Occupational Safety Culture of Workers at Shop Floor in Medium Scale Iron and Steel Industries of Punjab State in India: Development of Safety Index

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Abstract

Safety Index has been considered as an important quantitative method used to track safety changes, ranking a problem and also helps in facilitating the decision-making process. The main objective of this research was to develop a new safety index for the workers of medium scale manufacturing industries of Punjab using Delphi method with involvement of means and weights of the factors. To check the validity of the factors content validity index (CVI) was used, by taking expert opinion. The reliability of safety index was also examined by the analysis of data collected from 30 medium scale iron and steel manufacturing industries of Punjab, 10 workers were selected from each industry in order to fill the questionnaire. After calculating the results the standard value of safety index was found to be equal to 21.02 and the analysis of survey data suggested that all the 30 medium scale industries were below the standards of safety index. It means very less safety measures are maintained in the industries of Punjab and the working environment is found to be dangerous and unsafe for the workers of these industries. The main reason behind this scenario is the lack of knowledge among the workers and the greed of owners who don't want to spend money on maintaining the safety measures.

It is recommended to management of industries to improve or maintain their safety factors, so that the workers should feel safe and comfortable at the workplace.

Introduction

India is a developing country and industrial growth has added a lot to the development of Indian economy. Small and medium scale industries have played a vital role in development of India by enhancing the goods production rate and also by providing employment to the larger section of people. With increase in number of small and medium scale enterprises, number of operational injuries or casualties has also been increased.

According to the WHO, in each year 3.5 million deaths happen due to the accidents in the workplace. According to the ILO (International Labor Organization) in each year about 50 million job related injuries happen in the whole world. And in every 15 seconds, a worker dies due to the work-related accidents.

As per the data provided by DGFASLI in the year 2012, there are 1383 fatal injuries (causing death) and 28441 non-fatal injuries (not causing death) occur in India. According to ILO, in each year around 43,000 people die in India due to work related problems [1]. The increase in number of operational accidents can be attributed to carelessness or lack of knowledge (about safety parameters) among workers and owners of these industries. The direct or indirect losses due to work related mortality and morbidity of workers have made this problem a major issue of vital importance among these industries. There are many industrial accidents occurring in India. The Bhopal Gas Heartbreak (1984) was the whirling opinion in the antiquity of safety in India. The numbers of occupational accidents are increasing day by day [2-9]. In case of Punjab, if the numbers of factories are increasing then number of accidents is also increasing as presented in Figure 1.

The development of Safety index has always fascinated researchers of current era because of its ability to impart changes to the functioning and working environment of various sectors. Although, many researchers have tried to develop safety index for various areas for over

many decades, but to the best of our knowledge, no such study has been undertaken for Punjab region. Different methods viz. (Delphi method, Logistic regression method, fuzzy logic method and statistical analysis method using SPSS) for development of safety index have been reported in literature. Our work emphasizes on the development of safety index for the medium scale industries of Punjab region
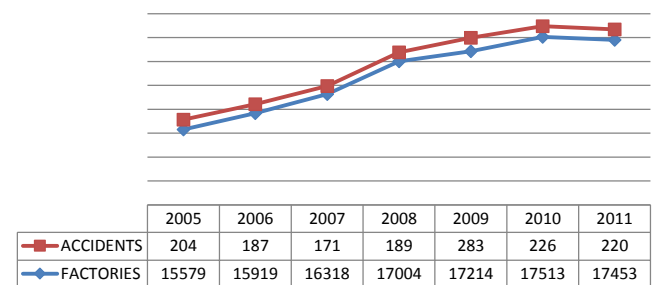
Figure 1: Graphical representation of accidents as per number of factories in Punjab from year 2005 to 2011.

	2005	2006	2007	2008	2009	2010	2011
ACCIDENTS	204	187	171	189	283	226	220
FACTORIES	15579	15919	16318	17004	17214	17513	17453

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using Delphi method. The principal merit of Delphi method is that it depends upon the judgment of selected experts after series of intensive questionnaire (keeping current scenario in mind) and does not rely upon the previous data available [10-15].

Classification of different enterprises According to the Micro, Small and Medium Enterprises Development (**MSMED**) **Act**, 2006 for the manufacturing sector with respect to number of employees and investment has been represented in Table 1 [15-18].

Methodology

This study emphasized on the development of safety index for medium scale manufacturing industries. A total of 300 employees participated in this study who worked in 30 different manufacturing industries of Punjab, in order to collect required data for development of safety index.

Safety index is a measure of safety parameters followed by a particular manufacturing industry. Following are the general characteristics possessed by the safety index:

a)   It should cover all the factors related to the occupational safety of workers.

b)   It should provide precise and accurate information about the safety culture and its advances with respect to time.

c)   It should provide platform or have scope of improvement in present scenario of occupational safety (Figure 2).

Identification and validation of factors affecting occupational safety

After following the above said methodology (step 1, 2 and 3),

S. no.	Company Category	Number of employees	Investment in plant and machinery
1	Micro	<10	<25 lakh rupees
2	Small	10–50	>25 lakh <5 crore rupees
3	Medium	51–250	>5 crore <10 crore rupees

Table 1: Category of the company according to the employees and investment.

Figure 2: Procedure followed for development of safety index.
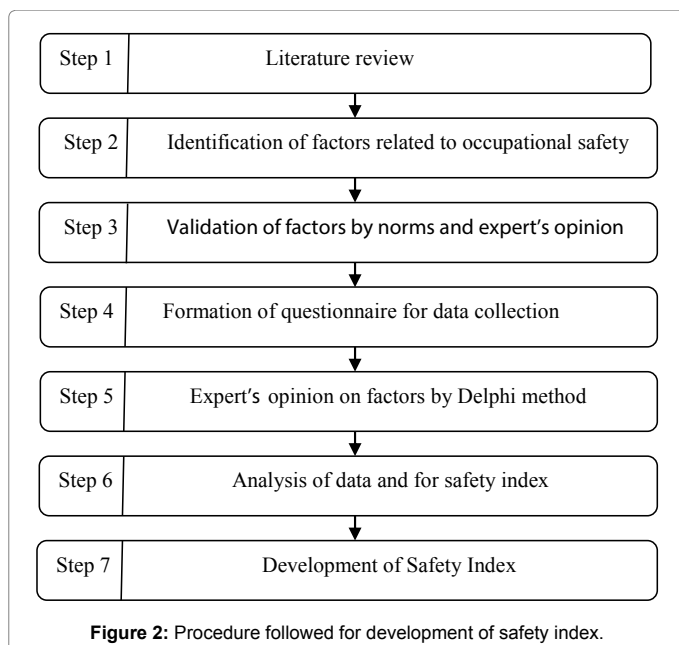
9 major (Organizational Attributes, Occupational Safety Services/documentation, Workplace Layout and Housekeeping, Equipment & Hand Tools Safety and Machine Guarding, Fire Prevention, firefighting and electrical safety, Material Handling and Storage, Occupational Exposures, Personal Protective Equipment (PPE) and Hygiene Factors) and 42 minor factors were identified and validated using CVI (content validity index). Table 1 represents the identified factors.

Content Validity Index (CVI)

Content Validity Index (CVI) is a method used to validate the content, or in other words, used to check whether the factors coverall the disciplines for concerned area of interest. Six experts participated for content validation from medium scale manufacturing industry. Classification of CVI has been represented in Figure 2.

After the content validity, questionnaire has been developed for expert opinion to develop the safety index using Delphi method (Figure 3) [18-20].

Determination of mean and weight for safety index using Delphi method

Selected valid factors were used to take expert opinion on the developed questionnaire by Delphi survey method. The questionnaire was filled by11 experts on the basis of 5-pointlikert scale i.e., (1=strongly disagree, 2=somewhat disagree, 3=neutral, 4=somewhat agree and 5=strongly agree).

Pi is the experts and Dj is the factors as fij where i=1 to 11 and j=1 to 16. Where i mean number of experts and j means the number of factors.

The calculation method has been represented in Table 2.

There are several steps while doing the Delphi Survey:

1.   Select the relevant experts of the respective fields, who will fill out the survey anonymously.

2.   The researcher has to conduct the survey.

3.   The same experts are asked to fill out the questionnaire again by giving them the feedback that, how many of experts give the points to which of the indicators.

4.   This procedure aims to assure that, the awareness of the expert view on the given questionnaire. These steps will be iteratively repeated as long as the experts do make changes on their judgments.

After this Delphi survey, we have to apply the below formula for the development of safety index [20-24].

$$SI = \sum_{i=1}^{n} w_i \sum_{j=1}^{mi} I_{ij}$$

SI is the safety index, Iij is the value of each indicator within factors

Figure 3: Schematic representation of CVI.
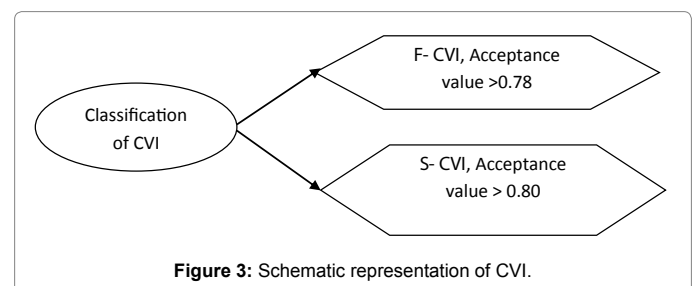
Factors			D_1	D_2	...	D_j	...	D_n	Description
		P_1	f_{11}	f_{12}	...	f_{ij}	...	f_{1n}	
		$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	
Expert:		P_i	f_{i1}	f_{i2}	...	f_{ij}	...	f_{1n}	
		$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	
		P_n	f_{n1}	f_{n2}	...	F_{nj}	...	f_{nm}	...
Mean:	$K_j = \sum_{i=1}^{n} f_{ij/n}$		K_1	K_2	...	K_j	...	K_n	
Weight:	$W_j = \dfrac{K_j}{\sum_{j=1}^{n} K_j}$		W_1	W_2	...	K_j	...	W_n	$K_j = \sum_{j=1}^{n} W_j = 1$

Table 2: Delphi method to calculate the mean and weightage.

Calculation of Content Validity Index	Value
Main Factors	09
Total Sub Factor	40
Factors Having F-CVI > .078	37
Mean F-CVI	36.32
S-CVI	0.98

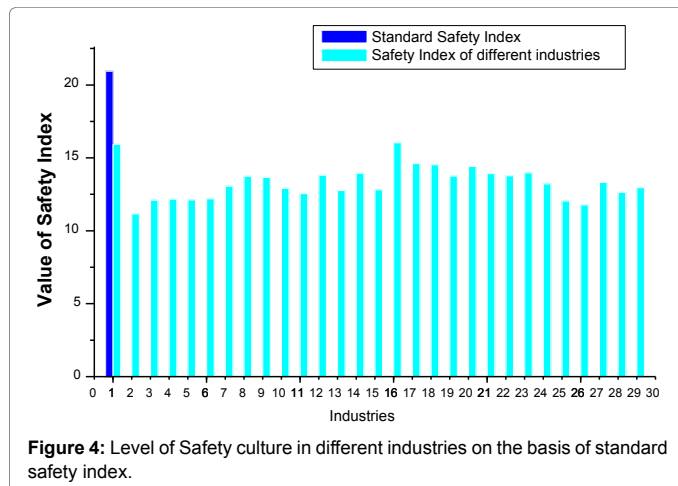**Table 3:** F-CVI and S-CVI values for validation of factors.

Figure 4: Level of Safety culture in different industries on the basis of standard safety index.

i, wi is the weight of factors *i, n* is the total number of index factors, *i* identifies each factor, *j* identifies each indicator within factor *i, mi* is the number of indicator in each factor [24-28].

Result and Discussion

By conducting CVI, nine factors and thirty-seven sub factors that are necessary to be in the workplace for the safety of the worker were finalized on the basis of standard acceptance values of F-CVI and S-CVI i.e.,(F-CVI >0.078 and S-CVI>0.98). Numerical values of F-CVI and S-CVI for validation of above said factors have been represented in Table 3.

The mean values of the score obtained for all the factors and sub factors related to occupational safety in medium scale manufacturing industries of Punjab has been represented in Table 4. As per expert opinion mean and weightage of all the factors were obtained and the data was utilized for the development of safety index. Mean and weight values of a particular factor represented its importance and contribution in operational safety culture. As per the data represented in Table 4, Personal Protective Equipment (f_8) and hygiene factors (f_9)

were considered as most important factors (highest mean and weight values) of occupational safety. The calculated value of safety index using Delphi method was 21.02 (Table 3).

Industrial implementation of safety index

A questionnaire consisting of 37 questions was designed to check the level of safety in 30 medium scale manufacturing industries of punjab. 10 workers per industry participated in the process of examining the reliability of safety index. The maximum value of sfatey index was found equal to 16.04 and the minimum value was 11.16. the average value of safety index in 30 different industries was 13.29 and the value was quite less as compare to stanard safety index (21.02) (Figure 4).

So the occupational safety culture among the medium scale manufacturing industries of punjab is very poor and it has been observed that it lacks in following safety factors:

- Personal Protective Equipment (PPE)
- Occupational Safety Services
- Organizational Attributes

The above said factors should be taken care of and consistancy in the remaining factors is required in order to provide safe and healthy working environment among the workers.

Conclusion and Future Scope

Conclusion

Saftey index is developed for the medium scale industries of punjab using Delphi method, and the value of stanard SI was found to be 21.02. On analysing the relaibilty of SI among the MSMI of Punjab, it was observed that safety culure was very poor and the operational safety of workers lacks primarily in four major and nine sub-factors. Operational safety of workers should be considered as a major concern and the improvement in safety factors is recommended for the better safety culture in the medium scale manufacturing industries of punjab.

f_i	Factors	Mean	Weight	f_{ii}	Sub-Factors	Mean	Weight
f_1	Organizational Attributes	4.5	0.1073	f_{11}	Requirement of Safety and health policy	4.7	0.344
				f_{12}	Requirement of safety department	4.5	0.325
				f_{13}	Qualified safety specialists/officers/engineer	4.5	0.331
f_2	Occupational Safety and Health Services/documentation	4.7	0.1105	f_{21}	Facility for periodical medical examination	5	0.178
				f_{22}	Provision of Health/medical insurance	5	0.178
				f_{23}	Provision of first aid services	5	0.178
				f_{24}	Documentation of safety program	4.9	0.175
				f_{25}	Records of accident and injury	3.3	0.117
				f_{26}	Need of absenteeism records	4.9	0.175
f_3	Workplace Layout and Housekeeping	4.4	0.1048	f_{31}	Adequate and smooth material flow	4.6	0.262
				f_{32}	Safe and smooth production line layout	4.3	0.241
				f_{33}	Neat and clean floors, walls and ceilings	4.5	0.251
				f_{34}	Provision of proper disposal of waste	4.4	0.246
f_4	Equipment & Hand Tools Safety and Machine Guarding	4.6	0.1096	f_{41}	Need of periodic inspection	4.5	0.246
				f_{42}	Availability of proper machine guards	4.6	0.251
				f_{43}	Proper space for hand tools storage	4.5	0.246
				f_{44}	Provision of training programs for hand tools and equipment use	4.8	0.261
f_5	Fire Prevention, firefighting and electrical safety	4.8	0.1131	f_{51}	Provision of fire detection system	5	0.149
				f_{52}	Provision of alarm system	4.6	0.138
				f_{53}	Need of firefighting training and emergency plan	4.5	0.136
				f_{54}	Need of extinguishing system	4.7	0.141
				f_{55}	Provision of emergency Exit and exit signs	4.8	0.144
				f_{56}	Covered electrical cables	5	0.149
				f_{57}	Proper electrical wiring	4.8	0.144
f_6	Material Handling and Storage	4.8	0.1149	f_{61}	Provision of safe and proper type of truck	4.8	0.249
				f_{62}	Safe cranes and conveyors	4.7	0.244
				f_{63}	Need of inspection schedule	5	0.258
				f_{64}	Provision of safe storage and stacking	4.8	0.249
f_7	Occupational Exposures	4.4	0.1045	f_{71}	Skin contact with liquid chemicals	4.4	0.246
				f_{72}	Exposure to noise and vibration	4.4	0.246
				f_{73}	Exposure to high thermal conditions	4.3	0.241
				f_{74}	Monitoring of occupational exposures	4.7	0.267
f_8	Personal Protective Equipment (PPE)	5	0.1176	f_{81}	Adequate provision of PPE	5	0.252
				f_{82}	Proper types and use of PPE	4.8	0.243
				f_{83}	Proper maintenance of PPE	5	0.252
				f_{84}	Adequate training on PPE usage	5	0.252
f_9	Hygiene Factors	5	0.1176	f_{91}	Availability of safe drinking water	5	0.252
				f_{92}	Availability of clean bathrooms, toilets, urinals	4.9	0.248
				f_{93}	Availability of rest area, canteen and closets	4.9	0.248
				f_{94}	Provision of proper lighting and ventilation	5	0.252

Table 4: Weight and mean values of factors and sub factors for safety index.

Future scope

• A similar application can be devised, developed and analyzed by replacing the medium scale iron and steel industry with another type of industry i.e. hand tool industry, fastener industry.

By taking the different kind of factors into consideration like vibration effect, hearing effect, temperature effect, etc. we also can proceed for further research.

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