Development of The Overall Operation Hazards Identification Model (OOHIM) For Industrial Plant: Case Study of Nakhon Ratchasima Province

Jadpol Paikhlaew*, Sanguan Vongchavalitkul and Marut Khodpun

Engineering Management, Faculty of Engineering Vongchawaritkul University, Nakonratchasima, Thailand
*Corresponding author, E-mail: jadpolastk@gmail.com

Abstract

As the current hazard identification technique is suitable for different factories and production processes., improper use of the hazard identification techniques may lead to the search for risk factors which does not cover operations. This research aims to develop OOHIM hazard identification technique that covers all operations of industrial plants with different production processes by using the strengths of Checklist technique, What If Technique, HAZOP technique and JSA technique to develop into OOHIM technique.

This research brings the OOHIM technique to test for risk factors with the auto-part manufacturing factory in Nakhon Ratchasima province to compare with the Checklist technique that the factory is using. Test results and analysis using the Radar Chart show that the OOHIM technique finds risk factors covering all four operations in similar ratios, 39% in Human, 17% in Machine & Equipment, 28% Standard & Method, and 17% in Environment & Facility. While each of the risk in the four operations of Checklist technique seems to have a distinguish ratio to others with 36% in Human, 7% in Machine & Equipment, 14% in Standard & Method, and 43% in Environment & Facility.

As a result, the OOHIM technique will search for risk factors, covering all four operations, rather than the Checklist technique, which will focus more on the Human and Environment.

This research is a comparative test of only one industrial plant. Further research should be compared with other hazard identification techniques and should be tested with many types of industrial plants to prove that it is suitable for certain industrial plants.

Keywords: *Hazard, Identification model, Process, Operation, Checklist*

1. Introduction

The national strategic plan for the industrial sector aims to develop the original industrial base to be a potential center for production, trade and investment in the sub-region. (Ministry of Industry Promotion, 2018) This affects the working environment from only human labor to automation machinery, including the work of people who cooperate with robots. In addition, new materials and chemicals were used for production. Industrial plants is finding ways to prevent the effects of changes in the work environment by selecting danger identification techniques that are appropriate for the production process. Therefore, the suitable choices of techniques to identify hazards for the production process and operating environment must be taken to a thorough study.

Umarat Sirijaroonwong (2019), studies technique for work accident prevention. The result finds that The Preliminary Hazard Analysis (PHA) technique is a tool used to search for basic hazards and hazards during the design of production processes or machines in order to set adequate safety measures before production starts. In addition, this technique is very useful for proactive safety management. The PHA technique has a complicated procedure that can be used to investigate the basic causes of accidents. However, this technique is only a Preliminary Hazard Analysis. To increase capabilities, this technique should be used with other techniques, such as failure mode effects analysis (FMEA) or What If.

Currently, the commonly used danger identification techniques are HAZOP, Checklists, What if, Event Tree Analysis, FMEA, and Failure Tree Analysis. (Office of Safety Technology, online) There are also other techniques which many more researchers around the world have studied and used in various industries.

Although the Department of Industrial Works issued the Government Gazette 1999 on the criteria for hazard identification (Notification of the Ministry of Industry, 1999), and risk assessment and risk management plan preparation cause the overall accident rate to decrease, but the rate of serious accidents at work is still occurring, such as the fires of industrial plants Deaths from falls and wastewater treatment plants. (Khaosod.co.th, online)

The researchers conducted a survey of the hazard identification in 110 industrial factories in Nakhon Ratchasima province, and found that most factories use the Hazard Identification Checklist technique, followed by the JSA technique, What if technique and HAZOP technique respectively. There are still many factories that do not have a hazard identification due to a lack of knowledge and understanding about the use of danger identification technology, and the difficulty in applying to factories with different production processes.

From the questionnaire data, 15% Industrial factories use alternative hazard identification techniques, and 85% of industrial factories in Nakhon Ratchasima choose to use the Checklist technique to identify hazards. However, Checklist techniques still have limitations in detecting risk factors. Therefore, the technique is not suitable for factories that have many machines and complicated production processes. The researcher should develop a hazard identification technique that can cover all operations and be easily used in all industrial plants and increase the strengths of other techniques.

2. Objectives

To develop a model for the identification of hazards that are suitable for industrial plants in the country.

3. Materials and Methods

3.1 This research will use survey to collect data of hazard identification techniques that industrial factories in Nakhon Ratchasima choose to use in their operations. According to the notification of the Ministry of Industry (1999) issued under the Factory Act 1992 regarding safety measures being implemented, it must be done to identify hazards in order to assess the risk of accidents. There are 110 factories that are within the scope of the announcement.

3.2 Develop a hazard identification model using data from the Hazard Identification questionnaire from industrial factories in Nakhon Ratchasima and combine the strong points of all-hazard identification techniques to develop a new hazard identification technique; “The Overall Operation Hazard Identification Model; OOHIM”

OOHIM combines the advantages of the What if ?, Checklist, JSA and HAZOP Hazard Identification techniques to find hidden risk factors in operations activities relating to people, machinery, standard equipment, methods, environment, and public utility system by considering defects that will cause danger to people, property and affect the environment both directly and indirectly.

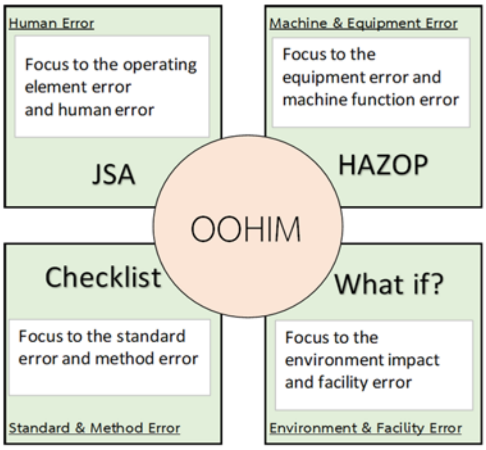

Figure 1 Overall Operation Hazard Identification Model; OOHIM

Figure 1 shows the OOHIM hazard identification model. It combines the strengths of 4 techniques to search for operational risk factors as follows:

The "What if?" techniques will search for operational risk factors related to environmental and utility defects by specifying the inspection topics in the inspection sheet.

The Checklist technique will search for operational risk factors associated with deficiencies in standards and procedures by specifying the inspection topics in the inspection sheet.

The HAZOP technique is used to find operational risk factors associated with defects in machinery and equipment by specifying the inspection topics in the inspection sheet.

JSA technique is used to find risk factors for actions related to human defects by specifying the inspection topics in the inspection sheet.

Checking each operation in the production process will specify the inspection topic for each operation in order to cover activities that will cause danger to operators. The most likely impacts is shown in Table 1.

Hazard identification procedures by OOHIM

1) Establish a team of inspection with 4-5 people who come from various departments, such as maintenance, engineering, production, and environmental department.

2) Write the procedures of the operation process on the inspection sheet which must include the main process and supporting process to cover all operations.

3) Check the actual site area and record in the OOHIM risk factor check sheet by checking the check symbol (✓) in the table that corresponds to the topic that will be the risk factor, and adding the reason in the remarks box

4) Take all risk factors from the examination sheet into the risk assessment sheet.

5) Establish measures to improve and prevent the high risk of such risk factors.

3.3. Use the new hazard identification technique to test with the sample production process. Analyze the results by radar chart and compare to the hazard identification technique currently used by the sample factory.

Table 1 Table the main topic for checking the risk factors of the OOHIM

Operations	Inspection topics
A: Human error	A1. Not using personal protective equipment.
	A2. There is a chance that the sharp object is cut, clamped, bumped.
	A3. There is a chance that employees will fall from a high place or slip down.
	A4. Not following the specified procedures
	A5. Unprepared expertise and physical condition
B: Machine & Equipment error	B1. The machine has a high pressure, steam system, high heat, low temperature.
	B2. The machine has no protective equipment such as cover or sensor
	B3. The machine has no protection against radiation, noise, dust, smoke and vapors
	B4. The machine has no electric shock protection system
	B5. The machine has no emergency stop button or emergency stop system
C: Standard and method error	C1. No working standard used to control operations
	C2. No emergency plan
	C3. The standard is complex and unclear and not enough warning
	C4. The standard does not cover legal requirements
D: Environment and facility error	D1. The structure of the building or utility system does not comply with the law.
	D2. There is no protection or control system when errors occur
	D3. There is no indication of the state of a public utility system.
	D4. No maintenance plan and monthly or annual audit plan
	D5. Insufficient controls and lack of qualifications

4. Results and Discussion

4.1 Survey results of hazard identification techniques used in industrial factories in Nakhon Ratchasima

The results show among 110 industrial factories, there are 71 factories (64.5%) identified hazard identification and 39 factories (35.5 %) that did not . It is found in those factory that performed the hazard identification that 4 techniques were chosen; 60 factories (85%) chose Checklist technique, 9 factories (13%) chose JSA techniques , 1 factory (1%) chose HAZOP technique and 1 factory (1%) chose What if? techniques.

4.2 The result of the hazard identification test by OOHIM techniques and Checklist techniques in the automobile parts factory of the dust cover production process of the shock absorber.

Processes of the production analysis of the dust cover for automobile shock absorbers by the OOHIM method are separated into the main process and the supporting process or related processes to cover all operations. The main process is the method of raw material filling, and the support process is the procedure of receiving and organizing raw materials, mold injection, trimming for dust cover, and car shock absorber as shown in figure 2.

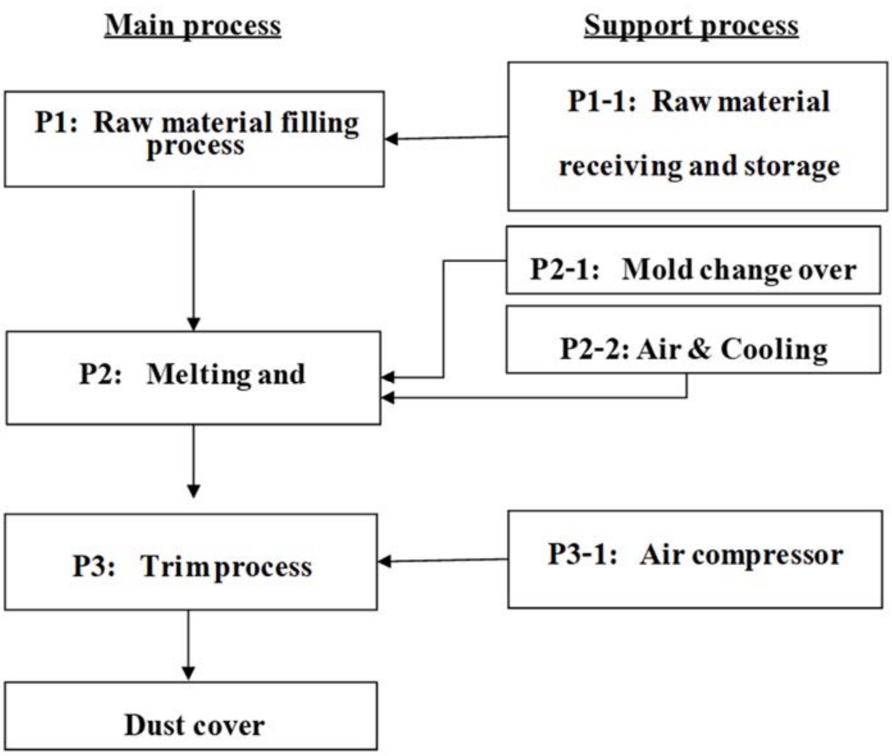

Figure 2 The dust cover production process

Hazard identification by OOHIM will examine the risk factors of the main process and the supporting processes or concern processes. The process, instead of the writings in Figure 1, is recorded as the process items and check marks (✓) in Table 2. The inspection topic items are assigned as letters A-D; Human (A), Machinery and equipment (B), Standards and methodological (C), or Environmental and utility (D). Each operation in the inspection topics shown in Table 1is replaced with the letter A1-D5. If any box is marked (✓), a comment must be written at the bottom of the table.

The researchers have trained the Hazard identification by OOHIM Hazardous Method in the production process of the dust cover of the car shock absorber in the sample factory to a working group with the safety officer and the factory safety committee. Hazard identification found 18 risk factors as shown in Table 2.

Hazard identification by Checklist method of the production process of the dust cover of the car shock absorber was inspected by the safety officer and the safety committee of the sample factory. The results of the examination of all 30 hazard indicators found 14 risk factors as shown in Table 3.

Table 2 Hazard identification by OOHIM method of the dust cover production process of the automobile shock absorbers

Process	**A: Human error**					**B: Machine & Equipment error**					**C: Standard and method error**				**D: Environment and facility error**				
	A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**	**D1**	**D2**	**D3**	**D4**	**D5**
P1				✓							✓	✓				✓			
P1-1	✓			✓							✓					✓			
P2		✓	✓			✓												✓	
P2-1				✓		✓					✓								
P2-2				✓							✓								
P3							✓												
P3-1																			

Comment
P1: A4 Employees do not know the sequence of steps to fill.
P1-1: A1 There is no protection device while filling the plastic granules.
P1-1: A4. Employees do not know the sequence of steps in storage and movement of raw materials.
P2:A2 The work conveyor can be clamped because there is no cover.
P2:A3. No sign to prohibit unrelated people on the 2nd floor of the device.
P2-1: A4. The employee does not know the sequence of steps to change the mold.
P2-2: A4. The employee does not know the sequence of steps to open the coolant system.

Comment
P2: B1. Cutting blades that are extremely hot when in contact with plastics while the machine stops incorrectly. Fire may occur.
P2-1: B1 The cooling water system will not flow, causing the plastic palletization system to overheat. Fire may occur.
P3:B2 The cutter cover has no sensor. An employee might put a hand into the machine while the machine is running.

Comment
P1: C1 There are no standards and procedures for adding raw materials.
P1: C2 There is no emergency plan when raw materials fall to the ground.
P1-1:C1 There is no standard in the storage and movement of raw materials.
P2-1: C1 There is no standard procedure for changing mold.
P2-2: C1 There is no standard procedure for coolant operation systems

Comment
P1: D2 No equipment to protect the environmental impact in the event of material leakage.
P1-1: D2 The storage building does not have a material barrier to find leaks or water barriers from firefighting.
P2: D4 No machine maintenance plan.

Table 3 Hazard identification by checklist method of the dust cover production process of the automobile shock absorbers

No	Question	Check result			Key point record
		Yes	No	N/A	
Checklist for storing raw materials					
1	[E] Is the location of the building suitable?		✓		Store together with general raw materials.
2	[E] Is the storage appropriate?		✓		Put on a wooden pallet
3	[E] Are there firefighting equipment or not?	✓			
4	[E] Is there an emergency plan in the event of a spillage of raw materials or chemical?		✓		none
Checklist for raw material storage management					
5	[S] Is there a clear label indicating the raw material name?	✓			
6	[E] With FIFO disbursement		✓		none
7	[H] Is there a duty determination, ccupational health, disbursement, 5 S?		✓		none
8	[H] Is there a regulatory body?		✓		none
9	[H] Do you have personal protective equipment to use?	✓			
10	[H] Is there a facility for operators?	✓			
11	[E] Is there a rule for operators if material spills occur?		✓		There is no document to proceed.
12	[E] Is there a device to clean the raw materials if spills occur?		✓		Device not found
Checklist for raw materials					
13	[E] Are the materials flammable substances?	✓			
14	[H] Are employees wearing personal protective equipments?	✓			
15	[S] Is there a manual for raw material transportation?		✓		There is no document to proceed.
16	[H] Are employees trained with emergency plans?		✓		No document
17	[H] Are employees trained for personnel regarding the use of personal protective equipment?		✓		No document
Checklist for machinery and equipment					
18	[M] Is there a document recording the inspection of machinery and equipment before working?	✓			
19	[M] Does the machine have a label indicating the control button?	✓			
20	[M] Does the machine have an emergency stop button in the right position?	✓			
21	[M] Does the machine have a cover to protect in danger point?	✓			
22	[M] With documentation of routine maintenance?		✓		No document
23	[M] is the machine installed with a ground wire?	✓			
24	[M] Does the machine have a warning system for abnormalities?	✓			
Checklist for operational					
25	[S] Do the staff have standard documents for work?	✓			
26	[H] Are the staff trained to have skills?	✓			
27	[H] Do the employees follow the specified procedures?	✓			
28	[H] Is there a clear positioning of equipment in the work area.	✓			
29	[H] Do supervisors regularly check the work of employees?		✓		No document
30	[S] Is changes in processes recorded?		✓		No document

Remark; [H]: Human, [M]: Machine & Equipment, [S]; Standard & Method, [E]: Environment & Facility

4.3 Analyze summary results compared with the tools currently used by the sample factory.

Below is the results of the examination of the risk factors in the production of the dust absorber of the car shock absorber in the automotive part factory in Nakhon Ratchasima province by the OOHIM and Checklist hazard identification techniques. The definition of the operation is the production process design, accepting payment storage, handling, or transportation of raw materials, fuels, chemicals or hazardous substances, products, or objects, working process, machinery or equipment used in production, and activities or situations within the factory. The group of operations related to work safety can be divided into 4 topics which are operations related to people, machinery and equipment standard and the environment and facility. To compare, risk factors obtained from the auditing from both methods are compared to the coverage of all 4 operations.

Hazard identification by OOHIM method found 7 risk factors for operators, 3 risk factors from machinery and equipment, 5 risk factors from standard and methods, and 3 risk factors are found from environmental and utility.

The results of the Hazard Identification by Checklist method found 5 risk factors for workers, 1 risk from machinery and equipment, 2 risk factor from standard and method, and 6 risk factor from the environment and public utilities as shown in Table 4.

Table 4 The risk factors in the operation process of OOHIM and Checklist

	Operation			
Hazard Technical	**Human**	**Machine & Equipment**	**Standard & Method**	**Environment & Facility**
OOHIM	7 (39%)	3 (17%)	5 (28%)	3 (17%)
Checklist	5 (36%)	1 (7%)	2 (14%)	6 (43%)

According to the Radar Chart, the OOHIM Hazard Identification Technique can find 7 risk factors (39%) from human-related operations, 3 risk factors (17%) caused by machinery and equipment, 5 risk factors (28%) caused by standards and methods, and 3 risk factors (17%) caused by the environment and public utilities. Meanwhile, Hazard identification by Checklist method can detect 5 risk factors (36%) caused by people, 1 risk factors (7%) caused by machinery and equipment, 2 risk factors (14%) caused by standards and methods, and 6 risk factors (43%) that caused by the environment and public utilities. When comparing the two hazard identification techniques together, the OOHIM technique can detect more risk factors that cover all 4 groups of operations than Checklist techniques, which the majority of the risk factors found is only in environmental risk factors, as shown in figure 3.

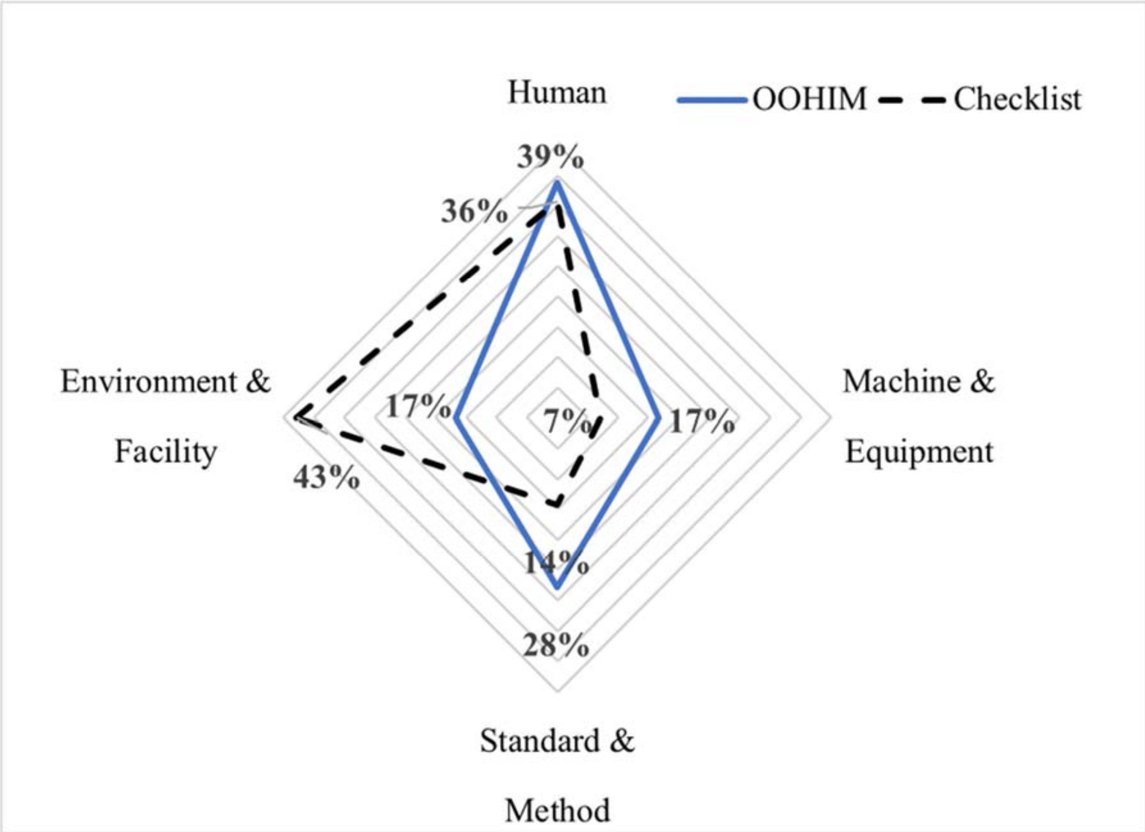

Figure 3 The risk factors of OOHIM and checklist in the operation

Discussion

1. The comparisons of the search for risk factors between OOHIM techniques and checklist techniques in production processes are studied. The OOHIM technique can search for operational factors that covers more than 4 areas. Meanwhile, the checklist technique only focuses on environmental and facility and human risk factors, which are the strengths of the checklist-oriented technique. The latter technique is suitable for factories with uncomplicated production processes, while OOHIM technique gives equal importance to all 4 operations.

2. The OOHIM technique is developed for using in industrial factories of all sizes and different production processes. Since this research tested only 1 factory, it may not be enough for application.

3. The validation topic of the OOHIM technique may need to be further developed when tested with the manufacturing process and found that it does not cover all operations.

4. The OOHIM technique must be tested and compared with other hazard identification techniques such as HAZOP, JSA, if so, FMEA will be effective in searching for risk factors that cover all operations.

5. Conclusion

The research found that the OOHIM technique is a technique developed to be able to search for risk factors that cover all operations and can be used in all industries easily. The research of testing the risk factors of the automobile parts factory in Nakhon Ratchasima and compare them with the Checklist technique found that the OOHIM technique covers all operations, compared to the Checklist technique.

This research is a comparative test of only one industrial plant. Further research should be compared with other hazard identification techniques and tested with many types of industrial plants to prove that it is suitable for all industrial plants.

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