SURESH CHANDRA SUMAN
and
PRAMOD PATHAK

Human errors: analysis of 96 serious accidents of an Indian coal company using human factors analysis and classification system (HFACS)

Coal is chief source of energy in India and accounts for 55% of country's energy need (www.coal.nic.in). Indian coal mining industry is manpower-intensive. Despite majority of coal mining is done by public sector coal companies, accident rates remain high compared to other major coal producing nations (except China). Human failures have been found to be major attributes of coal mining accidents. To identify human errors in accidents 96 fatal and serious accidents befell between 2009 and 2014 in a large public sector coal company of central India were analyzed on human factor analysis and classification system - mining industry (HFACS-MI). Analysis revealed that violations, skill based errors, decision errors, inadequate leadership and physical environment were the major contributing factors. These findings stress upon the need to focus on reduction of human errors during mining operations to arrest present trend of accidents. The results of the study represent a preliminary findings and subsequent detailed study is required to pinpoint activity-wise human failures.

Keywords : Accidents; coal mining; human errors; human factor analysis and classification system - mining industry (HFACS - MI)

1. Introduction

1.1 Background

Mining is considered a hazardous operation (Mitchell et. al. 1998; Patterson and Shappell, 2010; Quanlong et. al. 2016). Accident rate in the mining industry is found to be higher than other industries (Bennet and Passmore, 1984; Patterson and Shappell, 2010; Lene, M.G. et.al., 2012; Harris, J. et. al. 2014). They do happen with nagging frequency because mining is an attempt to destabilize nature (Paul, P.S., 2009; Pathak and Pathak, 2012). More so in coal mining (Geng and Saleh, 2015). The inherent chemistry of coal makes it more hazardous and naturally worst fears come true; in the form of explosions, fires, subsidence, strata failures and inundations that kill and maim scores (Prasad, 2003).

Reports of accidents have been observed since organized mining of coal began in India in the early 19th century in Raniganj coalfields. The government initiated legislative measures for mine safety in 1895. The first major Indian coal mining accident in record occurred in 1899 in Khost coal mine (in Baluchistan, now in Pakistan) killing 47 people (Naik and Basavaraj, 2013). The Indian Mines Act was enacted in 1901. The objective of this Act was to regulate mining and to make mining operations safer. Legislative measures continued to be enacted since then. Nevertheless, yearly average of coal mining fatalities during 2011-2015 is 75 (www.dgms.gov.in) which is a matter of concern.

Thus, safety needs to be a major concern for the companies engaged in coal mining. More so, because more than 90 per cent of coal mining in India is carried out by public sector coal companies (www.coal.nic.in) which are supposed to be model employers.

There have been regular accidents and mostly these have been found to occur because of the act of omission or commission. A case in point is the set of twin accidents/ incidents of inundation in the year 2001 in the mines of Jharia coalfields namely Chaitudih and Bagdigi (Pathak and Kumar, 2001).

The overall safety statistics of Indian coal mines has significantly improved in last few decades. In terms of the death rate per 1000 persons employed (herein after called fatality rate), it has fallen from 0.50 in 1973 (the year of nationalization of Indian coal mining industry) to 0.20 at present. But the number is still alarming and needs attention.

1.2. Human Errors

Human is an essential element of coal mining activities (Jianhua and Xiaoyan, 2014) and the tendency to err is a pervading human trait (Wiegmann and Shappell, 2001). Human failures are genesis of accidents and incidents (Ergai et al., 2016). Errors of various kinds in industries affect the quality of work that people do and contribute to injuries and fatalities (Pathak and Pathak, 2012; Kumar, P. et al., 2016). Almost 2.3 million employees die of accidents and diseases related to works and over 474 million people are victims of occupational disease and non-fatal accidents (Pillay, 2015). In almost all domains, accidents have been attributed to human failures (Lardener and Scaife, 2006). From aircraft accidents to road and rail accidents to marine accidents,

Mr. Suresh Chandra Suman, GM/PH, Talabira Project, NLC India Ltd., Sambhalpur, Odisha and Prof. Pramod Pathak, HoD, Management Studies, IIT (ISM), Dhanbad 826004

empirical evidence suggests that human error has always played a significant role (Prasad, 2003). According to US Department of Transportation 70-80% of all aircraft accidents can be attributed to human error (Shappell and Weigmann, 2000). Human errors were found to be responsible in 75-96% of marine casualties (Rothblum, 2002). Ministry of Road Transport and Highways, Government of India has identified that 80.8% of road accidents in India in the year 2013 are due to human faults (www.morth.nic.in). The Directorate of Rail Safety, Ministry of Railway, Government of India, in its report has stated that during 1994-2004 failure of railway staff has contributed 62% of all rail accidents and 22% that of caused due to failure of other than railway staff (Amitabh, 2004). Human factors found to be responsible in accidents of all spheres. Logically, it should be true of mining accidents, too.

1.3. Accidents in coal mines

Accidents take place right from space to below earth's surface. Happening of accidents on the earth's surface that include industrial accidents and transport accidents are frequent. Working in mines is considered to be hazardous due to very nature of the mining activities going on below the earth's crust at different depths (Pathak and Pathak, 2012). Since mining activities are different from that of other industrial activities on surface of the earth, the nature of accidents took place also differs from the latter. Some unsafe conditions prevailing in the mines are enumerated as below:

- Inadequate support of roof and sides.
- Poor strata condition or loose rocks.
- Accumulation of water or slurry.
- Handling of overburden and coal.
- Heavy earth moving machines (HEMM).
- Defective equipment, tools or supplies.
- Congestion of the work place.
- Less than adequate (LTA) barriers/warning signals.
- Difficult ingress & egress and poor housekeeping.
- Hazardous atmospheric condition (inflammable and noxious gases, dust, fumes etc.).
- Excessive noise.
- Poor illumination.
- Poor ventilation.
- Electricity.
- Explosives.

Involvement of human errors in such unsafe conditions aggravates the situation and increases the probability of happening of accidents.

A comparison of coal production for Australia, China, India, South Africa and USA during 2011 and coal mining fatalities of respective countries between 2006 and 2010 indicated in Table 1 and Fig. 1 depict comparative safety statistics of these countries (Harris, J., et al., 2014).

Table 1 : Comparison of coal production and coal mining fatalities

Country	No. of coal mines	Coal production in 2011 (in million tonnes)	Coal mining fatalities between 2006 and 2010
Australia	135	415.5	8
China	18557	3520	3532
India	572	588.5	519
South Africa		255.1	85
USA	1325	993.7	177

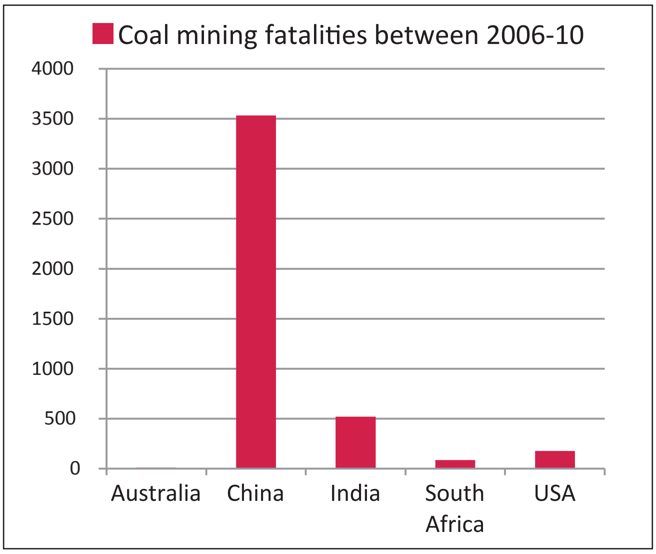

Fig. 1: Comparison of fatalities

Indian coal mining industry was nationalized in 1973 to prevent unscientific mining practices and poor working condition of miners, to improve safety standards and to increase coal production to meet the energy requirement of the country (www.coalindia.in). Accident data suggests that death rate has fallen steadily and has been possible for significant improvements made in safety legislation and other promotional measures to arouse safety awareness among mine employees (Kejriwal, 2001). The data (www.dgms.gov.in) indicated in Table 2 and Fig. 2 supports the statement.

Table 2 : Trend in fatal accidents in Indian coal mines (ten yearly average) and fatality rate (per thousand persons employed)

Serial No.	Period	Average no. of accidents	Accident rate	Average no. of fatality	Fatality rate
1.	1961-70	202	0.49	259	0.62
2.	1971-80	187	0.40	264	0.55
3.	1981-90	162	0.30	185	0.34
4.	1991-00	140	0.27	170	0.33
5.	2001-10	87	0.22	108	0.27
6.	2011-15	72	0.20	75	0.21

The statistics explains that fatal accident rate (per thousand persons) in India is almost constant since last 15 years.

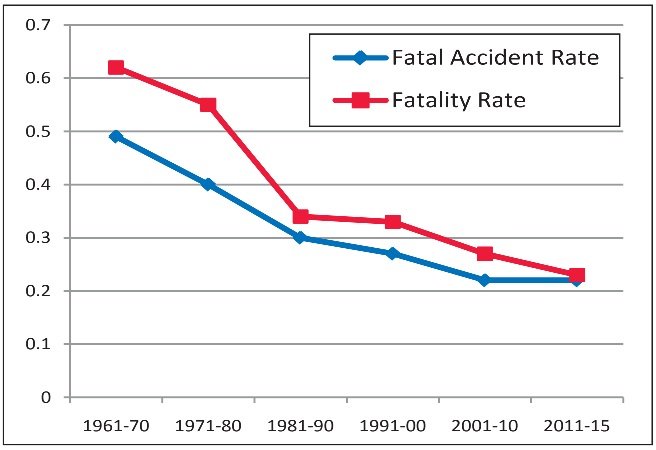

Fig. 2: Fatal accident and fatality rate in coal mines

Comparison of accident data depicted in Table 1 concludes that fatal accidents in India are high in comparison to major coal producing nations sans China (Geng and Saleh, 2015).

1.4. Rationale

Coal is the kingpin of Indian energy security and the focus of the Government is to increase production. The government has assigned Coal India Ltd (A Government of India Undertaking), major coal producing company, to achieve 1 billion tonne of coal production by 2019-20 from present level of 555 million tonne (www.coalindia.in). Other coal companies are also ramping up their coal production to meet the future energy demand. More production means more number of new projects, more deployment of manpower in mining operations and more mechanization. All these may make the industry more obsessed with production and at times lead to neglect of safety increasing the vulnerability of the coal mining industry to accidents.

1.5. Objective

Against the backdrop of above rationale the objective of the study was to review accidents of the past in the coal industry and identify the human components in those accidents.

2. Study

The statistics of accidents of last 6 years of a large public sector coal company of central India, having its mining operations in central India coalfields, Korba coalfields and Mand Raigarh coalfields were studied to find the attributes responsible for large number of accidents. It is an established fact that accidents cannot be attributed to a single cause or a single individual (Heinrich et al., 1980). Adverse working conditions of coal mines lead miners to be exposed to hazards like inundation, methane explosion, coal dust explosion, carbon-mono-oxide poisoning, electricity, dump failure, side failure, explosives and strata failure. Even after presence of these hazards in coal mines, the majority of accidents attribute to human errors (Michell, 1998; Chen, H. et al., 2012; Qing-gui, C., et al., 2012). US Bureau of Mines has found that almost 85% of all mining accidents can be attributed to at least one human error (Rushworth et al., 1999). In Australia two third occupational accidents are attributed to human errors (Williamson and Feyer, 1990). A study by Chen Hong et al. (2005) suggests that human factors accounted for 97.67% of all major accidents in Chinese coal mines between 1980 and 2000. Therefore it may be inferred that miners are more deadly than anything else in the mines. With high ratio of incidents and accidents attributed to human factors, it would be significant to include human error as contributing factors in all coal mining accident investigations (Patterson, 2009).

3. Method

Indian mining statute does not define accident. However, it defines fatal accident and serious accident. A fatal accident is defined as an accident which results in death of one or more persons and a serious accident as an accident which results in serious bodily injury to one or more persons. Serious bodily injury is, further, defined as injury which involves the permanent loss of any part of the body or the permanent loss of or injury to the sight or hearing or any permanent physical incapacity or the fracture of any bone or joint (Kejriwal, 2001). Indian coal mining industry and mine inspectorate maintains the statistics for fatal and serious accidents along with dangerous occurrences. Details of coal production, man-shifts deployed, fatal and serious accidents of the public sector coal company studied are as tabulated in Table 3 and Fig. 3.

Table 3 : Year wise accident statistics of a public sector coal company of Central India

Year	Coal production (in million tonne)	Man shift deployed (in million)	Serious accidents	Fatal accidents
2009	103.56	18.65	47(50)	9(9)
2010	111.78	18.07	52(62)	19 (33)*
2011	112.89	17.67	61(62)	11(11)
2012	118.48	17.46	43(45)	10(11)
2013	121.75	17.52	39(40)	13(13)
2014	126.56	16.85	31(32)	11(12)
2015	134.22	16.24	33(35)	10 (10)

**There was an explosion in an underground mine with 14 fatalities*
***Figures in bracket shows number of persons affected*

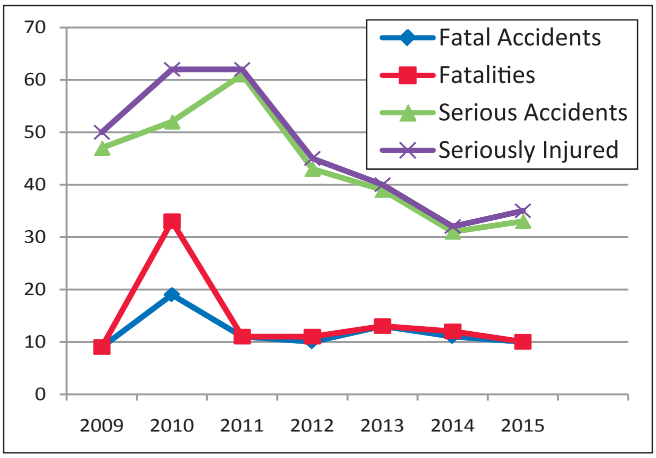

Fig. 3: Graph showing fatal and serious accidents

The coal mining company under study is operating with 89 mines (19 opencast and 70 underground) and managed through 13 administrative areas headed by area general managers. It has produced 134.22 million tonne of coal in 2015 and number of persons employed in the mines during the period was 65711 (excluding contractual manpower). The organization is having two tier accident inquiry systems. Fatal accidents and accidents with high potential to damage are inquired by safety personnel of corporate office and accidents which have caused only serious injuries are inquired by that of the mine. Besides, fatal accidents are also inquired by mine inspectorate. Statistics, data and accident inquiry reports maintained by corporate office were mulled over for subject study.

Wiegmann and Shappell (2000) developed HFACS to investigate and analyze human errors in US army. Seeing its validity, he used it for aviation industries. Later on the framework was used in other industries and researchers proved its validity (Ergai et. al., 2016). In 2009, J. Patterson adapted the HFACS framework for mining industries and called it HFACS-MI. HFACS-MI was successfully used for analyzing mining accidents occurred in Australia and the US. The framework was utilized for studying accidents in underground and opencast metal/non-metal mines; underground and opencast coal mines and quarries of Australia. Indian coal mining industry is manpower intensive and majority of mines are run by state run organizations. Moreover, the people at grassroots are not that educated and trained so hazards are somewhat different and hence human errors involved are to be recalibrated. In order to investigate human errors in Indian coal mining industry the authors took effort to modify the framework developed by Jessica Patterson (2009) and framework is named as Human Factor Analysis and Classification System-Coal Mining (HFACS-CM). The subjects of different tiers of HFACS-MI have not been changed however nano-codes/causal factors have been modified as per the validity/relevance for the industry under analysis. The nano-codes found to be pertinent were left unaltered and causal factors not applicable for the industry were deleted.

To diagnose the behaviour aspects of accidents of the coal company, brief description and inquiry report of fatal accidents and accidents not caused fatal injury but having the potential to cause fatal befell from 2009 to 2014 were examined afresh. During the period 96 such accidents occurred. Out of 96 accidents 73 caused 89 fatalities rest 23 were serious in nature like accidents caused due to poor handling of explosives, blasting of overburden/coal, toppling of heavy earth moving machinery etc. These accidents were inquired by safety personnel of corporate office due to seriousness of accidents. To deduce the role of human factors, those 96 accidents were analyzed on human factors analysis and classification System (HFACS) developed by Shappell and Weigmann (2003) for use with the aviation accidents and further modified by Jessica Patterson (2009) to better correlate to Mining Industry. The modified framework is termed as human factor analysis and classification system-mining industry (HFACS-MI). The original HFACS framework (Weigmann and Shappell, 2001) describes 19 causal categories which are extension of Reason's four levels of human failure. HFACS-MI framework (Patterson, J., 2009) is a further extension with 20 causal categories customized to suit investigation of mining accidents. The codes of 20 causal factors ascribed in two or more than two cases are indicated in Table 4. The figures in brackets show the number of accidents for which the particular code was analyzed as attribute.

Table 4: HFACS-MI with codes of causal factors

Unsafe/Inappropriate Acts	Skill Based Errors	Failure to recognize hazard (5)
		Improper position for task (5)
		Inadvertent operation mechanically induced (5)
		Improperly maintained equipment/vehicle (4)
		Failure to use horn (4)
		Failure to recognize self in line of fire (4)
		Operating vehicle at incorrect speed (3)
		Incorrect application of procedures (3)
		Failure to apply safety device (2)
	Decision Errors	Failure to take action against known hazards (11)
		Failure to recognize hazardous condition (6)
		Working in unsafe area (3)
		Working under unsupported ground (3)
		Failure to gain authorization before beginning task (3)
		Improper attempt to save time (3)
		Improper procedure (3)
		Inappropriate maneuver (3)

Unsafe/Inappropriate Acts	Decision Errors	Caution/warning ignored (2)
	Perceptual Errors	Misjudged surface condition (5)
		Misinterpreted warnings (2)
	Violations	Disregard for SOP/Permission orders (25)
		Entry into unauthorized area (10)
		Violations of training rules (5)
		Improper proximity to equipment or vehicle (4)
		PPE not used (4)
		Taking shortcuts (4)
		Failure to wear seatbelt (3)
		Operating vehicle/equipment at epeeds greater than posted limit (2)
Preconditions for Unsafe Acts	Physical Environment	Inadequate ground control/loose strata (17)
		Explosives (6)
		Energized electrical equipments (4)
		Poor housekeeping (4)
		Inadequate lighting (3)
		Fire or explosion (2)
		Slippery roadways (2)
	Technological environment	LTA or defective fencing/guard (2)
		LTA or defective warning signs (2)
		Defective equipment/tools (2)
	Condition of miners	Overconfidence (4)
		Carelessness (4)
		Sleep deprivation (4)
		Drowsiness/sleeping while on duty (3)
		Perceived haste to complete task (2)
		Lack of competency (2)
		Inexperience with job task (2)
	Personnel Factors	LTA communication of hazards (4)
		LTA communication between miners and leadership (3)
	Fitness for duty	Hung over at work (2)
Unsafe Leadership	Inadequate Leadership	Inadequate monitoring of work (12)
		Failure to conduct worksite inspections (4)
		Lack of accountability (3)
		Failure to perform adequate risk assessment (3)
		Leadership unaware of risks associated with task (2)
	Planned inappropriate operations	Inadequate hazard assessment (2)
		Inadequate working plan (2)
		Inadequate maintenance planning/scheduling (2)
	Failure to correct known problems	Inadequate correction for prior safety hazards (4)
	Leadership violations	Failure to initiate corrective actions (3)
		Inadequate identification of work place hazards (2)
		Violations of SOPs, policy and procedures by leaders (13)
		Inadequate inspection (5)
		Authorized unnecessary hazards (4)
		Failure to enforce rules and regulations (4)
		Authorized unqualified worker to perform tasks (2)

Organizational Influences	Organizational process	SOPs inconsistent with work practices (17)
		Lack of SOPs (3)
		Lack of working involvement with SOP creation (2)
	Organizational climate	Safe organizational climate not established ((6)
	Resource Management	Excessive cost cutting (1)
Outside Factors	Regulatory Factors	No data was available
	Other Factors	

4. Process

The inquiry report of each accident was studied, discussed and analyzed by a team comprising the author, one mining personnel working in coal mining industry for more than 15 years and one personnel from human resource who was engaged in imparting training to mine workers and supervisors. The mining engineer involved in analysis was working with safety department of the organization and involved in inquiring accidents. The inquiry reports comprised headlines namely description of events prior to accident, occurrence of accident, inquiry findings, responsibility and how the accident could have been averted. After detailed deliberations of each inquiry report human factors were identified and classified in HFACS-MI framework.

5. Results and discussion

5.1. Overall Results

As stated earlier all the accidents analyzed were serious in nature and consequence of most of them were fatalities. During the analysis it has been found that majority of them are the result of two or more types of human failures. The analysis supports the Reason's Swiss Cheese Model of human error causation (Reason, 1990). One fatal accident was found to have been the result of 9 human failures. The number and percentage of causal factors are tabulated in Table 5. The percentages at each level can add up to more than 100% as more than one human factor could have been contributing to one accident/incident. Out of 96 accidents, violations were pointed out in 65.63% cases. Skill based errors were found in 55.21% cases and decision errors in 50% cases of accidents. Physical environment were responsible in 46.88% accidents. Inadequate leadership was observed in 38.54% cases. Operational processes were found to be responsible for 30.21% accidents. Because outside factors were not deliberated in the inquiry reports, attributes of outside factors in accidents could not be determined.

5.2. Unsafe/Inappropriate Acts

Unsafe/inappropriate acts of employees have been categorized into errors and violations (Reason, J., 1990). Errors can be explained as those activities outcome of which are not intended whereas violations are behaviour with willful disregard or disobedience for rules, regulations or/and SOPs

TABLE 5

	Causal factors	No. of Cases (N=96)	% of Cases
Unsafe/inappropriate acts	Skill based errors	53	55.21
	Decision errors	48	50.00
	Perceptual errors	12	12.50
	Violations	63	65.63
Preconditions for unsafe acts	Physical environment	45	46.88
	Technological environment	10	10.42
	Adverse mental state	23	23.96
	Adverse physiological state	6	6.25
	Physical/mental limitations	3	3.13
	Communication, coordination and planning	11	11.46
	Personal readiness	4	4.17
Unsafe leadership	Inadequate leadership	37	38.54
	Planned inappropriate activities	13	13.54
	Failed to correct known problems	15	15.63
	Leadership violations	31	32.29
Organizational influences	Resource management	4	4.17
	Organizational climate	6	6.25
	Operational process	29	30.21

(Weigmann and Shappell, 2001). Improper positioning of support personnel or/and support equipment during support of the roof in underground mine is an error and not supporting the roof/strata before other mining operation is a violation.

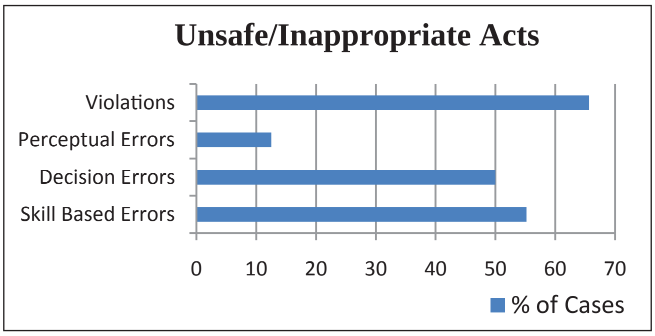

Fig. 4

Violations, skill based errors and decision errors were observed to be the main contributing factors in accidents studied.

5.2.1. Skill based errors

These are the errors arisen out of failure of memory, attention or technique. It occurs because of little or no conscious thought. In an underground mine a person from material handling crew went with the roof dresser to open a cable hanger fastened from a roof bolt fixed to support the roof. In course of opening the cable hanger, a sand stone layer measuring 1.2 meter × 0.75 meter × 0.6 meter fell over the Roof Dresser from a height of 3.1 meter and he succumbed to his injury. As a roof dresser he was expert in checking and dressing the loose layers of rock but he failed in doing so and lost his life. This is a classic example of skill based error. Carrying out work without checking roof condition in underground mines has become the main reason of roof fall accidents in the organization under study. Failure to use horn by the vehicle operator at corner/sharp curve was another example of skill based error. Some other prevalent skill based errors were found to be improper position for work and incorrect application of procedures.

5.2.2. Decision errors

Also termed as honest mistake, decision errors are outcome of poorly executed procedures, inadequate job knowledge or poor choice. A working area was fenced in an underground mine for poor roof condition, but the fencing was not properly and effectively made. During blasting operation of another area in close vicinity a worker took his shelter at a place after crossing the fencing. Due to vibration in the roof out of blasting, which was already in poor condition, a layer of rock measuring 2.0 meter × 0.75 meter × 0.3 meter fell over him and the person succumbed to his injuries. Putting inadequate fencing and choosing an improper place for taking the shelter during blasting operation are decision errors for which the miner got killed. An electrician fell from the ladder while fixing a street light without using safety belt and received fatal injury because of decision error. Improper inspection of mining operation sites by mining supervisor before start of the shift can be categorized into decision errors. Failure to take appropriate action regarding known hazards and failure to recognize hazardous condition were observed to be two most frequent decision errors.

5.2.3. Violations

Willful disregard for the rules, regulations or orders that govern safe operations are violations (Shappell and Weigmann, 2000). Indian coal mining industry is having prescriptive legislations (Paul, P.S., 2009). The provisions of Indian Mines Act-1952 and Indian Coal Mines Regulation-1957 and orders made thereunder are to be followed by each coal mining establishment. For different mining operations permissions are to be obtained from Directorate General of Mines Safety (DGMS). DGMS stipulates different precautions and provisions while granting permission. Standard Operating Procedures (SOP) of regular mining activities are to be framed by the mine management and approved by DGMS. Disregard of SOPs and permission orders was analyzed as largest violations and in 25 of the accidents this was one of the causal factors. One such accident caused in an underground mine while 3 drill operators were drilling shot-holes with hand drill at coal winning face. In course of drilling of a shot-hole the drill-bit encountered a misfire shot-hole and exploded the explosives lying therein resulting injuries to 3 drill operators. Regulations and SOP to detect and deal with misfire was violated and accident happened. Next most frequently occurred violation was entry into unauthorized areas.

5.3. Preconditions for unsafe acts

5.3.1. Environmental factors

By virtue of its operations for exploitation of minerals the environments that miners work in keep on changing. The tough and changing environment of the mines are usually hostile and difficult. As shown in Fig.3 physical environment is single largest precondition for unsafe acts. Indian underground mining is a manpower intensive industry. Deployment of large manpower at working place exposed them to harsh and hostile working environment and that became one of the reason of more fatalities in underground operations. Out of 89 fatalities studied during 2009-2014, 62 fatalities were caused during underground operations and 26 were the results of roof/side falls. It was inferred that ground movement was the single largest preconditions for unsafe acts. Besides, majority of coal production comes from blasting and so explosives related accidents are also frequent. After blasting due to intense vibrations strata got dilated and even after support of strata sometimes rocks/coal got dislodged and caused accidents.

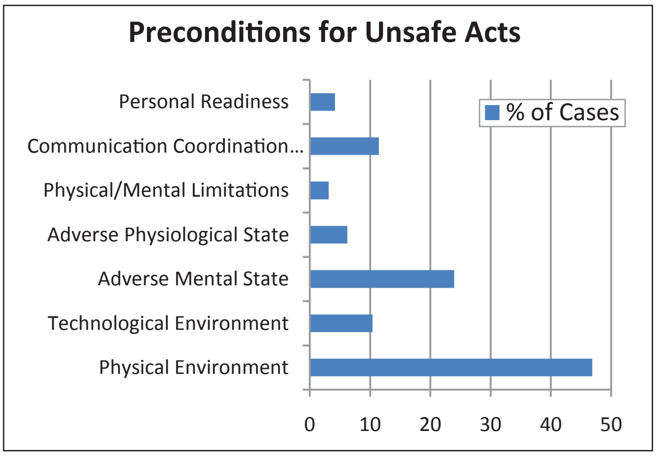

Fig. 5

5.3.2. Condition of employees

5.3.2.1 Fatigue factors

High workload, intensity of work beyond the employee's scope and/or unreasonable work plan causes fatigue to the employees. Fatigue employee used to have decreased alertness and so increases the occurrence of human errors (Wenwen, S. et al., 2011). Because of increased cost in departmental operations, many of the mines were having outsourced operations in overburden removal, surface coal transportations, material transportation and civil works. Longer working hours, fatigue due to lack of rest and high workload were observed to be the reasons of accidents.

5.3.2.2. Biological clock factors

Mining operations were carried out round the clock and as such employees were to work in shifts. Biological clock reduces the alertness and reflection at workplace during night hours and so fatigue and drowsiness happens more easily and causes accidents out of wrong operations (Wenwen, S. et al., 2011). There were 9 fatal accidents caused due to fatigue related to lack of rest or sleeping on duty or drowsiness and 7 have occurred between 10 pm and 6 am.

5.4. Unsafe leadership

Indian mining statute stipulates three tier workplace supervision - assistant manager, overman and mining sirdar. These supervisors should possess respective valid certificates issued by DGMS. The organization under study follows the same hierarchy of mine working supervision. Despite provision of such a close system of supervision accidents found to have happened due to inadequate leadership in quite a high number of cases. Accidents were analyzed to happen due to inadequate monitoring of work, failure to conduct worksite inspection and leadership failed to correct known problems. The organization under study was a government organization so complacency in leadership might be the reason of such a poor performance by frontline supervisors and requires verification with separate study. Leadership violations were also observed wherein it was found that leadership failed to enforce rules and regulations. In 14 of the cases leaders themselves violated the Standard Operating Procedure(SOP) and laid down procedures.

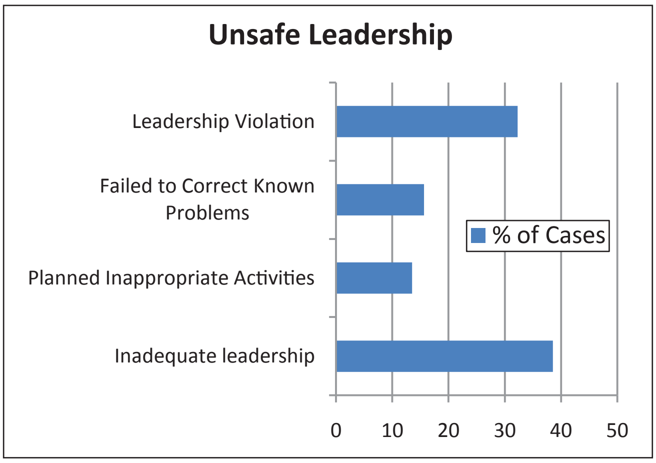

Fig. 6

5.5. Organizational influences

The influence of organization was visible in safety culture of the operational process. Human failures were found in organizational processes for which accidents occurred. Most frequent failures were SOPs inconsistent with work practices and lack of working involvement with SOP creation. During visit of some of the coal mines by the authors it was observed that majority of the miners were local villagers and most of them were either uneducated or without any school qualifications. However demographic survey is required to ascertain the population. Good education level of miners play an important role. Educated workforce understands safety instructions and avoids errors in his day to day works (Kaihuan and Fuchuan, 2012). Vocational trainings provided to them were not effective for want of formal education. In preparation of SOPs involvement of miners was not sufficient as a result there remained a gap in implementation of SOPs in hazardous operation.

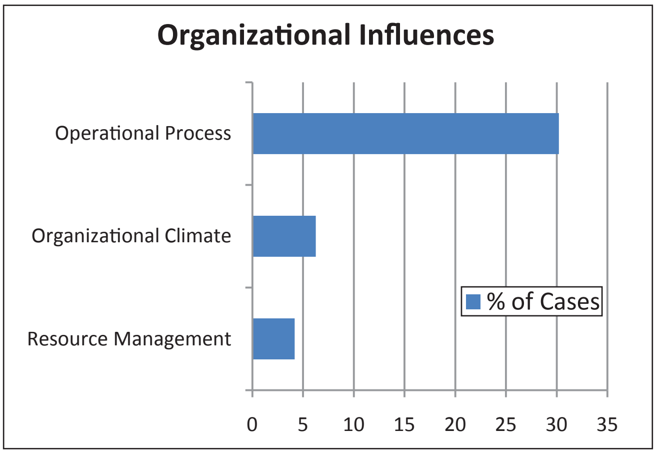

Fig. 7

6. Limitations

The study was carried out on the basis of literature prepared by Internal Safety Organization (ISO) of the coal company for inquiry of the accidents. Detailed reports were not collected from the persons involved in the accidents or from the mines. Many an accidents which happened during the period but not investigated by ISO were not analyzed due to absence of their details at the corporate office. The study was carried out with one coal company so findings should be generalized with caution.

One psychologist, one personnel from human resource development and two mining engineers having experience to work in safety department were involved in human factor analysis of the accidents. Ideally involvement of personnel with expertise in human error analysis would have been better.

7. Conclusions

This paper depicts the trend of accidents in Indian coal mining industry and comparison with that of major coal producing nations. Present trend of accidents in the industry requires immediate attention. The paper analyzes accident causes on human factors analysis and classification system. The study identifies that HFACS-MI is a good tool to identify the human factor causes in coal mining accidents. Presently accident inquiry is conducted with more stress on system failures. Human failures should also be analyzed during inquiry of accidents. Identification of errors have been made on the basis of accidents occurred. Further study/evaluation is required for operation-wise type of human errors involved. Identification of human errors will enable the industry to take corrective action. Actionable efforts to reduce human errors would play a big role in arresting present trend of coal mining accidents.

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