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A step toward achieving a zero accident potential in Indian mining industry

Mining has been and continues to be an industry where the concern for miners' safety is of great importance. Even though the mining industry has experienced a considerable improvement in the reduction of accident rates in underground and surface mines, further reduction of accident rates is necessary. In general safety problems in the Indian mining industry in terms of the reduction of accidents and injuries are mainly being addressed through reactive measures of hazard control rather than proactive measures. Though, mining employs one per cent of the global workforce, but it is disproportionately responsible for eight per cent of fatal workplace accidents due to the nature of the work, injuries and deaths which have historically been accepted as an inevitable consequence of mining. With this track record, focus on safety improvement, and all the improvements that have been made over the years, we believe that our industry are in a position to drive for the ultimate goal – that NO ONE is hurt in mines. The tool for achievement is for each manpower company to develop a zero accident potential with their measure of achievement being zero first aids, injuries or illnesses.

Keywords: *International safety status, statistical analysis, safety compliance and outcomes, zero accident potential.*

Introduction

From the last decades of 20th century has experienced a considerable amount of success especially in coal mine safety in India. The mining industry has for many years focused on injury prevention at the workplace through procedures and training, and has achieved considerable success. However, the statistics on major accident events such as fatalities and reportable incidents has not shown the corresponding levels of improvement. Safety problems in the Indian mining industry in terms of the reduction of accidents and injuries are mainly being addressed through reactive measures of hazard control rather than proactive measures. Further, attention is mainly being focused on fatal and serious accidents leaving aside the reportable, minor and near-miss / near-hit incidences which are the potential safety problems in mines. Moreover, the role of human factors at workplaces is ignored, which is a significant factor in determining the level of safety in any given situation.

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Mines safety

Safety is an abstract term, the dictionary defines it as the state or condition of being safe from hurt or injury or less. It is used to denote an absence of risk or hazard. Presence of hazards in a work system is the root cause of occurrence of accident. Hazard is defined as a thing that has potential to cause harm, or a source of danger (Paul, 2012). The well established risk assessment methodology starts with hazard identification. Miners have to work in severe work conditions in narrow openings with substantial heat and humidity, heavy noises and vibration, poor illumination, airborne dust and noxious gases (Verma et al., 2014). Maiti and Bhattacherjee (1999) stated that degree of injury is also an important variable to measure the injury severity, which is also an indirect measure of the cost of an accident. Further understanding of the etiology and circumstances of these injuries will allow engineering controls, administrative controls and perhaps personal protective equipment to be developed to reduce the incident and severity of injuries from falls from equipment (Moore et al., 2009).

National safety status in coal and metalliferous mines

Despite the stringent regulatory provisions, Indian mining industry still continues to pose threats to lives and injuries to miners. Such an impact can only be revealed objectively from the study of accident statistics of the mining industry. According to the Directorate General of Mine Safety report of accident statistics, there were 117 and 101 fatalities and 509 and 52 serious injuries in the year of 2015 in coal and metalliferous mines (DGMS Standard Note, 2016). The national level fatalities, serious injuries and their rates per thousand persons employed since 1951 in coal mines are shown in Fig.1. It may be observed from Fig.1 that the fatality rate excluding disasters steadily came down over the years from 1951 to 1978, and thereafter it remained more or less stagnant. The serious injuries and serious injury rates are also shown in Fig.1. The figure revealed that there have been fluctuations over the years, but the long-term trend was characterized by a steady decrease since 1960 till it became practically stagnant since 1982. On an average, there are 83 and 49 fatal and 729 and 94 serious accidents in coal and metalliferous mines, respectively over these years. The average death rate per 1000 persons employed per year is around 0.26 and 0.42 and that of serious injury rate is around 1.95 and 0.74 in coal and metalliferous mines, respectively. Whereas, the average death rate per 1000 persons employed per year is 0.30 in all mines. Effective surveillance system should be installed in mines for capturing the characteristics of major hazards. The findings of surveillance should be made available to appropriate authorities for immediate actions. The accident/injury experience figures clearly show that for the last 35 years there is no significant improvement in terms of accident/injury occurrences in Indian mines. This is perhaps due to the fact that the traditional approaches to safety through existing engineering control and heavy reliance on class room and on the job (rarely) training have reached its limit of effectiveness in accident/injury reduction. A fresh approach is deemed necessary for further reduction of accidents.

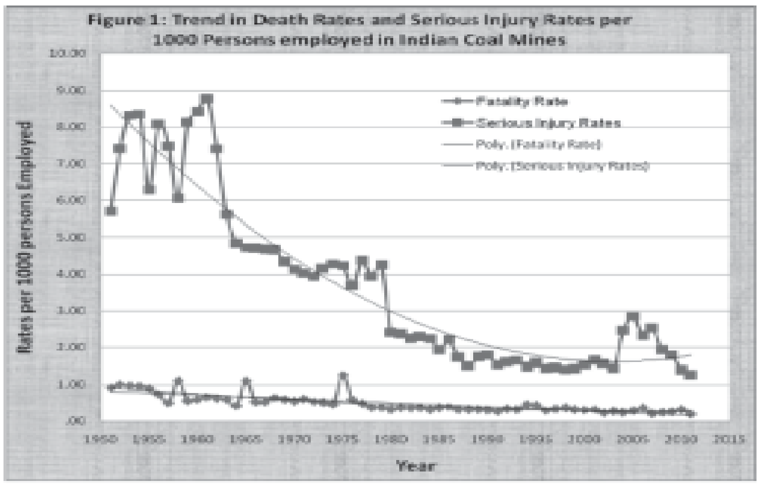


Fig.1 Trend in death rates and serious injury rates per 1000 persons employed in Indian coal mines

Quantitative analysis in mine safety

In this recently developed subject area in the arena of accident research, it remains necessary to develop investigations that help to clarify the influence of technological development on occupational accidents. These, in turn, should help to improve practical safety work and changes to work organization, forms of remuneration, safety systems, or safety regulations. Possession of such information on work safety should also further our capacity to assess, more specifically, the impact of technological development on fatal accidents. The application of these analyses highly depends on the depth of the study, area of application and quality of results. The statistical based analysis primarily dealt with analyzing the fatal and nonfatal accident data based on several factors, such as functional classification of mining activities, equipment related factors, worker's occupation, job activity, tools involved, body parts injured and source of injury.

Occupational health and safety

A major occupational accident is defined as “an accident that causes injuries to three or more persons or causes the death of at least one person at the time it occurs”. Many reasons have been proffered in answer to the question of why the industry has such high accident rates. In view of the fact that virtually all types of work accident involve a combination of multiple factors, it is likely that no single factor can be identified to provide a complete explanation for the high incidence of serious work accidents in all industries.

Apart from the inherently dangerous nature of work, more than 90% of researchers point to worker factors as a crucial issue. This highlights the role of unsafe acts of workers in incidents. 83% of studies, on the other hand, indicate a connection between environmental and equipment factors and accidents. Furthermore, project factors (7.58%) and management factors (8.67%) were also found to be significant. characterized the factors influencing safety performance in the following stark terms: “poor safety awareness of top management”; “lack of training”; “poor safety awareness of project managers”; “reluctance to input resources into safety measures”; and (in general) “reckless operations”. Cheng et al. (2012) indicated that increased safety training; enhanced safety awareness; encouragement to develop a safety management system; and improved safety commitment, are all essential for private property developers to encourage the introduction of adequate effective safety measure to their projects.

International mine safety status

China is now the largest coal producer and consumer in the world followed by USA and India. As the dominant source of energy, particularly, India and China's coal sector underlies their economic and social development. Though, the United States is one of the largest coal producers and consumers in the world, but with regards to coal mine safety production, the United States is far ahead of China and India. In recent years, the annual coal output in the US steadily remains 1.0 billion tonnes or so, with annual fatalities within 30 to 50 which are under controlled. It is revealed from Table 1 that the fatality rate of China’s coal mines 10 times higher than in other developing countries like India and 100 times higher than in the US coal industry. Coal mine safety is a serious problem and is regarded as a top priority for worldwide workplace safety. The assessment of the occurrence of road accidents and the management of

TABLE 1: COMPARISON IN DEATH RATE IN COAL MINES BETWEEN THE THREE LEADING COAL PRODUCING COUNTRIES FOR THE PERIOD 2001-2010

Year	Fatality			Fatality rate per one million tonnes of coal produced			Production in million tonnes		
	USA	China	India	USA	China	India	USA	China	India
2000	38	5,798	144	0.04	5.80	0.43	1073.6	1314.4	334.3
2001	42	5,670	141	0.04	5.11	0.41	1127.7	1458.7	341.5
2002	27	6,995	97	0.028	4.93	0.27	1094.3	1380.2	363.3
2003	30	6,434	113	0.031	4.00	0.30	1071.8	1667.6	379.2
2004	28	6,027	96	0.027	3.01	0.23	1112.1	1956.4	409.3
2005	23	5,986	117	0.021	2.73	0.28	1131.5	2190.3	420.9
2006	47	4,746	137	0.04	1.99	0.32	1161.4	2380.5	430.3
2007	28	3,770	78	0.03	1.44	0.16	1145.6	2523.5	481.1
2008	30	3215	93	0.03	1.18	0.18	1171.8	2716.0	506.3
2009	18	2631	96	0.02	0.89	0.19	1179.0	2960.0	558.8
2010	48	2433	117	0.04	0.84	0.23	932.00	3162.0	538..0

Source:
1. Guiling Wei (2011). "Statistical Analysis of Sino-U.S. Coal Mining Industry Accidents", Vol. 2, No. 2; 2011.
2. MSHA, USA website 3. DSMS Statistics, 2012

infrastructure to deal with this risk are therefore research areas of considerable interest. Numerous studies have been performed to identify the most important risk indicating variables that contribute to the occurrence of road accidents.

The frequent happening of mine disaster is largely due to inadequate management, weak enforcement of legislation and policies, lack of safety awareness among the mining communities, poor involvement of government, civil social organizations and the private sectors, and insufficient safety education, etc. These factors basically fall into the category of sociology. Therefore, it is feasible to study coal mine safety from a safety sociology perspective. Table 1 shows the evolution of the number of fatalities coal mining industry between 2000 and 2010 in China, India and the US, the leading coal producer countries in the world. In 2010, the number of fatalities in the US is 48, whereas that number is 2,433 in China which is 51 times as many as that of the US and 117 in India which is 2.44 times as many as that of the US. A decreasing trend in fatalities in China is noticeable in the figure, but the number of fatalities still count tens of times more than that of the US. Calculated from Table 1, the average number of annual fatalities in coal mine production in China is nearly 5,000 in the past decade, more than the total number of death toll in other coal mining countries worldwide. The local decreasing fatalities trend in China however should not be considered a robust indication of safety improvements in this industry, compared with developed countries, the index of death rate per million tonnes (DRPMT) is still too high. Fig.1 and

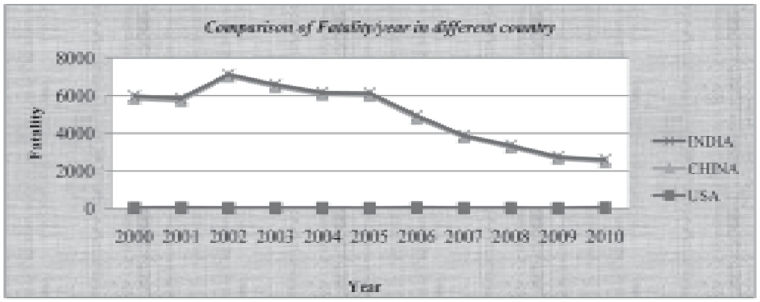


Fig.2 Comparison of fatality/year in different country

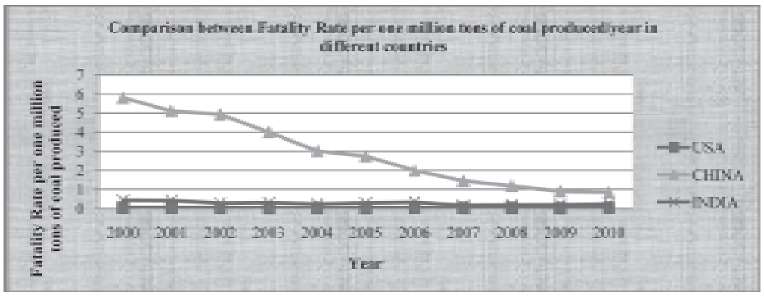


Fig.3 Comparison between fatality rate per one million tons of coal produced/ year in different countries

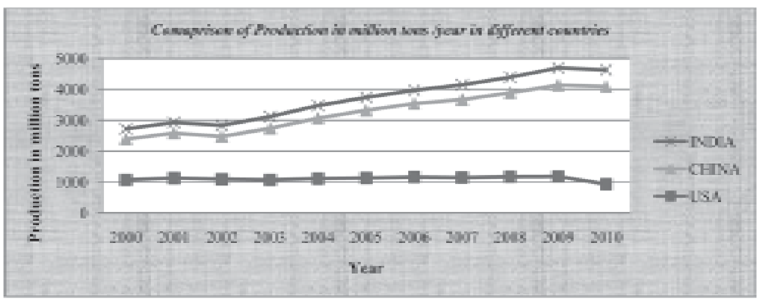


Fig.4 Comparison of production in million tons /year in different countries

Table 1 reveal that number of fatalities per year and death rate per million tonnes (DRPMT) curve of Indian coal mines are almost flat for the last 30 years with small standard deviation.

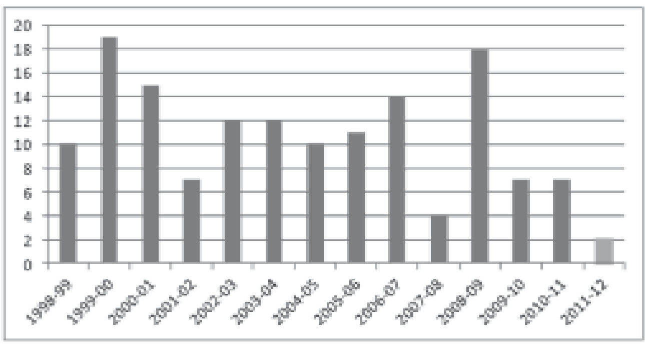
In the Figs.2, 3 and 4, we have seen that India and China have more fatality in comparison with USA simultaneously China used to produce more coal than USA and India but in association between fatality rate per one million tonnes of coal produced/year China has been reduced where India and USA have almost the same rate.

Australia is also fourth leading coal producer country in the world (353 Mt/Year; 2010). Their safety status in mineral industry is quite attractive compared to even US mines. Table 2 shows the comparison of death rate per 1000 persons employed between Indian and Australian coal mines. The number of deaths in Australian mineral industry since 1998-99, are shown in the Fig.5.

TABLE 2: COMPARISON IN DEATH RATE IN COAL MINES BETWEEN INDIA AND AUSTRALIA FOR THE PERIOD 2003-2007

Year	Fatality rate per 1000 persons employed	
	India	Australia
2003	0.27	0.00
2004	0.24	0.06
2005	0.29	0.00
2006	0.36	0.03
2007	0.21	0.04

Source: Mininstry of Coal website



Source: MCA Safety Performance Reports (as at 17 February 2012)

Fig.5 Fatalities in Australian minerals sector

Safety compliance and outcomes

A lack of safety compliance is an antecedent of workplace accidents, which makes it of interest for the present study. Safety compliance may take the form of abiding by safety regulations, making use of the appropriate safety equipment, or following protocol to report accidents. Researchers have identified a variety of predictors of employee compliance with safety rules. Striving to reach a goal as a team, there is more accountability and motivation to proceed in accordance with safety regulations. Factors that positively predict safety-related workplace behaviours include safety knowledge, safety motivation, the ability to predict dangerous outcomes, and an internal locus of control for influencing safety in the work environment. It is clear that individual differences have a strong impact on employee safety compliance.

For example, in the United States, employees (and their organizations) are required to report any work related injury or illness that results in death, loss of consciousness, days away from work, restricted job duty or transfer, or medical treatment beyond first aid. However, some organizations voluntarily take an even more conservative approach by also requiring that employees report all minor injuries (i.e., those only requiring first aid) as well as all near misses (i.e., any unplanned and uncontrolled event that could have resulted in injury, but did not). Thus, to properly investigate underreporting, researchers must ensure that their analyses take into account the specific reporting requirements of the particular organization where the data are collected. Under-reporting then can be said to occur when there are discrepancies between the number of events that meet the employer's definition of a reportable event and the number of events that are actually reported by the employee to the employer. As the discrepancy between the numbers of experienced and reported events increases, underreporting can be said to increase.

Social and economic ramifications

A workplace accident rate suggests the comparative analysis which is primarily focused on those indications and data that reflected significant differences in the various countries. Indicators that were the same or which only slightly differed were not included in the study (Silva and Jacinto, 2012). The comparative study was based on the premises such as although fatal accident is defined as an accident that causes the death of a victim within a period of time from the date of the accident, the duration of this time period is not specified in Swedish law, whereas in Spain, it is 1.5 years; accident indicators do not include self-employed workers; Swedish information sources were public organisms (e.g., the Social Security and Labour Inspectorate). Spanish information sources were the agencies involved in the management of Social Security (e.g., liability insurance for work accidents); and itinerant accidents or accidents with no direct cause-effect relationship were not considered (Morillas et al., 2013).

In addition to the personal consequences, the severe pain and suffering caused by these misfortunes cannot be quantified; the social and economic costs can be estimated. Lebeau et al. (2014) states that lost of wages, medical expenses, insurance claims, and production delays, lost-time of coworkers, equipment damage, fire losses, and indirect costs. Although all of these estimates are enormous, the numbers also indicate that the cost of industrial injuries is increasing at an alarming rate. And, it is likely that these numbers underestimate the true impact of industrial injuries because of problems with current surveillance techniques and the fact that many injuries are not reported (Tawiah et al., 2013).

Self management

Self management is a behaviour based improvement process whereby individuals change their own behaviour in a goal directed fashion by manipulating behavioural antecedents, observing and recording specific target behaviours, and self administrating rewards for personal achievement, an antecedent presentation (similar to feed forward) with a consequence presentation of behavioural information within the framework of self safety management. The introduction of the safety self-management intervention was clearly beneficial in improving the safety of two of five non target behaviours for the pre-behaviour condition (i.e., knee position during lifts and body position during lifts) and three of five non-target safety behaviours for the post behaviour condition (i.e., glove use, knee position during lifts, and body position during lifts) (Hickman and Geller, 2003).

Workplace health and safety remains an important international socioeconomic issue, but the progressive declines in reported incidents may be slowing. The British Government has responded by launching a new policy initiative aimed at "Revitalizing Health and Safety" by establishing targets for improvement, strategies, and a series of action points, mainly targeting employers and organizational issues. The emphasis throughout is that improving workplace health and safety makes good business sense. The government aims to lead by example through demonstrating its own commitment to health and safety in the public sector. Furthermore, in attributing health and safety failures largely to "poor management and ignorance of good practices", the essential role of education at all levels is stressed most strongly. The strategies are supported by 44 action points focused around the themes of the business case, leadership, partnership, and dealing with failures. While this work is orientated around Britain, it is germane elsewhere, since Britain has had considerable success in reducing occupational health and safety incidents in comparison with other developed countries. The successful implementation of the British Government's policy should offer lessons for other nations, as will a science based critique of this policy and the literature. The impact of work environment upon health and safety is well understood. However, it is split into many parts under the guises of health and safety environment, workplace characteristics (including management organization and control), and compensation and conditions (worker motivation) (Biddle, 2013; Smallman, 2001).

Psychomotor ability

Psychomotor is the relationship between cognitive functions and physical movement. Psychomotor learning is demonstrated by physical skills such as movement, coordination, manipulation, dexterity, grace, strength, speed; actions which demonstrate the fine motor skills such as use of precision instruments or tools, or actions which evidence gross motor skills such as the use of the body in dance, musical or athletic performance. It is the process of interaction between the perceptual systems (or five senses), the brain (where perceptual information is interpreted) and the body (where the individual reacts to such perceptual stimuli). This ability has been studied for centuries, and has largely been tied to job performance as the outcome of interest. Psychomotor ability is predictive of job performance; it is also likely related to safety outcomes. We found support for this notion, providing evidence for a connection between psychomotor abilities and accidents within a mining context. When job complexity is low, psychomotor ability will be much more highly related to job performance than when the job complexity is high. Psychomotor ability is a more relevant, better predictor of performance for simple frontline jobs than it is for higher level managerial jobs (Sayed et al., 2012).

Cognitive ability

Cognitive ability has been described as: The ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings – 'catching on,' 'making sense' of things, or 'figuring out' what to do.

As operating solely in educational or vocational contexts, cognitive ability is, in fact, an individual difference that penetrates all aspects of life. Cognitive ability has been a central topic of study in the social sciences over the past 100 years and it has been connected to many outcomes of interest. Cognitive ability is a predictor of numerous outcomes such as physical, economic, and psychological well-being, socio-economic status, positive effect, counter-productive work behaviours, and training success. There is some research tying cognitive ability to workplace injury, however, the outcome most frequently and strongly associated with cognitive ability is job performance. The nature of the cognitive ability and job performance relationship is the inverse of that between psychomotor ability and job performance. The more complex a job, the better cognitive ability will predict job performance. This suggests that possessing high cognitive ability in a more complex job is important and should minimize negative outcomes by successfully meeting the cognitive requirements.

Target zero accident

Industry has to focus on safe operations, proven safety programmes and technical innovations known to save lives. Add up the benefits of all these efforts, and the results are impressive - but still less than perfect. Accidents continue to happen, and people continue to be hurt on the job. Becoming an accident-free, injury-free workplace requires more than programmes, policies and technology. It requires a companywide culture that puts safety into the forefront of every employee's thinking.

The intent of target zero, a new framework for current and future safety initiatives that establishes a safety target for the employees of coal mining industry: zero accidents. Zero incidents. Zero harm to people. Zero harm to the environment.

The purpose of the Zero Harm Culture model was to create, a consistent proactive culture for safety across all operations. By measuring, understanding and actively developing the prevailing safety culture at every site, it would foster a set of shared values enabling a step change in safety performance with an ultimate vision that 'everyone goes home safe, every day, everywhere'.

Four pillars of zero accident potential

Zero harm is based on four pillars: prevention, culture, compliance, and capability. It requires a partnership between individual employees, managers, and the business as a whole to achieve the objectives of each pillar.

PREVENTION

Proactive approach have to risk reduction through global programmed such as risk assessment, incident reporting, trending and root cause analysis, as well as our global hazard reporting tool to proactively identify and control site hazards.

CULTURE

Zero harm relies on the engagement and behaviour of every employee. Safety culture framework and consultation processes have to assess and influence safety attitudes and behaviour at every site, placing particular emphasis on our leaders being role models for best practice.

COMPLIANCE

Risk management has to be designed to ensure that employees at every site have access to best practice guidance on health and safety. Managers at each site are required to ensure compliance with risk management and legal requirements. This is assured for every site through regular formal independent assurance audits.

CAPABILITY

To ensure our people have the skills they need to deliver zero harm, a competency standards supported by safety training. Sites are also required to assess contractors' safety management systems and competencies to ensure they are sufficient to deliver zero harm.

Conclusions

In the Indian coal mining context zero accident culture will have to be implemented in near future otherwise country like Australia, China, and USA would have to be more developed in safety education and training programmes. Rule and regulation changes have a long-term aspect and a shock effect aspect. On the one hand, new scientific knowledge about industrial hazards, risks, techniques, etc. lead to continuous regulation changes. It should be noted that research reports of older accidents and their findings are part of the knowledge development process. On the other hand, societal disruption induced by a shock effect due to a major accident leads to legislation changes as well. In both cases the purpose of the changes are to prevent/reduce the zero risk of illness or death and/or to prevent/reduce and zero damage to the environment.

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