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An Evaluation of the Quantitative Risk of Plastic Process Manufacturing Industries by Means of the 4M Method

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Abstract : This study includes a case study among plastic process manufacturing companies, based on which, the currently used 4M method is applied in terms of machine, media, man, and management, to conduct quantitative risk evaluation, and thus to contribute to reducing human and material loss as well as preventing accidents in industrial fields. The result of this study is analyzed based on the 4M-risk assessment to find out the hazardous risk elements, and the quantitative evaluation made it predictable the value of risk(frequency x intensity) in such classified levels as serious risk, critical risk, and intolerable risk. Further, Among the businesses with hazardous risk elements and high frequency of industrial disaster, risk analysis was conducted for each process, and as a result, 38 cases among 76, including those of serious risk, critical risk, and intolerable risk, were improved, and the risk was reduced. Besides, it is thought that with the engineering approach with 4M-Risk Assessment, the attempt to improve safety level contributes to prevention of accidents.

Key words: risk factors, risk evaluation, 4M-risk assessment

1. Introduction

Due to the drastic development and aggressive investment in domestic industrial markets, the operation of automative facility has caused the increase of the number of unskillful workers involved. Especially, as for the human resource system, the rates of temporary position workers and foreign workers are increasing, which has resulted in more and more industrial disasters and thus safety measures are urgently required.

As industries and new products are developed, manufacturing areas are getting more complicated and varied, and new types of potential risk elements are increasing too. Plastic is classified into 30 kinds in general, and there are thousands of subclasses for each kind. Even the ingredients of the same kind have a lot different physical, chemical characteristics

Plastic process manufacturing is a part of the chemical product manufacturing industry, and domestically there are about 11,959 work-places, 96%(11,453) of which are small companies with less than employees. The disasters happening include skin burn · electric shock due to the element characteristics of the organic compounds and high-temperature process conditions, as well as stricture · crash · electric shock · skin burn·bone disorders risk due to the operation of power machinery(injecting molding unit · pulverizer · molding robot, etc.).

One of the methods to prevent these accidents is to find and remove the on-site potential risks, and risk evaluation is the effective method to figure out the potential risks.

In this study, therefore, a case study was conducted among plastic process manufacturing industries, at which 4M risk evaluation of the factors such as Machine (mechanic), Media(material · environmental), Man(human), Management(management) is applied to contribute to preventing human and material loss as well as accident in industrial fields.

2. Risk Evaluation Method

The risk evaluation method consists of the following steps in general: drawing up of the risk factors; qualitative evaluation to confirm and establish the safety measurement on the risk factors; quantitative evaluation to

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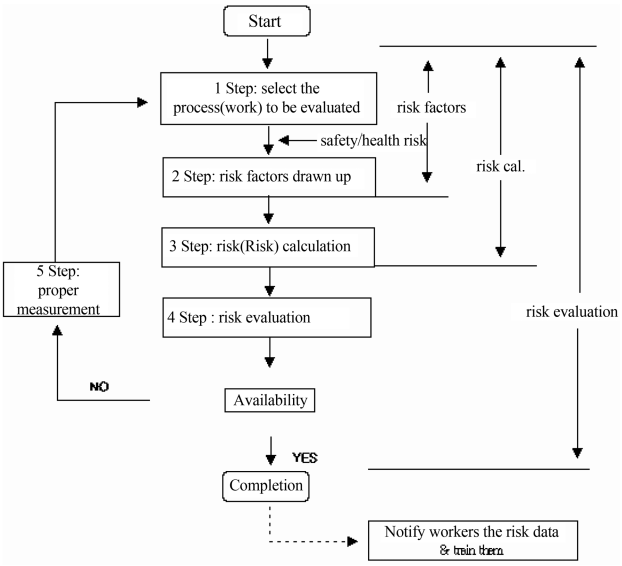

Fig. 1. 4M way risk evaluation procedure

calculate the possibilities and potential accident scale of each risk factor, and make measures for risks out of the tolerated range.

This study, with the quantitative evaluation method, draws up the risk factors by means of the 4M method, categorizes the frequency and scale of disasters, and determines the risk for the risk evaluation.

The risk evaluation procedure of the 4M way method is presented in Fig. 1.

3. Risk Evaluation Criteria

To easily confirm the risk evaluation criteria, the frequency level and intensity level are combined, and the risk level is determined, whose result is presented in Table 1~4. According to the determined values of the 4M way risk determination method, the management criteria is established, and the measurement is set according to the level: 「high risk」 「critical risk」 or 「untolerated risk」 .

Table 1. risk frequency

frequency class	frequency level	description
possibilities rare	1	1/10year frequency
possibilities low	2	1/3year frequency
possibilities middle	3	1/1year frequency
possibilities high	4	1/1month frequency
frequent	5	1/1day frequency

Table 2. risk intensity

intensity class.	intensity level	description
no effect	1	no human loss due to the disaster
negligible; no shutdown	2	if any, negligible disaster but no shutdown
negligible; shutdown	3	disasters causing shutdown
serious	4	serious disasters causing death, workforce loss, etc.

4. Case Study

4.1. Outline

This study selected a connector manufacturer among plastic process manufacturing industries, and conducted a case study by means of the 4M way method. The onsite visit was followed by investigation and analysis done by the two management inspectors. During the work process, the risk was evaluated in terms of the mechanic, physical, environmental, human management areas respectively.

4.2 Manufacturing Process

The manufacturing process of the plastic process manufacturing industry varies according to the product. The general process, major machinery, and risk factors are summarized in Table 5.

Table 3. risk determination criteria table

	intensity	no effect	negligible; no shutdown	negligible; shutdown	serious
frequency level	**level**	1	2	3	4
rare	1	1	2	3	4
low	2	2	4	6	8
middle	3	3	6	9	12
high	4	4	8	12	16
frequent	5	5	10	15	20

Table 4. Risk Determination Criteria Table

risk level		management criteria	note
1~3	negligible risk	maintaining the current safety measures	**risk tolerated** (able to continue the current work)
4~6	trifling risk	safety information & regular work safety education needed	
8	ignorable risk	risk sign, work procedure mark, and other management measures needed	
9~12	serious risk	safety measures in planned maintenance terms needed	**conditional risk toleration** (work may continues when there is no risk, but measure should be taken)
12~15	critical risk	urgent, temporary safety measure plan needed and followed by safety measure in planned maintenance terms	
16~20	untolerated risk	Instant shutdown(To resume the work, prompt measurement needed)	**work not allowed** (instant shutdown required)

5. Risk Evaluation Result of the 4M Way Method

5.1 Risk Evaluation Pre-improvement Result of the 4M Way Method

In application of the safety related risk information and risk property evaluation, 76 risk factors were found, and 38 requiring improvement among them are presented in Table 6. Especially, industrial robot molding, molding production and repair, raw material warehousing and forwarding turned out to be unsatisfactory, and consultation with safety professionals as well as improvement planning should be followed.

5.2 The risk evaluation post-improvement result of the 4M way method

By investigating the risk evaluation result, finding out hazardous risk factors, make measures to minimize the possibilities of developing into accidents, the risk can be minimized. The result is summarized in Table 7. The each process average risk were calculated and the comparison of the state before and after the improvement is shown in Fig. 2.

6. Conclusion

This study investigates the quantitative risk evaluation by using the 4M way method among plastic process manufacturing industries. The conclusion is as follows:

1) The hazardous risk factors are drawn up by 4M-Risk Assessment, and the risk values(frequency×intensity), classified to serious risk, critical risk, and untoler-

Table 5. Outline of each process, major machinery & risk factors

Class.	raw material warehousing and forwarding	mixing, combination	molding	product properties	inspection	pulverization	industrial robot molding(test)	molding production, and repair
process outline	raw material delivery by a power forklift	raw material mixing, combination	product molding	use hand tools and remove the taken-out product	eye inspection	defective product, and molding pins pulverization	product sample injecting molding	molding production, and repair
major machinery	battery car, freight car	mixing unit, combination unit, hopper loader	injecting molding unit, auto take-out robot, conveyor, crane	hand tools such as a knife	magnifying glass	pulverizer	injecting molding기, auto take-out robot, conveyor, crane	machinery, crane
risk factors	crash, stricture, falling	stricture, crash	stricture, electric shock, skin burn, crash	fracture	muscle & bone related diseases	stricture, noise	stricture, electric shock, skin burn, crash	stricture, falling, crash

Table 6. Pre-improvement result of 4M way risk evaluation

Classification	No. of risk factors	risk level (negligible risk, trifling risk, ignorable risk)	risk level (serious risk, critical risk, untolerated risk)	average risk
raw material warehousing and forwarding	12	5	7	7.5
mixing, combination	8	4	4	6.8
molding	11	7	4	5.6
product properties	7	5	2	6.0
inspection	7	5	2	6.7
pulverization	10	7	3	5.4
industrial robot test molding work	9	-	9	11.2
molding production and repair	12	5	7	7.7
total	76	38	38	

Table 7. The post-improvement result of 4M way risk evaluation

Classification	No. of risk factors	risk level (negligible risk, trifling risk, ignorable risk)	risk level (serious risk, critical risk, untolerated risk)	average risk
raw material warehousing & forwarding	12	12	-	4.0
mixing, combination	8	8	-	3.9
molding	11	11	-	3.8
product properties	7	7	-	4.0
inspection	7	7	-	4.4
pulverization	10	10	-	3.8
industrial robot test molding work	9	9	-	5.3
molding production & repair	12	12	-	4.2
total	76	76	-	

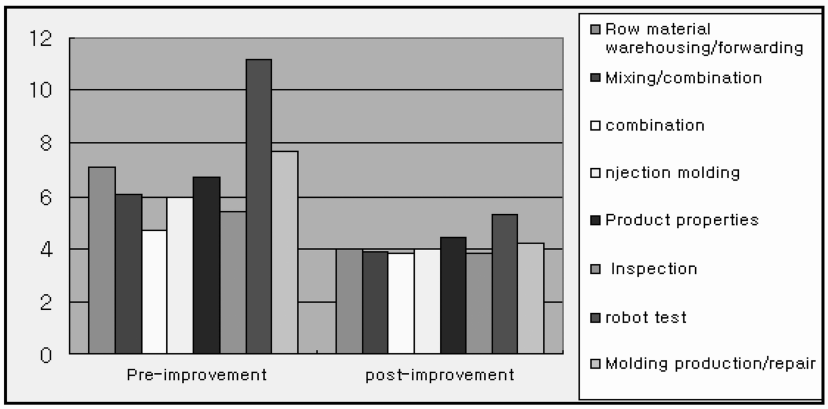

Fig. 2. Average risk pre-improvement·post-improvement comparison of each process

ated risk, are predicted through the quantitative evaluation.

2) Many businesses were found to have hazardous risks of outstandingly high industrial disaster frequency, and analyzed in terms of the risk factors according to each process. Among the 76 cases in total, 38 cases indicating intolerable risks or critical risk were managed, and as a result, the risks went down.

3) It is expected that the scientific approach with 4M-Risk Assessment in an effort to improve the safety level

will contribute to accident prevention.

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