A STUDY ON EMERGENCY MANAGEMENT IN MANUFACTURING INDUSTRY BY USING THE BOW-TIE ANALYSIS

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***Abstract* — All organizations are vulnerable to unexpected or uncertain events that require them to plan for emergencies as part of their health and safety and overall management framework. While expert advice may be required, the generalist Occupational Health and Safety professional has a role in facilitating and monitoring the emergency planning and preparedness. This project involves the "Study on the emergency management in the manufacturing industry by using the Bow-tie analysis". This study presents the analysis of the emergency preparedness and response arrangements in the industry that helps the organization to avert or minimize the impact during emergency situations. The existing emergency response plan of the company are analyzed based on which recommendations are provided in order to improve the preparations for potential and unexpected incidents at the workplace. The Bow-tie analysis gives a visual representation of the prevention and mitigation steps that are required in the workplace to eliminate or at least reduce the chances of accidents. All the probable accident scenarios that could exist around the hazard are summarized to determine its threats and consequences.**

Keywords: Emergency, ERP, Bow-Tie, Mechanical hazard.

I. INTRODUCTION

An emergency refers to a dangerous situation that can be serious and unexpected and requires immediate action in order to prevent or mitigate it. Workplace emergency refers to the event that occurs and endangers the people in and around the workplace and risks disrupting the operations by causing damage. Irrespective of the safety system developed, organizations need to prepare for all the possible emergencies so as to avoid or control the consequences that arise out of the emergency. Some emergency like a fire, explosion, flood, etc., needs complete plant evacuation in which all the live equipment are turned off and the people inside the organization are moved to a safe place. Some emergency situations like medical emergencies do not need complete plant evacuation as it only needs the victim and the equipment associated with the incident to be taken care of. The significant factor in emergency management is to prevent an emergency situation by implementing technical and organizational measures that are reasonably practicable. Planning such emergency situations well in advance demonstrates the commitment exhibited by the organization in providing a safe working environment to their employees and thereby increasing the organization's safety awareness.

The Bowtie method is a method to evaluate the risk in a workplace that analyzes and demonstrates the causal relationships that exist in high-risk scenarios. The method is given the name Bow-tie as the diagram looks like a men's bowtie when the causes and consequences are drawn having the top event at the center. A Bowtie diagram does two things. The first thing is that the Bowtie analysis gives a visual summary of all plausible accident scenarios that could exist in an industry around a certain hazard. The next thing is the identification of control measures that are displayed by the Bowtie and the measures that are done by a company does to control those scenarios. Being considered as a significant hazard analysis technique, it combines the fault tree analysis (FTA) and the event tree analysis (ETA) and can be used in any scenario. Fault tree analysis (FTA) is helpful in identifying the basic events that have the potential to cause an accident event, whereas Event tree analysis (ETA) is helpful in identifying the sequence of events based on the initiating events to accident scenarios. This study would focus more on the mechanical hazard in the hydraulic moulding machine. The assessment is done by Bow-Tie Analysis using the QIMACROS software.

II. METHODOLOGY

Study of Emergency management involved in the Industry

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Identification of Mechanical Hazards

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Analyzing the risk using the Bow-Tie analysis

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Preventive and control measures for Reducing the Risk

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Suggestions and Recommendations

The literature review was done based on 25 journal papers that are related to the emergency management and Bow-tie analysis to perform the study. Based on the literature review, the existing analysis of emergency management using Bow-Tie analysis were determined. Site observation was done on the shop floor of the industry and mechanical hazard that are present in the hydraulic moulding machine was studied. The hydraulic moulding machine was chosen as it mas the mainly used equipment in the industry in which the research was performed. The emergency management systems that are followed in the industry are identified with the help of the documents like an emergency plan, risk assessment, etc., through physical inspection and interviews

with the staffs. Workers perform medium risk and low risk activities like loading, unloading, and manual handling out moulds, cleaning, etc., and maintenance activities are performed both by the operators and by the authorized third party persons who are competent such machines.

BOW-TIE ANALYSIS:

Bow-Tie diagrams depict the relationship between sources that causes the risk to occur, control measures, escalation Factors, events, and consequences of the event.

1. Hazard: Activity or state that has the potential to cause harm.
2. Top event: The point in time when control over the hazard is lost.
3. Threats: A Possible cause for top event.
    - People
    - Primary Equipment
    - Environment
    - Concurrent operations
4. Consequences: An unwanted event that are caused by the top Event.
    - Consequences are the factors that are risk-assessed using the Risk Assessment Matrix (RAM).
    - Must be specific which can be grouped later.
5. Barriers: Control measures taken to prevent or mitigate events. The barriers are placed both before the top event and after the top event.

Barrier hierarchy:

- Eliminate or substitute – Hazard
- Eliminate – Threat
- Prevent -Top Event
- Control – Consequence
- Mitigate – Consequence

6. Escalation factors: A condition that defeats or reduces the effectiveness of a barrier.

III. RESULTS AND DISCUSSIONS

INFERENCE

The study is conducted on the compression moulding in which activities related to moulding of oil seals and other rubber components are done based on which the following inferences are made.

HAZARD AND TOP EVENT

Hazard is the activity or state that has the potential to cause harm. Working on the moulding machine is the hazard that is considered for the study. It is also categorized under the machine hazard category. A machine hazard occurs in a mechanical system at the point of operation where the actual work is performed, and can be created by the components that transmits energy like pulleys, belts, chains, gears, etc., or other parts which move while the machine is working, including reciprocating, rotating, and transverse parts. These type of hazards mostly causes medical injury like cutting, entanglement, strike against, etc. and is mostly managed with the help of fixed or movable guards, or personal protective equipment in order to isolate or minimize the impact due to an event.

Top event is the point in time when control over the hazard is lost. The top event that might occur as a result of the hazard is the access by the worker into the danger zone where physical contact might occur when being touched or caught in between.

CAUSES

People

1. Negligence of the worker: occurs when the worker is distracted from the work being performed. Some of the reasons for negligence include use of mobile phones, having a conversation with the other worker, etc.,
2. Lack of knowledge: occurs when the worker was not provided or does not have the necessary skills and expertise for the particular task.
3. Work stress: occurs due to the pressure from the management to perform higher level of production within a stipulated time.

Preventive actions:

1. The Standard Operating Procedure is provided for each and every equipment in the local language so that the worker understands and is aware of the procedures that needs to be followed while performing the activity.
2. Information, Instruction, Training, and Supervision is provided to the worker at regular intervals in order to ensure that the operator is aware of the safety standards and the emergency response measures that needs to be followed while performing the activity.

Primary Equipment

1. Machine failure: occurs when the equipment is not properly maintained and calibrated. Most of the accidents happen during the maintenance activities and hence it is the responsibility of the management.
2. Lack of adequate protection: occurs when there are non-availability or insufficient guards to protect the workers from reaching the accident prone zones in the equipment. Guards are provided in the back of the equipment as well to protect the people from reaching inside of the equipment while they are passing on the backside.
3. Failure of safety system: occurs when the safety arrangements that are provided are not working properly due to poor maintenance or any specific reasons.

Preventive actions:

1. Fault Indication systems are regularly monitored in order to ensure that the machine is safe to work. Such factors are also calibrated annually through an authorized third party.
2. Safety curtains and other safety systems need to be checked on every shift before the worker starts the activity to ensure that it is working properly.

3. Daily inspection on the machinery are conducted by the operator and is monitored with the checklist so as to ensure that all the checkpoints are checked.
4. Permit to work (PTW) systems should be implemented for non-routine works to determine the safety of the operators performing the maintenance works and to ensure that competent person is performing the maintenance activity irrespective of the severity of the failure.

Escalation Factor:
The escalation factor refers to the failure of safety systems when a particular measure is not handled properly. In this case, escalation factors might occur when the safety systems are bypassed in order to deliberately access such danger zones.

Environment
Environment factors: include weather, lighting, ventilation, etc., which are considered while designing the workstation. It also includes uncertain events like flood, heavy rain, etc.

Preventive actions:
As the activity is done indoor, the environment is not a major factor. Adequate lighting and ventilation are provided to ensure a safe system of work for the workers.

Concurrent operations
Concurrent operations occur when other equipment in the process are responsible for the negative impact.

Preventive actions:
1. Adequate space is provided between the other machinery so as to ensure that both the machines and the workers do not affect each other's activities. If possible, fencing needs to be provided between each equipment so as restrict the access during the operation.
2. Designated pathways are provided so that the people who around or pass the work area does not interfere or disturb the activities of the operator working in the hydraulic moulding machine. Emergency lightings should be provided in these pathways so that it is visible during emergency situations or power failure.
3. Appropriate and adequate signage needs to be placed so the operators are aware of the risks associated with the other equipment.

CONSEQUENCES

The major consequences that might occur due to the top event are the accidents which can be minor, major, or critical. In terms of property damage, the equipment might get damaged due to the loss of control. Human injuries include caught in-between the press, direct contact with hot surfaces, overexertion, and amputation. Though the chances of fatality is minimum, it might still happen due to mental shock or over loss of blood. External emergency arrangements are available with hospitals and fire stations nearby to control the incident if it goes beyond the internal emergency management measures.

Loss Reduction actions:
Emergency stop buttons are provided for each and every equipment in an accessible area so as to stop the equipment during emergency situations. In case of physical accidents internal emergency includes trained first aiders and firefighters available for each and every shift. First aid boxes are to be maintained with adequate number of first aid items available in the workplace. Assembly points are clearly marked and contact details of the internal and external emergency response team members are displayed on the notice board.

Escalation factor: occurs when the first aid boxes are not maintained with adequate number of first aid items. Trained first aider must ensure that all the materials are available in the first box all the time. If a particular item is being used, it must be replaced with a new item in the first aid box.

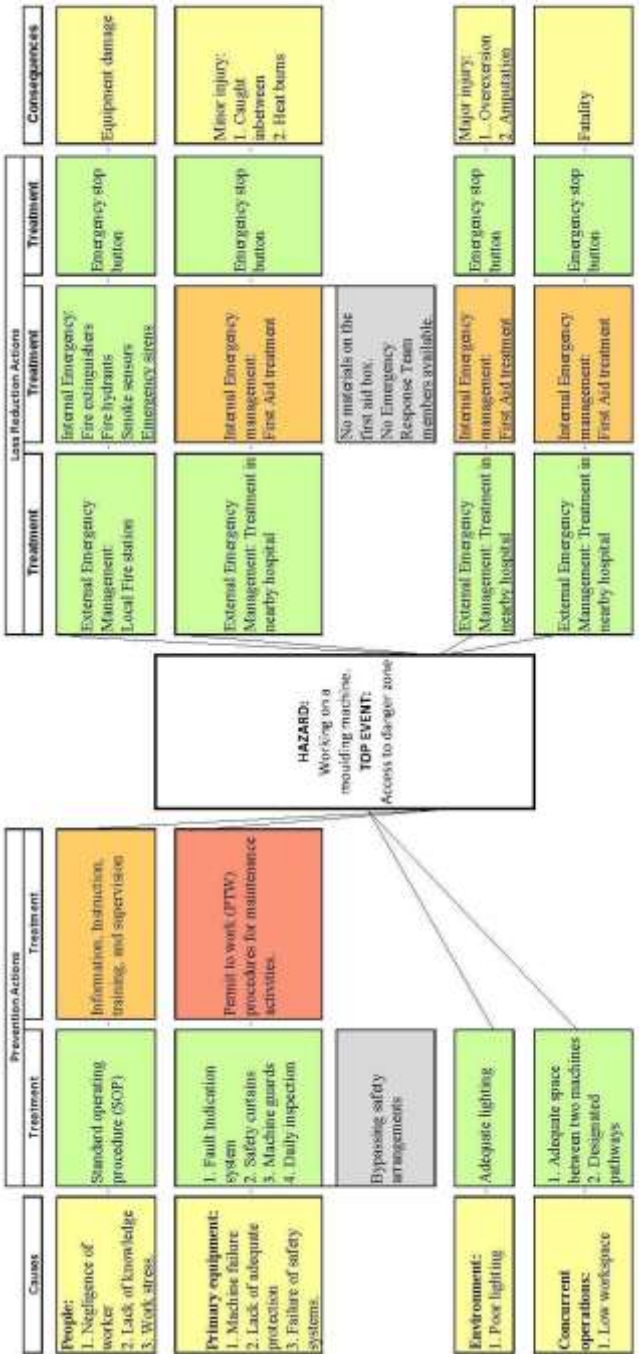

Fig 3.1 BOW TIE ANALYSIS

CONTROL MEASURES FOR REDUCING THE RISK

1. Instruction, Information, Training, and Supervision on safe work procedure must be increased through toolbox briefing, refresher trainings, third party trainings, etc., Use of personal protective equipment must be closely monitored and stringent actions need to be taken on the workers in case of repeated violation of safe work procedures.
2. Permit to Work system must be implemented for non-routine activities in the workplace like maintenance, construction, etc., so as to ensure that the safety arrangements are in place and to ensure that qualified people are performing the maintenance activities under appropriate supervision and knowledge of the management.
3. Materials in the First aid box are not adequate and must be restocked whenever a particular items is used. First Aid box must be under the control of a certified first aider and must be documented with a checklist.
4. The emergency plan shall be rehearsed and practiced at regular intervals to test efficiency of personnel, to improve on the co-ordination between the essential work teams, equipment and to increase confidence and experience to operate such plan. Based on such rehearsal, the plan so prepared should be strengthened by bridging the gaps, if any, updated annually and uploaded in the factory website for easy reference.

IV. CONCLUSION

Though emergency situations are more likely to occur especially the medical emergencies while working on the machineries and equipment, prevention measures can be given as far as reasonably practicable so as to avoid the occurrence of uncertain situations. Recovery measures also plays a crucial role in reducing the impact of hazardous event. Each and every hazard that exists in the workplace must be identified and control measures must be put in place to protect the people and property. The SOP (Standard Operating Procedures) for each and activities involved in each and every equipment were implemented and the same is displayed on the workstation so that maximize efficiency of production can be obtained by reducing the human errors.

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