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Research Article

A Study on Various Risks Associated with Commercial Vehicle Cabin Manufacturing and Development of Contingencies

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ABSTRACT

In the commercial vehicle business, where durability, accuracy, and safety are crucial, the truck cabin manufacturing sector plays a crucial role. The purpose of this study article is to discover, evaluate, and suggest workable solutions to reduce the hazards related to truck cabin production. The research divides hazards into two categories: technical and regulatory. Each category presents different difficulties for the production process. Design errors, material malfunctions, and technology obsolescence are examples of technical hazards. Regulatory hazards include following changing safety regulations. The study assesses these risks' influence on manufacturing results as well as their likelihood using a thorough risk assessment approach. To boost resilience and guarantee continuous output, contingency plans including staff training initiatives, sophisticated technology management, and flexible regulatory compliance frameworks are created. The results provide producers practical guidance on how to manage complexity and preserve a competitive edge in a changing sector.

Keywords: Cabin, Truck, Cabin Manufacturing, Risk, Contingency Development, India.

1. INTRODUCTION

In the recent decades, process of automation has become common in most manufacturing firms (Scott et al., 1997). With increased global competition, performance of manufacturers rely on the success of their manufacturing project (Shenhar, 2001). More often some manufacturing projects may be delayed, modified, failure and few might be withdrawn (Shenhar, 2001; Andre and Paulo, 2008). Such drawbacks of manufacturing sector is due to the inefficiency in the management of project risks (Andre and Paulo, 2008). Risk management and development of contingencies have become a vital specifically in the manufacturing sector (Carbone and Tippet, 2004). Meanwhile, tools and techniques for managing risks has been developed but not widely used in the manufacturing sector (Kumar, 2002). In spite of advanced tools and techniques in the truck manufacturing industry, there are certain areas where manual work plays a vibrant role in complex facilities such as decoiler, stamping presses, welding machines, painting booth and trim assembly. Though equipment used in the production of truck cabins are simplified, material handling and process involved in making a finished good is still under manual operation (Scott et al., 1997). Significantly, “trucks are manufactured in the form of light-duty, medium duty and heavy duty classifications depending on their chassis weights” (Pawin et al., 2020).

In general trucks are manufactured and assembled with different set parts include chassis, cabin, and axles. Since trucking become a significant sector in the Indian market, it is considered as a major force for the transportation of “food, raw materials, imports, exports, manufactured products and continues to grow”. Moreover, truck industry accounts for 2.07% contribution to the GDP of the country, India (Statista, 2024). Truck manufacturers in the recent days emphasize more on cabin designing and manufacturing, in order to enhance the driving comfortableness and safety of the truck drivers. Specifically, most Indian trucks are manufactured with limited features and specifications. However, the road transport is considered as the most dominant transport systems in terms of global trade and logistics. With more than 70% of freight movement is carried out using trucks, the truck drivers required to operate the freight movement for a large proportion of kilometres (Jaroslava and Iveta, 2020). Furthermore, the present study provide a comprehensive analysis of associated risks and suggestions for contingency development within the cabin manufacturing sector.

2. BACKGROUND OF THE STUDY

As a result of covering long distances, trucks may expose to certain risks, for instance cargo theft may happen. Therefore the truck cabin should be equipped with modern security systems for the ease and convenient monitoring and controlling of truck and as well as experience smooth and comfortable riding. In particular, the Indian market have huge proportion of truck movements inside the nation. Enhanced and improved driving comfort would be the greatest challenge for the cabin manufacturers. Even though a successful manufacturing of truck cabin may encounter certain risks, specifically during the manufacturing process. Generally, issues related to cabin manufacturing activities may occur due to the inefficient management risk associated with the production methods (Andre and Paulo, 2008). Effective risk management is required for the successful production and launch of truck cabins (Carbone and Tippet, 2004). Enhanced cabin may attract the industry, since truck drivers spend long hours on transportation of goods.

However, driving for long hours, shortages of facilities, and challenging working conditions may result in the risk, high turnover ratio of truck drivers, due to the conventional cabin setup inside the truck (Beilock, 2005). Moreover, buyers of trucks are not always its users and very few drivers are owners. “For fleet owners, trucks are essentially tools and aspects directly related to the cost benefit are more important to a purchase decision than usability, egronomics, and user comfort issues” (Ana et al., 2015). Whereas drivers as well as driving owners of the trucks, such issues become a major concern during the purchase decision making process of trucks, since truck cabins are considered as the main workplace and temporary house for most truck drivers. Prior to the purchase of trucks, truck users may not have the experience of the real utilization of the cabin (Ana et al., 2015). According to (Johnson et al., 2011), “the beneficial aspects of being a truck driver involve several aspects such as independence, ability to make decisions, operation of new and better trucks, high income potential, and the ability to explore and travel to different parts of the nation”. Due to the exposure of longer travel distance, truck drivers need to work with large proportion of time period. Therefore, it is necessary for the cabin manufacturers to manufacture and design the cabins with the objective of enhancing and improving the cabin setup.

In terms of designing, developing and manufacturing advanced and new model of concept can be applied over truck might be the better strat6egy to improve the standard of truck cabin. Differentiating the other kinds of automobile designs, it is easier to separate the chassis and cabin in varied modules. For commercial vehicles such as buses, cabins are chosen by the purchasers, whereas for trucks, cabins are manufactured and assembled from the manufacturer’s ideas and concepts (Roberto et al., 1997). Though modern trucks are equipped with advanced cabin setup, there are some areas to be improved, particularly the Indian manufacturers. In consideration with “Manufacturing the future” (EPSRC, 2018), “Advanced Manufacturing Technologies and Industry 4.0” (Siemens 2015; Jorge et al., 2023), are the workplace systems started linking to technologies (Jorge et al., 2023). Moreover, modern manufacturers with the implementation of advanced technologies, ensures product customization and automation (Karre et al., 2017; Ribeiro et al., 2022). The inclusion of Industry 4.0 within cabin manufacturing firms has not been investigated deeply in the literature. Hence, the current research discusses existing gaps to provide valuable recommendations for contingency development required for the cabin manufacturers in India.

3. RISKS INVOLVED IN CABIN MANUFACTURING

The primary objective of the study deals with the associated risks of cabin manufacturing process. The associated risks can be segmented as, risk involved in the implementation of advanced technology in cabin manufacturing process and physical risks that arises at the production plant or workplace when handling heavy machinery manually.

3.1. RISK ON IMPLEMENTING INDUSTRY 4.0

Increased competition in the commercial vehicle sector, including trucks and buses affects the lifestyle of working individuals and functioning of organization which constitute an ambiguous area in the workplace (Jorge et al., 2023). However, "the implementation of industry 4.0 not only regarded as a technological issue to increase to increase productivity, as it impact work organization and demands people-technology of integration, which has a human-centric perspective since its conceptualization" (Ribeiro et al., 2022). Such innovations, specifically in the cabin manufacturing firms have long-range consequences for the working environment, distribution of income and employees' social well-being (OCED, 2017; Ribeiro et al., 2022; Jorge et al., 2023). Meanwhile challenges faced by the workers at the manufacturing sector is due to the implementation of industry 4.0 has achieved limited focus in the literature (Kipper et al., 2020; Muniz et al., 2022a; Muniz et al., 2023a; Ribeiro et al., 2023). In terms of cabin manufacturing, "industry 4.0 connects suppliers, equipment plants and organization digitally to create an integrated network and value chain" (Ling, 2017), which are referred as social system enhanced by the linkage between firms and people (Jorge et al., 2023).

(Schuh et al., 2017) suggests that implementation of industry 4.0 within the cabin manufacturers can be accompanied with social structure , cultural practice, structure of organization, production rate, employee well-being, attainment of sustainability, regional development, competency level of firms, and employees' qualifications. As a consequence of industry 4.0 implementation, employees and firms required to handle the challenges related to future working conditions of employees (Ribeiro et al., 2023). In manufacturing firms, employee well-being is a major concern, since people at the workplace required to handle heavy machinery, particularly in the production of cabin setup. However, altering the employees' role in the working environment encompasses a significant research topic (Pham et al., 2018; Schneider, 2018) to consider the effectiveness of new technology inclusions on workers (Lee and Lim, 2021). This may lead to concerns related to "required qualifications" (Dobra and Dhir, 2020), "new tasks and work routines" (Schneider, 2018), "career sustainability" (Sony and Naik, 2020), "behaviour of workers" (Pham et al., 2019), "autonomy for decision making" (Kipper et al., 2020), and "expectations" (Kaasinen et al., 2020).

3.2. RISK RELATED TO AIR QUALITY OF CABIN

In recent decades, interest towards transportation air quality has been rising, which include air, and ground transportation such as trucks and buses. However, the air quality of truck cabin is similar to that of indoor environments, based on "temperature, relative humidity and the concentrations of air-borne contaminants". Such components might have a significant impact on the health and well-being of truck drivers. However, in the cabin of truck, "temperature and humidity have a direct impact on the thermal comfort and the performance of drivers" (Spengler and Wilson, 2003). Moreover rise in temperature and humidity inside the cabin have a serious effect on human body include irritation on skin, irritation on eyes, nose bleedings and impaired functioning respiratory systems (Spengler and Wilson, 2003).

3.3. MUSCULOSKELETAL DISORDERS RISK

In the automotive sector, the prevalence of musculoskeletal disorders are found to be high, also the disorders become a major challenge for the automotive manufacturing sector (Mohsen et al., 2020). In addition, musculoskeletal disorders represents a high degree of total "diagnosed work related diseases across occupation and worker groups", specifically in the manufacturing sector (Oranye and Bennett, 2018; Mohsen et al., 2020). Adverse characteristics of jobs such as "physical, organizational and psychological risk factors" have a direct impact on health and well-being of workers, particularly in truck manufacturing and assembly plants (Driessen et al., 2010; Daniels et al., 2017; Widanorko et al., 2014). In truck cabin manufacturing plant, operators in the assembly line might be exposed to a number of physical risk factors such as, “repetition, forceful exertion, awkward postures, manual materials handling and vibration (zare et al., 2016; Falck et al., 2014). Apart from physical risk factors, there are few organizational factors include imbalanced working environment and efficiency in recovery time that exist in designing, manufacturing and assembling the cabin (Kazmierczak et al., 2005; Otto and Scholl, 2011).

4. RECOMMENDATIONS FOR CONTINGENCIES DEVELOPMENT

Though trucks are considered international market products, they need to adapt to conditions of the local market where the trucks are being used. Designing a cabin for trucks can be approached in two include user-based design and empathic design. However, studies suggests that both designing approaches were derived on the basis of user’s ideas and knowledge through a real time interactions with users. The user based cabin design is primarily focused on developing and designing the cabin setup of trucks as per the requirements of users or drivers. (Ana et al., 2015) termed the user-centered approach as “a philosophy based on their needs and interests, to pay particular attention to the issue of making products usable and understandable”. The user-based designing approach of cabin manufacturing takes into account “physical, cognitive, emotional, social and cultural characteristics of users”. Putting the one-self in the position of another individual and experiencing the same emotions as them in situations they encounter is a key component of empathy. Based on seeing customers use the goods and services in their homes and during their regular activities, the Empathic Design research methodology comprises a series of methods for product development research. The first step in the Empathic Design process is to observe products in real-world settings. This allows for the identification of needs and problems that users may not mention in interviews or questionnaires because they are too familiar with the cabin setup and find it difficult to imagine changing. Additionally, it permits interaction with the user's surroundings, the observation of modifications and customizations made to the cabin, and the sense of the object's intangible qualities (Ana et al., 2015).

The materials handling, lifting equipment, cranes, pneumatic guns, torque machines, conveyors, worker work patterns and deviations, and working environment were all observed during the manufacturing process of the cabin and assembly line in order to identify the hazards and exposure. Employees engaged in conversation to gather information about hazards that have happened and might happen during the assembly line observations. Mechanical risks include things like being struck or falling because of the assembly line's overhead lifting machinery. Pneumatic guns, torque machines, lifting apparatuses, conveyors, pressing machines and cranes are some of the equipment that are used in an assembly line (Pawin et al., 2020). Recently, a few studies have created ideas that present technical risk management and its effects in a more comprehensive way (Puente et al., 2002; Trammell et al., 2004; Carbone and Tippett, 2004 to mention just a few). The integrated hybrid model proposed by (Trammell et al., 2004) makes use of layers of protection analysis to assess and implement efficient controls, as well as the strengths of hazard and operability analysis (HazOp) and FMEA to identify failure modes and priority rank hazards. According to these investigations, there could be a number of benefits from this, including improved customer specification identification, lower launch costs (by avoiding re-design and modifications and reducing the number of tests necessary), higher product and process quality and reliability, which would increase manufacturing process safety and responsibility, and higher customer satisfaction. Reducing unfavourable occurrences in the project and raising the likelihood and effect of positive ones are the goals of risk management (PMI, 2004). As a result, it takes into account how engineering resources are allocated and how decisions are made during project development (Pate´-Cornell, 2002). (Edwards and Ramirez, 2016) show that when it comes to technological change, like the digital transformation process, management has a history of including employees and unions only very late. Although there is a propensity to employ technology to lessen workers' authority over the production process or to advance the interests of capital, workers do have some interest in the growth of the forces of production since it may lead to the creation of more and better jobs. The potential benefits of the new forces of production for workers exist, but they must be achieved in two ways: first, by people being aware of them, and second, by the benefits actually materializing.

The implementation of industry 4.0 should have a careful consideration, since it does not involve workers as key users (Kipper et al., 2020; Muniz et al., 2023). Due to the digital transformation in the manufacturing sector, workers arose their demand for effective participation in course of discussion and decision making specifically at the integration of inclusion of industry 4.0 in the business operations. The participation of worker encourages their job security and performance towards given tasks. For the ergonomic improvement at the job floor of cabin manufacturing plant, this study conducted a SWOT analysis (shown in Table 1), suggesting an aspect for workers' job enrichment, professional growth, and improved income.

Strengths	***Weaknesses***
• Effective communication system to support worker participation in discussion and decision making. • Improvement in productivity, quality and enhancement of ergonomics. • Increased payment options, job enrichment, and mobility of job. • Increase in participation of women.	• Approach towards cabin manufacturing is reactive. • No trust relation on the implementation of industry 4.0 in cabin manufacturing sector. • Poor training for workers towards technological advancements. • Partial implementation of industry 4.0 within cabin manufacturers.
Opportunities	***Threats***
• Regional establishment. • Institutional support to educate workers about technological upgrading. • Enhancing worker's participation in management decisions. • Engagement of global and local manufacturers to support transition.	• Rise of unemployment. • Minimization of jobs. • No participation of workers in implementation of technological decision to support lean principles. • Modest actions of firm's HR management.

Table 1: SWOT analysis

From the SWOT analysis it has been suggested that "proactive ergonomics and remedial actions" are the significant measures to prevent musculoskeletal disorders and enhance the productivity as well as the quality of cabin" (Driessen et al., 2010).

CONCLUSION

Due to sustained development in the manufacturing sector, technology selection has achieved greater attention amongst academicians and industrial managers. Truck cabin modernization has become a major requirement in the Indian market. Although the study on analyzing the associated risks on cabin manufacturing, identified and suggested certain improvements to be considered by the manufacturers. However, the study's objective is to provide strategy for efficient and improved cabin setup. In accordance with (Reinikainen et al., 1992; Lindgren and Norback, 2002; Sapengler and Wilson, 2003), allergic reactions such as skin dryness and sensation dryness can be minimized by humidification of air. Therefore, cabin with improved humidification would be the better choice for the cabin manufacturers to ensure truck purchasers as well as drivers to drive the truck with comfort and ease. However, only few studies have highlighted the air quality level of cabin of public transportation such as cars, buses, trains, and aircraft. Whereas, least studies were undertaken to notify the air quality level of commercial truck cabins which remains a great challenge from the cabin manufacturers to design and develop a safe and secured cabin. Furthermore, the paper's major goal is to emphasize how each manufacturing technology alternative presents possibilities and challenges that influence the decision-makers' strategic choices. Realizing how important it is that supply chains fight with one another for global market share rather than individual enterprises of cabin manufacture encourages determining risk while taking the supply chain environment into account. The technology managers at the manufacturer of the cabin mentioned that having access to numerical analyses of various technology alternatives in three different decision-making environments helped them learn more about both new and existing manufacturing technologies. It also gave them insight into how the choice of a particular manufacturing technology will affect their supply chain and manufacturing operations and how to choose a manufacturing technology that gives them a competitive advantage in the manufacturing process. Overall, this paper's technology selection methodology profited substantially from the body of knowledge on industrial strategy, lean, and technology management.

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