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HUMAN ERRORS IN MAINTENANCE ACTIVITIES: AN OVERVIEW OF SOME CONTRIBUTING FACTORS AND PLANS TO MITIGATE THEIR EFFECTS

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ABSTRACT

This paper was intentionally designed to highlight the human as the aspects that lead to errors in maintenance practices. It is important to consider the human factor in maintenance activities in order to help minimize their errors and promote a safe working environment. In this regard, the maintenance strategy versus maintenance practices has been acknowledged by many researchers as an excellent key consideration for human factors programme. Consequently, this paper will explain the important considerations on the factors that influence human errors in maintenance programs and provide suggestions to reduce these occurrences.

Keywords: *Workers, maintenance, human errors, safety performance*

INTRODUCTION

Humans play a significant role in accomplishing various activities such as in the designing installing , producing and maintenance phases of a product in an organization (Johnson and Maddox, 2007). However, human errors and their forbidden actions may bring disruptions to routine business operations as there are risks of and the loss of property and products. In addition, Mason (2001) stated that Individual errors in maintenance may affect an organization’s safety performance in many ways. For instance, an operating worker’s poor knowledge on how to prevent minor problems may lead to the risk of equipment failure and personal accidents.

In the meantime the maintenance has various definitions given by various scholars but Reason, (2000) defined the maintenance as series of activities that are required to maintain, clean and fix the existing facility in organization “as-built” condition in order to have an continuous rolling or the equipment without disturbing the original productive capacity. It was also stated that maintenance strategy can contribute to major benefits to the industry’s business performance.

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This is because equipment stoppage are most often due to breakdowns or human error issues, which in return, will redouble the manufacturing operating cost (Arnold, Javorcik, Lipscomb & Mattoo, 2015). In this light , if the maintenance operators are highly motivated and well qualified, they can efficiently perform under the time pressure of the given job and it will promote more machinery maintenance knowledge which will also result in more efficient maintenance job which will reduce the working hours. Moreover, Loahavilai et al., (2015) stated that workers' knowledge on machinery maintenance workers is one the major aspects that need to be considered by manufacturing companies in reducing possible accidents at the working site. Furthermore, it is recommended that workers must be capable in learning how to speedily and accurately handle and conduct maintenance activity on old machines. For instance, a line operator should be able to perform maintenance tasks on the machines, without depending heavily on the maintenance department. To address this issue, this paper focuses on examining the extents of human errors occurrences, and identifies the factors behind the issue.

MAINTENANCE ACTIVITY

According to Dhillon, (2002) the maintenance activity has various categories however he categorised all of them into the three categories that become identical for the researcher; In first category the preventive maintenance was stated as a famous strategy that applied in that involves activities of planned, periodic, and specific schedule activities to maintain an item or equipment in order to remain the equipment in working condition. These preventive activities basically involve the process of checking and reconditioning process to the item or equipment. Second, is the corrective maintenance which involves the process of the unscheduled maintenance or majority is known as repair activities to the return items or equipment that has certain problem at defined state and basically these errors were identified by the engineers. This corrective maintenance basically is carried out when the maintenance person (Engineer, operator, Site supervisor, maintenance officers or workers) detect any kind of deficiencies or failures to the equipment and take action by applying the corrective maintenance. The third category was predictive maintenance which required high level skills to conduct this maintenance activity. Basically the predictive maintenance known as a modern measurement and signal-processing method is widely used to predict and diagnose accurately to the items or equipment condition during operations. Furthermore, McGrath (1999) mentioned that maintenance can enhance the work culture and professionalism of field personnel in regard to safety.

HUMAN ERROR

Meanwhile, according to Bohgard (2008) and Rasmussen (1983), human actions are influenced by one of these three level of actions, skill-based activities, rule-based actions and knowledge-based actions. The skill-based actions can be referred to the things that the persons do automatically and they don't have to think about it. The activity involved is basically refers to the example of; opening a door by a person. Meanwhile the rule-based actions are basically know as actions that involve an activity that only can be done by the person who knows well how to handle the situation that should be handled in a professional way; the example of the activity can be e.g. using a computer programmer to program the equipment. On other hand these action also can be considered as a knowledge-based actions that require several problem solving expertise that have huge experience to solve the unpleasant or unfamiliar situations.

Smuc (2015) stated that Skill-based level of human errors was basically referred as an errors that occur due to the slips and lapses. A slip incident could happen when humans (operator, technician, and supervisor) perform the action wrongly, for example, when employee is trying to install a screw on the wall but he accidently drops it on the floor leading to the major injuries. Meanwhile several scholars found that the lapse that occurs in the working areas when the employee fails to recall that led to the wrong action performed. In this regard, Kleinberg (2015); Jahangiri et al., (2015); Adya and Lusk (2016) found that basically the human can make mistakes due to certain consequences and these mistake were categorized as a Rule-based and Knowledge-based level mistakes. These can be observed when the human minds choose the wrong method, action and rules to solve the problem in their working area, either when they encounter a critical situation that really is out of their control and that reflects when they are performing a familiar task in their work site that also can be performed in various kind of methods (Zhiqiang et al., 2009). In addition, there were also some intentional human errors as identified by Bohgard (2008) , such as when the particular attitude when some workers skipped the safety procedures in order to save time and cost that lead to situation of the working area being exposed to the hazardous situation and if anything goes wrong will lead to the situation of ;breakdown incidents or injuries to the workers that happened due to dis-obeying the maintenance activities by skipping this activity in order to achieve their production goal on time. Inherently, this "Skipping attitude" is one the main reasons for damages and errors in the workplace, which have led to major disaster at working sites.

CLASSIFICATION OF HUMAN ERROR

According to Dhillon and Liu (2006), human errors cannot be avoided in any organization and these kind of human errors are basically classified into six categories, operating errors; assembly errors; design errors; inspection errors; installation errors and maintenance errors.

HUMAN ERRORS	EXPLANATION
Operating Errors	Operating errors refer to unintentional humans actions without malice or forethought (Reason, 1990). These errors can occur due to failure of the workers to understand and analyze in detail the given instruction and inherent unreliability of workers

	(Dekker 2006; Petersen, 1998).
Assembly Errors	Almgren and Schaurig (2011) classified assembly errors as wrong assembly or wrong positions of the component or when the assembly is performed wrongly.
Design Errors	Design errors basically occur due to the failure of the person in charge in the design department , or the slight mistakes that occur due to scheduling pressure (Han, Love and Peña-Mora, 2013). This action also contributed to the schedule delays and cost overruns in management.
Inspection Errors	Inspection tasks are basically classified into three basic categories, visual scanning, measurements and monitoring (Khan, 2011). Based on Khan (2011), inspection error is basically caused by illumination, task complexity, level of training and psychological factors.
Installation Errors	Installation errors here refers to a person who wrongly installed a component or part against the required criteria (Ismail et al., 2009; Peng et al., 2012).
Maintenance Errors	According to Dhillon, (2002) the maintenance related errors occur due to human factors due to incorrect repair or preventive action. Consequently , these maintenance errors were increased due to the major work load in the manufacturing site and increase in frequency of maintenance activity to the reduce the breakdow issues to the older equipment. Similarly, Loahavilai et al. (2015) stated that when the workers at the work site operate the machine without proper knowledge or the technicians handle the machine parts wrongly, the consequences that would be faced include machinery damage, downtime, poor quality product, customers' dissatisfactions , low customers' order, which finally leads to poor financial performance.

FACTOR THAT INFLUENCE HUMAN ERRORS IN MAINTENANCE

Human errors can also occur due to environmental aspects and physical loads. According to Bohgard et al., (2008) environmental aspect can constitute of workplace environment, including, factory settings such as surrounding of working area temperature and level of brightness of the lighting in the employee working are, air pollution, which is not considered as one of the problems. In the meantime, Lin et al., (2001) found that time pressure and postural stress by the manufacturers are among the crucial factors that cause human errors. The result of their study indicates that more errors could happene in manufacturing site where it was predicted to occur in the surrounding area if the employee has a task that required more time to complete. Moreover, the stress and time pressure also significantly influence the high possibility of human errors occurrences. On the other hand, Falck (2009) asserted that insufficient work task has led to harmful ergonomic situation which impacted the quality of output. In addition, Yeow and Sen (2006) stated that time consuming and cost intensive activity organized by organisation specifically contribute to possible accidents at the workplace, while Yao et al., (2016); Eldrige and Dale (1989) stated that another crucial time consuming factors that is the action taken by the management to reduce time spent at the production site, which involves direct costs. In this light , Ax, Johansson and Kullvén (2007) stated that cost incentive is a method to allocate appropriate actions to reduce the costs by identifying costly activities. In the meantime, humans are constantly affected by both physical and cognitive ergonomics factors (Bohgard et al., 2008); physical aspects refer to all physical influences such as the temperature of the room and working environment. Meanwhile, cognitive ergonomics factor also become the concerns that affect the employee from the mental aspects, such as information processing, social relationships with the colleagues, stress and the psychosocial context. Bohgard et al., (2008) and Pheasant and Haslegrave (2005) also stated that an employee's was facing difficulties in handling and assembling toward the different product or parts can be very tiring and arduous. As a result, the variation of the tasks done by the operator is among the aspects that play crucial roles in the occurrence of human errors.

Moreover, Dhillon (2014) found that the possibility to an error to occur is high when humans are exposed with many tasks. It was asserted that literature review shows numerous reasons for the occurrence of workplace accident due to the human errors that that need to emphasize hazard caution at the workplace. These hazards included; poor level of bright lighting in the working area, the arrangement of equipment was inadequate, employee has low level skill or knowledge to handle, operate or run the machine, lack of training given to the staff by management on equipment handling , older equipment, inaccurate production work flow, high level of noise that lead to worker loose focus, inadequate work layout, and inappropriate tools which were not replaced with new equipment by organization in order to cut cost and poorly crafted equipment maintenance and functioning procedures. Furthermore, the defects in product quality may be caused by human errors which are due to fatigue, lack of proper training, or others (Khan, 2011).

ACTION TO PREVENT HUMAN ERORS

In the meantime , human errors in accomplishing routine maintenance activity can be prevented upon by increasing situational understanding especially among novice personnel (Wachter and Yorio, 2013). This can be done by giving the new staff a moment to review or perhaps explore the working environment and compare the current situation with the data from the pre-job briefing. Using this instruction, preventive measures accomplished through predicting unexpected hazards, developing safety measures, identifying factors and conditions for errors and practicing safety preventative measures (Gasaway, 2013). Furthermore, identifying the frequent types of human errors at the working site can help eradicate possible hazards through establishing appropriate defenses activity.

On other hand, few authors had recommended that developing and employing a "*stop work criteria*" and knowing when to find the help form supervisor or experienced workers will encourage the safety approaches and procedures are important among the workers in the organization especially, when a person operates the machine without basic knowledge (Skjerve and Axelsson, 2014; Thomas, 2013). Moreover, this kind of method can promote strong awareness among staff with limited knowledge working with specific work situations and uncertainties. In this light, workers can typically seek support from supervisors, maintenance workers and co-workers in handling the job and in developing more knowledge in the operations.

In the meantime , many high-performing organizations promote a work culture where the practice of *"questioning*" is accepted and encouraged (e Costa et al., 2012). This inquisitive attitude will endorse a choice of facts over viewpoints and assumptions. It also encourages the adoption of safety precaution ahead of actions to be taken. This helps the person to maintain a greatly accurate understanding on any work conditions at any time given. In this light, the look-listen mentality is usually used to predicate the requirement of a given task . As a result, this process provides a worker-centric action where field workers gain knowledge by questioning the tasks and workplace conditions (Caron and Kellerhals, 2013). Employees can question the occurrence of error precursors and error traps, and the non-confirmations seen.

Meanwhile, critical steps refer to the activities that will trigger instant, intolerable and irreversible injuries when the previous action was performed wrongly (Meyers, 2012). In this condition, by lowering human error through the essential steps identified, individuals will be extra cautious when performing activities and they will be much less wary of making mistakes through their skills, rules and knowledge related working behaviors among employees. This creates situation were the level of awareness among employees could improve and it could heightens the sense of uneasiness among the workers in the production site. Examples of critical steps is where the employees enter to the confined space by or touch a rotating pump; once critical steps of this process are identified, the workers can anticipate errors that can occur at each critical step, estimate their consequences, and evaluate the existence of controls, contingencies and the stop work criteria.

Meanwhile, training and observation involving managers and workers (Morshuis et al., 2014) may be helpful. In this regard, some high-performing organizations provide coaches on-the-ground human performance and this integration of human performance principles can be promoted through training workers about the potential dangers, the performance mode, error traps and use other tools for human performance (Pershing, 2006). In addition, through training, workers can identify small problems before these issues become major problems. Workers can identify the precursors of errors and error traps before there is an error, and injuries can be reduced by providing employees with the knowledge and skills to detect whether they are operating in a particular error trapping and escape using various tools. Therefore, the aim of the comments in-the-field is to assess the quality and effectiveness of prepared work, practices and performance (Roth and Patterson, 2005). As a result, these observations may discover critical learning points that can be institutionalized to reduce or eliminate possible errors.

In the meantime , as suggested by Kim and Park (2012), the concurrent verification strategy is actually crucial and must be followed by workers in plant in order to reduce human errors at the workplace. It was explained these concurrent verifying actions are processes that can be done by two or more individuals who simultaneously work together in order to reduce the possible consequences by perform the action separately in order to confirm the working condition at workplace and the condition of the component or equipment in a time of; before, during and after an action. This action could be great example to reduce the workplace hazard especially when the consequences of the wrong condition or action may contribute to great harm. Using this protocol, the performer and verifier agree on the action to be taken. They separately self-check the action to be performed and after an agreement is reached, the verifier will observe the performer’s execution of the action and the verifier will stops the performer if action is incorrect (Shek, Tang and Han, 2005; Billett, 2001). In the meantime , when the employee performed the concurrent verification that is basically applied on the typical job that required the verify conditions, peer checking is more oriented towards verifying actions (Vyatkin and Hanisch, 2003). In this light the peer checking is used by the employee who worked in the machine that little old that required routine maintenance activity in order to prevent from breakdown problem to prevent the performer’s error. Meanwhile the employee also can prevent the action by augmenting his action or work condition through implementing the self-checking task work.

This technique basically required the expert review or inspection that reflects the advantage of a fresh set of eyes. Here, the performer (worker) who perform the self-checks activity in their working area due to follow the maintenance protocol that will lead to the situation of the all the production site will perform efficiently with correct component or hazards present and the peer self-checks the correct component or hazard present, then, the performer and peer agree on the action and the peer observes the performer before and during execution. Consequently, as the performer executes the intended action the peer will assure that the performer's action is correct or stop the performer that the performer. Meanwhile if the performer who is responsible in operating the machine could have done incorrect actions. Inherently, these tools could engage the workers in terms of mentally and physically because they use these tools themselves and they also conduct this work as a team.

Meanwhile, to use, the procedure as stated above each worker must first understand the intentions and purposes of maintenance activity and they must know why this activity was performed in order to follow the procedure step -by-step as written, with mindfulness and an orientation for appraisal (De Toni and Tonchia, 1998; Kouvelis, 1992). Consequently, situational awareness can be elaborated on as a procedural awareness which requires the deeper focus of the employees when performing a job. However, if the maintenance precaution procedure is written or taught incorrectly it might lead to the activity that could not be implemented safely leading to the operating process to be stopped and the maintenance procedure to be revised; employees need to be briefed before the work can be restarted. As a result, workers are more vigilant in assessing a procedure's accuracy, completeness, usability, lack of vagueness and internal consistency. Thus, a major outcome of using this maintenance tool is the continuous improvement and relevance of procedures by workers engaged in this review and improvement process. Furthermore, organizations might use this tool for activities associated with rule-based performance mode as many errors precursors are related to procedures. Common examples include unclear work guidance or instruction and the lack of real guidance in users' decision making. In this regards, the users are given multiple options in choosing the course of actions, and they have the options to choose the next course of action contingent based on the conditions. This requires the user to determine whether such conditions are present. This includes the multiple actions procedures can be completed in one step or the procedures with embedded actions that could be easily missed.

CONCLUSION

This paper explains the details on the factors that cause the basic incident that lead to the human errors in maintenance activities and the actions that can be taken to reduce the potential hazards at the workplace. This study found that human errors contributed to error at the workplace which led to possible hazard and machine breakdown that disturbed the entire system and the identification of deficient work context. This paper suggests the implementation of the prevention action to reduce the occurrence of potential errors among workers. Consequently, it will encourage them to perform well at the workplace in normal operating conditions. Finally, through the application of preventive actions, the worker can perform the tasks given in advance of work activity and, the maintenance personnel can prevent or reduce the potential human errors by identifying the weak points in the work context.

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