who completed phase 6 was instructed to perform the inspection for this phase. The operator took two minutes to inspect the work piece. The finished goods were shifted to storage room and the defective products were tested for compatibility for lower configurations or were scrapped.

In phase 10, the finished goods were shifted to storage room. The worker performing the inspection operations for phases 6 and 9 transported the finished goods to storage at the end of the day.

III. RESULTS AND CONCLUSIONS

Currently, the company employed eight workers for eight different machines and one person for inspection who produced 5.5 finished units per hour. The cost for producing one unit was about $32 with about 293 minutes of idle time for all the workers. It was, therefore, understood that the company was not utilizing its resources efficiently. In the current arrangement, each worker operated only one machine for each cycle resulting in idle time for each worker.

An essential component that needs an improvement, when implementing lean production concept, may be related to human performance (Genaidy and Karwowski, 2003, Womack et al., 2009). There were few to no variables that hindered some of the collected data. The worker performing the task worked at a very efficient pace; there was minimal error during his cycles. The worker worked at a rate were there was minimal idle time between tasks, there was a constant feed of un-milled caps, so whenever un-milled caps were placed in the machine two more filled the place of the previous caps. Instead of a critique for this particular workstation, the manufacturing company should applaud the performance of their worker, and the efficiency of their operations at this point in time (Meller and Gau, 1996; Phillips, 1997). If one, were to provide suggestions on how to improve these operations, I would suggest the company to take a more ergonomic approach when assigning these type of tasks (Landsbergis et al. 1999). Provide mats for the workers to work on to help relieve stress and strain from areas such as the knees and other parts of the legs. Also, if the company would like to alleviate some of the movement of the worker, they could move the machines next to each other. Place the conveyor belts in between each machine, so movement would be strictly from the torso and up. Scheduling breaks and maybe supply a water station nearby to cut down fatigue on the workers body.

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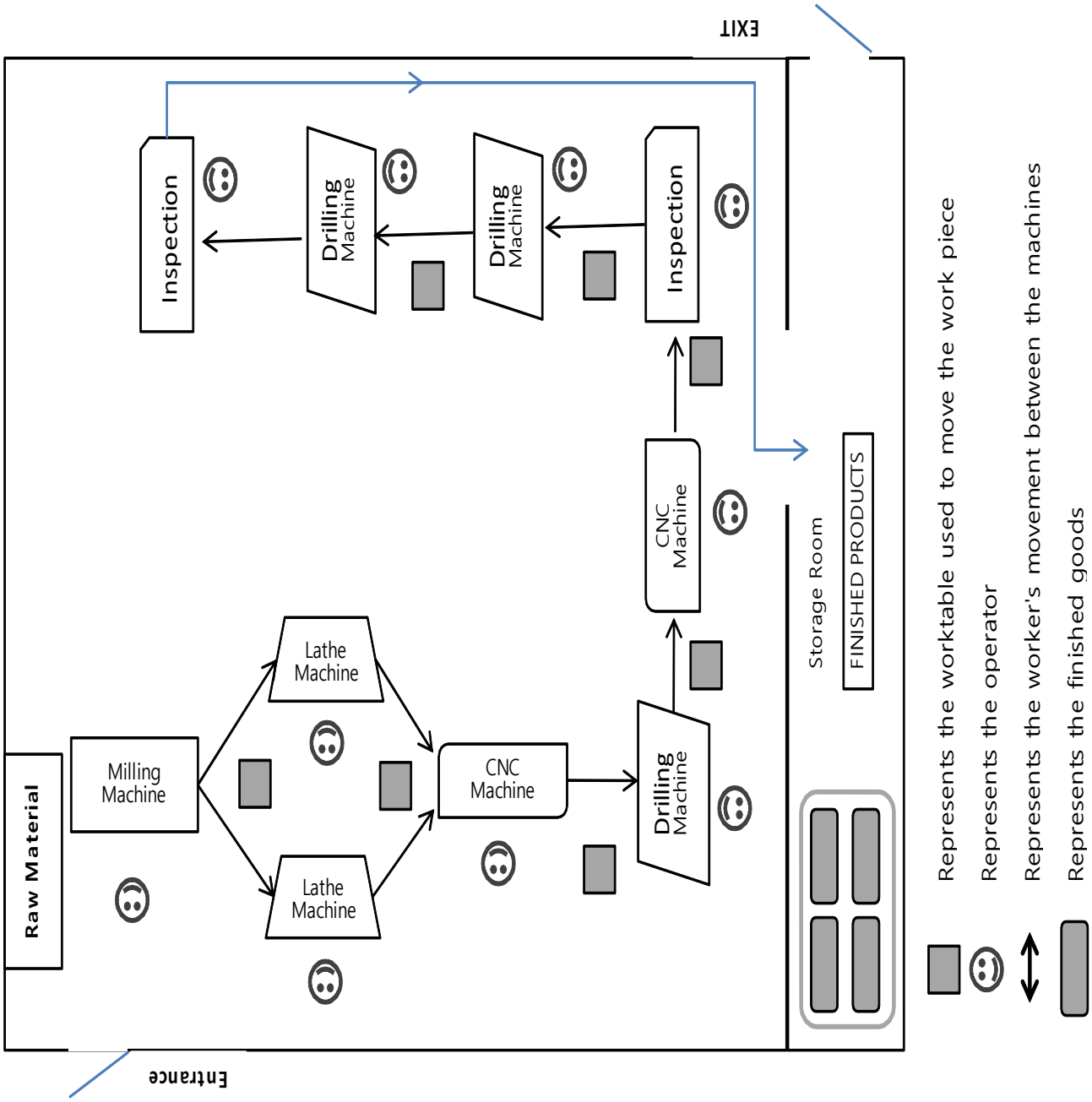

Fig 1: The process layout prior to any improvements

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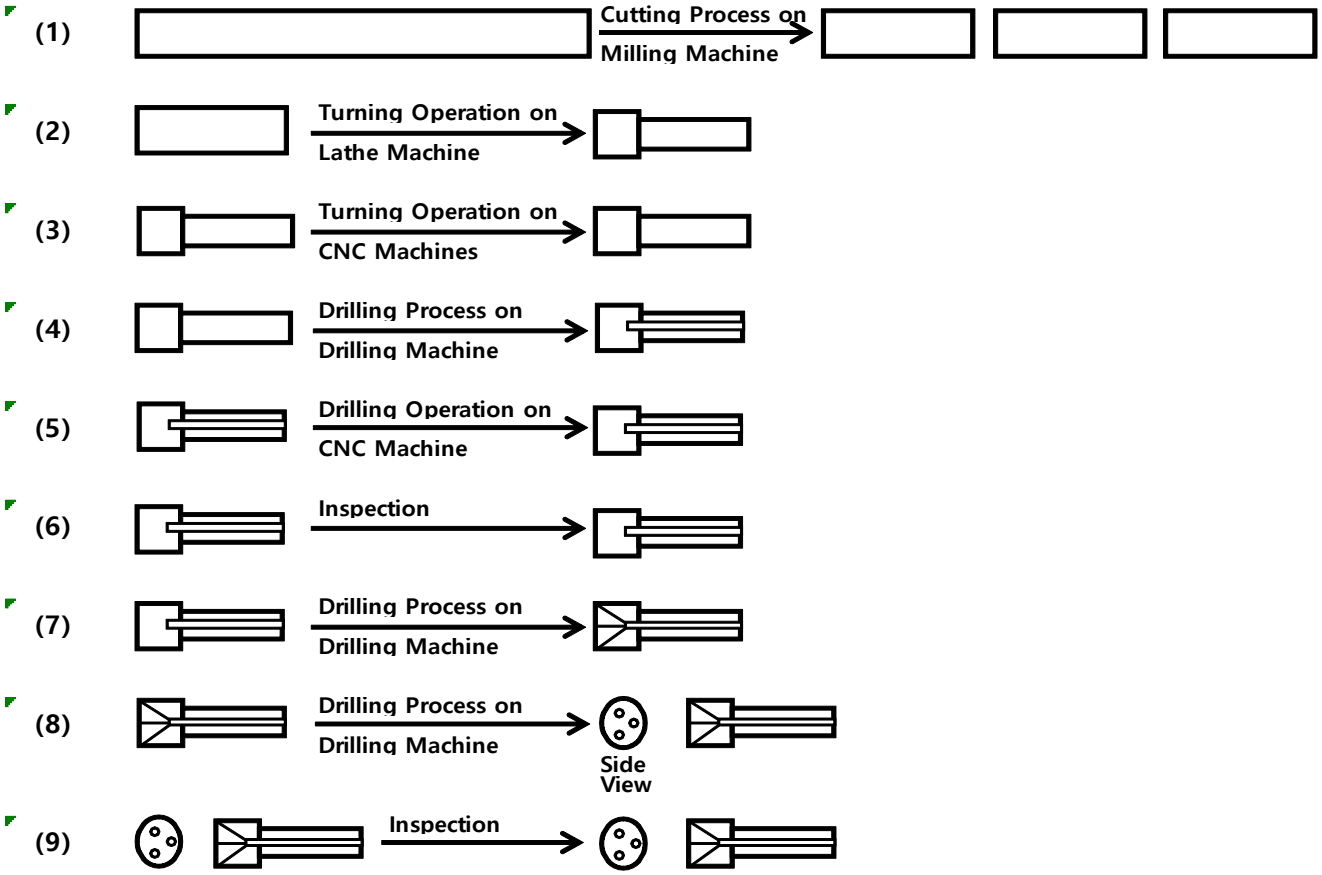

Fig 2: Process operations prior to improvements

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