2. Review of Literature:

Some part of Indian economy depends on the yield of small scale or home based industries. Carpentry is one of the small scale or home based manufacturing industries in India. In all over the world majority of furniture were made up of wood. That means wood is used as raw material of furniture making industry. These trades undergo many obstacles due to use of conventional type of equipment and lacking of modernization in working procedure. The workers of this unorganized sector were suffering from work associated stress which affects their physical health. The scientific investigation in this type of manufacturing field was very few. Furthermore, a small number of ergonomic investigations have been found on this field in the literature. So, in the following paragraphs highlighted the ergonomics studies on carpenters or similar groups of workers in small scale or home based industries.

According to the protocol of ergonomics database administration by the US Occupational Safety and Health Administration, a numbers of companies reported for instigating ergonomic program from last 90es. But no ergonomic program for carpentry industry was noted. A project was introduced by OSHA, (2012) for the implementation of ergonomically designed equipment ,workplace etc to identify and diminish the exposures to ergonomic risk in trades. But there was a little bit of data about the carpenters. In the literature not any methodical ergonomic surveys have been observed about carpenters.

2.1 Occupational Health Problems:

At the working sector when the preventive measures were not successfully used, occupation related health hazards were found to be increased. According to the report of International Labour Organization report (ILO, 2013) it was noted that more than two million deaths and above 150 million occupation related illness per year in all over the world in organized and unorganized sectors of the industries. Because of work related health problems or illness, the productivity was diminished that might directly affect the earnings , health and treatment of the workers.

A review of literature on Indian workers, the evaluation of pulmonary function parameters on carpenters have not been found. However, it was noted that the pulmonary parameters were studied on other industrial workers like, handloom wavers, jute and cotton fabric workers (Chatterjee et al., 1998; Jadhav et al., 2016), copper mine workers (Luz Fde et al., 2011; Beshir et al., 2015) etc.

National Research Council Panel of Ohio State University and NIOSH (National Institute for Occupational Safety and Health) made an epidemiological study to find out the reasons behind the occurrence of low back pain of the workers and they noted a relationship between factors of working environment and pain / discomfort in back muscle and upper part of the body (Putz-Anderson et al., 1997; Marras and Karwowski, 2006).

The workplace is the second home for the workers. They had to spend the majority of hours at the workplace. The conditions of the workplace as well as the occupations lead to enormous pain and suffering. Edmund E, 2015 studied on the workers of seven industries (agriculture, building, construction, Energy/ power, communications, Education and transport) and reported that there was a policy guideline in any of this industry. Gómez et al., 2010 worked on the workers of Armenian carpenter's workshop to evaluate the health and working condition of the workers. They worked on 10 carpenters' workshop. From their observation, it was established that most of the workers were exposed to wood dust and that caused the risk of chronic respiratory disease.

Review study established the fact that the workers in informal small-scale industries (SSI) in developing nation involved in different tasks like welding, spray painting, woodwork and metalwork were exposed to various occupational hazards with prevalence risk to health. Small scale industry workers have to suffer numerous health problems due to using of poor levels of protective equipments (Rongo et al., 2004). Some of the morbid factors were found in industrial workers among of them most of the prevailing factor was MSD some of the time this factor becomes in alarming stage. Workers of small scale industry were paid

for fewer wages which affects their socioeconomic status (Saha et al.2006). Some research work showed that using of not only heavy weight equipments as well as weight lifting task, but also heavy physical work with frequent bending and twisting postures were very common industrial works which has a significant relation with occupational health hazards (De Beeck et al., 2000). There was a strong association between the type of work and occupational health disease. A strong significant link was found with MSD in the upper part of the body and repetition of work (Van Eerd et al., 2016). That kind of MSD in the upper portion of the body was one of the supreme relevant aspects for task associated incapacity in developed countries. According to Nicoletti et al., 2008 and Junior et al., 2015 rotator cuff disease which is followed by carpal tunnel syndrome (CTS) and lateral epicondylitis were very common and frequently found in industrial workers mainly who involved in repetitive tasks. All the amalgamation of unwell posture, body movement, high powers physical load elating, frequent strain full activity, lengthy stagnant postures and unceasing a continued gripping had been altogether allied with the occupational health disorder.

2.2. Work-related Musculoskeletal Problems:

All over the nation MSD was a well known health problem among all types of industrial work. It was a cluster of very painful disorder of nerve, tendon and muscle.

The fact was established by the J.N.Saraji et al. (2004) that the work associated MSDs were the risk factors among the crew workers. This research stabled that the work associated MSDs were significant problems in most of the countries and are also crucial causes for occurrence of work inefficiency and loss of work days. Waters et al. (2015) stated that long duration erects and sitting postures during the work period was accompanied with uneasiness in the lower part of the body and with the advancement of syndromes of varicose veins was noted. Evanoff et al., (2014) found the association between knee joint pain and nature of job. They stated that both occupation and joint pain were interrelated by multidisciplinary way. OSHA (2012) reported that in construction workers, wood craft

manufacturing workers and foundry workers had augmented risk of knee discomfort related with knee bend posture and also probably with the lifting of heavy things during the task execution period.

Singh et al. (2012) studied on the workers of small scale forging industry to assess the musculoskeletal risk by RULA method and they reported that 20.33% of the workers were under high risk and needs immediate change. About 45.32% of the workers were under low risk and 34.33% of the workers were in medium risk levels.

Noraziera and Norzaida (2018) made a study on the workers of a manufacturing company to assess the occurrence of work associated MSD among them and they observed that the majority of the workers (95.3%) were affected by the work associated MSD. The body segments with MSD symptoms were the lower back (70.9%), shoulder (68.6%) and neck (65.1%).

Bandyopadhyay (2012) studied on the workers of garment industry and observed that musculoskeletal disorders were most prevalent (78.5%) among the workers and it was followed by hyperacidity and heartburn (23.3%). The Neck (60.7%) was the most affected with the musculoskeletal disorders symptoms.

Jagadish et al.(2018) studied on different small scale industrial workers like stone cutting and polishing, saw mills, brick making and dal mill workers and it was concluded from their studies that the work related musculoskeletal disorder were associated with the working posture like bending, twisting, heavy load carrying, etc.

Ayub and Shah (2018) investigated on the workers of manufacturing industry for the assessment of work related MSD and the study reported that experienced workers suffering pain in upper part of the body due to inappropriate design of the workstation.

Foster et al. (2013) reported that the BMI and MSD were closely associated. Particularly the musculoskeletal symptom was found in the lower extremity of body for changing the BMI from the normal range.

As per ongoing examinations, four out of five construction labourers were accounted for to have MSDs (Bodhare et al., 2011), while another investigation showed that 59.4% of labourer had MSDs. Furthermore, Aghilinejad et al. (2012) reported a high occurrence of MSDs in the aluminium manufacturing industry, and there were additional reports of different kinds of works that could enhance the danger of creating MSDs, for example, brick laying (Das, 2014).

Past studies pointed out that the activities such as welding might promote injury to the joints and encompassing tissues (Schneider,2001; Fallentin,2003). Past epidemiologic investigations had demonstrated that despite the fact that the actual work might be little, e.g., administrative work, monotonous work, fixed over-burden tasks, and keeping up awkward stances might be dangerous factors for creating MSDs (Baeka et al., 2017)

2.3. Socio economic and nutritional problems:

The research reports of WHO (1995) and Stevens et al., (2008) stated that anthropometric data and indices like body mass index (BMI) was used as a determining tool for assessing the nutritional status of the workers. In rural area of developing countries, the most common community health problem was that a greater number of people, specially under privilege adults, was suffering from under nutrition and they showed low range of BMI value. In many investigations the BMI was taken as the most commonly used and reliable anthropometric parameter for determining the nutritional status of the people (Lee and Nieman, 2003; Banik, 2012). Some other parameters were also used for evaluating nutritional status of adults like, mid-upper-arm-circumference (MUAC) of a person (Brito et al., 2016). To evaluate CED, the BMI was widely used, i.e., an irrespective relation showed between body weight and body energy stores when a ‘stable’ underweight found to be energy stable (Khongsdier, 2005). Many research findings had found the association of socioeconomic status with BMI and CED within multiple populated areas (Islam et al., 2016; Cohen et al., 2013 and Clausen et al., 2006). According to Chakraborty et al., (2011),

the socioeconomic status of the slum population in India was proportionally related to BMI. As per research statement of Deopa et al., (2013) and Dempsey et al., (2004), showed that within a family also within the country and between the countries anthropometric data were varied. Some of resources stated that the anthropometric data was found to vary with sex differences (Abidin et al., 2013; Hardy et al., 2017). In addition to this, some other factors are related to anthropometric disparity such as altitude eroticism (Ray and Selvamurthy, 1998), area distinction (Musaiger, 2011), ecological, socio-cultural circumstances , way of life, and climatic change (Bagordo et al., 2017). Trespalacios et al., (2016) noticed that the anthropometric data of general working groups were commonly equivalent to the other trade employees. Anthropometric studies of different dimension of India have been reported by Vyavahare et al., 2012 and Chandna et al., 2010. The necessity of anthropometric dimension not only necessary for nutritional evaluation of workers, but also for the designing of tools and workstation in industrial sector.

2.4. Respiratory Problems:

The World Health Organization (WHO) identified most remarkable causes of occupational health risks in all over the world. Few of those causes were aching in back (37%), hearing disability (16%), chronic obstructive pulmonary disease (13%), asthma (11%), wounds (10%), cancer (9%) (Fingerhut et al., 2005 and Reda et al., 2010). Most frequent occupational risk factors allied to Indian context were musculoskeletal disorders, chronic obstructive pulmonary diseases (COPD), accidents, asbestosis and work stress etc. (Pingle, 2012).

According to Global Burden of Disease report by WHO and World Bank, the COPD had hold 6th foremost rank due to death accounts in developing nations, more or less 4.9% of deaths caused by COPD (Marie et al., 2016). In association with the habit of smoking, COPD was accompanied with the huge burden of pulmonary syndromes in most of the countries (Meriam et al., 2016).

According to Mohanmmadien et al., (2013) in small and medium scale industrial workers were suffering from pulmonary malfunction because of long-term exposure to a large amount of dust and some workers also exposed to harmful gases during their industrial activity. Mohanmmadien et al. (2013) also stated that the intensity of pulmonary obstruction was dependant on several surrounding factors like, type and amount of inhaled substances and level of harming capacity and time of exposure. Supplementary demographic features had been shown to disturb pulmonary capacity, counting oldness, heaviness, smoking habits and socioeconomic status (Ahmed et al., 2016; Menezes et al., 2011).

The population based epidemiological research stated that job related workplace exposures, something like carbon-based and inanimate dusts, metallic vapors, biochemical vapors were the threat aspects of pulmonary disorder (LeVan et al., 2016). Consequently, there was a substantial high possibility for breathlessness, COPD, wheezing and asthma in different industrial workers (Fishwick et al., 2015). The reason behind high occurrence of job related asthma in industrial workers was that they were highly exposed to air pollutants and smoking habit those had an additional effect on pulmonary function parameters (Das et al., 2017; Kayhan et al., 2013).

Another research study revealed that the pulmonary disability and its damage among the employees was due to the job related sprinkle or vapors, fumes and substances (Hamzah et al., 2016). Maximum number of pulmonary function related study were conducted in industrialized countries, while in Indian small and medium scales (SMS) industries, particularly in the carpentry industry, very minimum literature was noticed. Hence, it is an actual necessity to find out the level exposure in these carpentry industry and accordingly to explore the level of pulmonary function parameters deterioration.

2.5. Work Rest pattern:

Analysis of work rest cycle is one of the essential tools by which an ergonomic researcher can evaluate and modify the structures of work pattern and diminish the cardiac stress (Majumder et al., 2015; Keyserling et al., 1991). According to Chen et al., (2008) proper work rest cycle could progress the productivity, work competence, life satisfaction and psychological exhaustion. It was also reported that the optimum pattern of work-rest cycle diminished the muscle fatigue, moderate the prevalence of work-associated MSD (Wang and Liu, 2014). Optimum work-rest patterns could similarly be used as a factor for grip span strength (Ekşioğlu, 2016). According to Faucett et al. (2007), frequent and transitory rest pause can reduce the symptoms of occupational stress related to workplace for the workers.

2.6. Work Posture of the workers:

A sound number of ergonomics researches pointed out the task burdens in tough postures. Most of the industrial workers (e.g., workers of foundry, blacksmiths and others industry) were frequently obligatory to espouse such kind of uncomfortable postures, like squatting, stooping and kneeling for a longer period of working hours. Workers who were engaged in industrial activities and were also required to adopt circumscribed or unusual postures for longer duration seems to be the advanced threat of work associated MSDs and also diminished the strength of lifting capacity (Middleton et al., 2016 and Gallagher, 2005). Review on the industrial workers stated that awkward bending posture of back and employed in the same place were together significantly associated with the occurrence of lower vertebral pain (Feng et al., 2016; Roffey et al., 2010). According to Labbafinejad et al. (2016) there was a significant association between difficult work postures and lower back pain. Longer period of flexion of particular muscle was the main sources of restriction of soft tissue, declined vertebral force endurance, tissue faintness and bodily laziness (Jandre Reis et al., 2015; O'Sullivan et al., 2006). A typical or unusual positions of the

extremities of the body created a tension on tendons and tissues of the muscles that circuitously created the back arc at the lower region and with this enduring lower spinal ache caused by the lower lumbar spine (week Lee and Kim, 2015). There were several methods for evaluation of postural stress during performing the work. All those methods were established on the basis of the categories of posture (Mc Atamney and Corlett, 1993; Keyserling, 1986). According to De Looze et al., (1994) the surveillance method was a novel process for determining the postures during work when there was obliged of total body movement and it was recognized that the cogency of optical surveillance to evaluate posture in a workshop replicated substantial management task.

2.7. Ergonomics in work place:

According to the statement of Jaffar et al. (2011) and Erlandson, (2007) incorporation of ergonomic ideas in workplace acted as the science of compatibility among man, machine and workplace. Many industrial workers were exposed to ergonomic risk factors during performing task. That factors increased the occurrence of permanent disability of the workers that might hold them from their frequent daily work schedule. Scott (2008) and Bennett et al. (2006) established that for executing industrial work or any type of task smoothly implementation of ergonomics in work procedure is a necessity and also its activity added more potential in industrial activity for developing countries. Among all industrial developing countries, primary necessary for development of Indian industry is the ergonomic interventions. Demission of risk factors in industrial work environment could enhance the work capacity for the workers (Mokarami et al.,2017). The ergonomic intervention in industrial life might innovate or improved more instruments or tools which could be compatible with the users. Task schedule and work procedure in industrial activity should be modified through ergonomic intervention (Bhattacharyya and Chakrabarti, 2016). Frequent involvement of ergonomic approach in the work culture could increase

productivity that might diminish the poverty faced by the rural workers (Scott, 2008 and O'Neill, 2000).

2.8. Designing of Hand Tools:

Ergonomics and bio-medical engineering modalities were introduced during the designing of appropriate hand held instrument or tool for the users. Not only a suitable hand instrument could benefit the fundamental mechanisms but also the operator could use the tool to predict the performance of a biological system in varied situations. According to Eaves et al., (2016) the development and the alteration of the existing equipment, tools, machinery and technique of tasks were of prime importance and had a significant role in diminishing in bodily stress and exhaustion and enhancing productivity. The work culture and work atmosphere could be enhanced by modifying hand equipment, it could also help to reduce the physiological stress and to enhance of work output.

From the past few years, modifying or designing of hand tools became a stimulating activity for industrial activities. Most of the time tools which were used in industrial work were task specific. Designees of hand tool should have an ergonomic approach which could actually fit or adjust the human factors. Most of the research work put extra effort on ergonomic tool design for extra comfort and user friendly option also with less risk of MSD for the users. Most of the research work on ergonomic tool design proved that the impact of ergonomic factors on tools could diminish the work related health hazards (Mukhopadhyay and Srivastava, 2010; Bhattacharya et al., 2008 and Trejo et al., 2007). Bearing in mind of those ergonomic approach, before finalize the actual perfect model of an ergonomic tool, dissimilar supplementary models might be rational and consistent with prior information and existing statistics of magnitude, outline, span, consistency, width etc. As per investigation of Vyavahare et al., (2012) and Kuijt-Evers et al., (2004) six wellbeing features which remained documented as obligatory for production of hand tools and equipment were usefulness, posture and strengths, handle physiognomies, crossness of hand

exterior, irascibility and discomfort of hand and fingers, and aesthetics. Shin et al., (2008) and Mahone et al., (1993) suggested a modest and hands-on process for prototype designing entailing of 8 points: desires of valuation, ergonomics rules, anthropometry, knowledge sketch and brainstorming, pilot model, execute and enlisting, operational sample, and operator trials. According to Sancho-Bru et al. (2003), the optimal width for a hand tool have need of least possible strength essential to grasp the tool and execute gripping accomplishments that the optimal width of the tool handle also inhibits the real joint constructions, and diminish the probability of rising cumulative trauma disorder (CTD) allied with extended tedious task with additional grip armed forces and stroppy postures. In the handle of the tool uses of rubber grip can avoid the slippage and deliver a feeling of relieving at the tool handle area. The research work of Sengupta et al. (2012), and Fellows and Freivalds, (1991) was also stated the same conclusion regarding the rubber grip uses in tool handle grip. Hand anthropometry can ease the task of designing the appropriate hand implements where were less uneasiness in addition to good efficacy and less weakness. According to some of the researcher, biomechanical methods were used for the determining of grip strength and physiological benefit formed by finger joint angles in addition to differences in muscle length (Parvatikar et al., 2009; Kozak et al, 2015).

From the above discussion, it may be stated that previous research works provided ergonomic information on the job related health problems of carpenters. Not much information has been found on the wood product manufacturing sector , especially on the carpenters engaged in furniture making and repairing. Ergonomic intervention in the activities of carpenter is also scanty. No or little study on the design of work station or hand tools of carpenters was appeared in the literature. In this present research work, in demand to overcome the said lacunae, some efforts have been made to assess the work associated MSD, physical stress, work-rest patterns, posture related strain, and hand tool design in the carpenter's workstation.