

6. Summary and Conclusion

6.1. General Conclusion:

In the present research work, investigations were made for assessing the work related health hazards of workers engaged in carpentry task, redesigning of the chisel which was frequently used by the carpenters and optimizing the height of workstation used for hand plane operations. The risk issues related with physiological and occupational stresses among the chisel users was reduced by redesigning the chisel. Optimizing the height of workstation for plane users also diminished the occupational risk factors for the workers.

During assessing general health status of the workers it is noted that there was nutritional deficiencies among the carpenters as indicated by BMI and other nutritional parameters. This research work enumerated that about 41.02% of the malnourished carpenters were belonging to different grade of CED (BMI<18.5). The socioeconomic status might be one of the reasons for nutritional deficiencies of carpenters.

The high occurrence of work-related MSD was exhibited by the carpenters. The prevalence of MSD was task specific. As for instance, waist and lower back problems were generally pretentious by both chisel and plane users, whereas saw users had prevalence of shoulder and knee problems. Furthermore, in all carpenters engaging in different carpentry tasks, the main affected body segments were shoulder, neck, waist, and lower back. High discomfort rating was also observed in those body parts of the carpenters. In comparison to the other tasks of carpentry, saw operator had lesser occurrence of work-related MSD.

According to the findings of cardiovascular parameters, the carpenters were belonging to the heavy work category. From the study of cardiovascular stress index (CSI) it was concluded that the carpenters were exposed to high degree of cardiovascular stress. This study also revealed that the CSI and work-rest pattern were related with each other. Direct association was found between CSI and duration of work whereas, inverse relationship was observed

between CSI and duration of rest-pause. Hence, to diminish the cardiovascular stress, proper designing of work-rest pattern might be a significant intervention. For reducing the cardiovascular stress of the carpenters, it may be proposed that instead of a long break, more numbers of small breaks may be incorporated.

The pulmonary functions parameters were analyzed and observed that the carpenters had lesser values of pulmonary variables in comparison to some others working groups. It might be caused by the prolonged exposure of wooden dust in carpenters' workshop. Further, smoking habit of the carpenters also might affect the pulmonary function parameters.

During execution of task the carpenters were suffering from high degree of postural stress. The sitting with folded leg in forward bent posture was the dominating work posture in cases of chiseling and planning task among the carpenters. From the results of postural analysis made by OWAS, RULA, REBA and QAC methods it was found that during performing three major tasks of carpentry work, the workers adopted distinctly stressful postures which projected that carpenters were the high risk working category and remedial measures should be taken as early as possible else musculoskeletal disorder of the workers might be augmented gradually. The factors like, repetitive motion, frequent changing the posture, manual load handling etc might be the causes for emerging problems of work-related musculoskeletal disorders among the carpenters. Due to these consequences, ergonomic interventions, which are mentioned in the following subsections, were necessary.

6.2. Main Achievements of the Study:

According to the norms of management of industry, "Safety is first but productivity is must". Few years back, safety and productivity both caught in same dimension at the same time was a critical problem in the framework of industry. Ergonomic intervention was one of the key factors for industry which was not only obligatory for task design but also to

workstations and hand tools that harvests a best deal of facts for improvement of well-being, safety and productivity.

From the study of work-related health problems of chisel users, it was found that they were stressed with various levels of cardiovascular and musculoskeletal problems. Mismatched design of the chisel was one of the causes for above said problems of workers. Through the study of different design features of the chisel it was proved that the conventional type of chisel generated discomfort and strain among the chisel users during operating the tool. From ergonomic point of view, the chisel was redesigned which fulfilled some of the desires of chisel users. For this purpose, couple of ergonomic design concept was developed. Considering the psychophysical needs and also anthropometric dimensions of the chisel operators, the final physical dimensions and other design features of the chisel were settled. The key points of interventions were:

(i) The length, breadth, shape of chisel handles was optimized.

(ii) The interface between the users and the handle of the instrument was the key part of designing. By keeping in mind the optimum handle length and diameter, the chisel handle was designed

(iii) The features of safety were incorporated in the modified design. A suitable rubber grip was added in the handle of the chisel which ensured better gripping while holding the tool during work and it also prevented slippage of hand during operating the chisel. In addition to that a rubber safe guard was introduced at the top portion of the handle which could protect the gripping hand from the hitting of the hammer which might be caused often due to miss hit.

(iv) The improved design criteria of chisel handle fulfilled the necessities of the chisel users during execution of the tool. The physiological and biomechanical stress was reduced. Post intervention productivity resulted also in favour of modified chisel handle.

Another important achievement was the optimization of height of the workstation for panning. There was no standard height of the workstation in the conventional system. It produced different work related health problems among the workers. A suitable height of the working surface of the carpenters' workshop, especially for the planning and sawing tasks, was standardized considering anthropometric criteria of the carpenters and psychophysical tests. The results of the EMG studies of shoulder and back muscles and as well as joint angle studies confirmed the optimized work surface height. The occurrence of MSD was reduced when the workers performed the tasks with modified workstation. The productivity of the planning task was found to be increased in the modified workstation in comparison to the existing one.

6.3. Limitation of the Study:

. In the present study anthropometric database of the carpenters was formed with the subjects selected from the West Bengal state only. There would be some limitations for implementing the outcome of the study in all over the country because of some variation in body dimensions in different states of India. There should be a long term longitudinal follow up study for the usage of redesigned hand tool and workstation for the carpenters, so that the limitation of the design, if any, could have been identified. This scope of further modification could not be availed.

The carpenters were exposed to different environmental problems, like, wood dust, heat stress and noise. Their work related health hazards might be intensified due to environmental stresses which in turn might affect the efficiency and productivity. Those environmental factors could not be taken into account in this study. For evaluating physiological efficiency of the carpenter the heart rate and the lung function variables were measured. The oxygen consumption of the workers could not be measured due to lack of time. The evaluation of oxygen consumption of the workers might yield the better evaluative results of the carpentry tasks.

6.4. Scope of Further studies:

The present study was made on the workshop of the carpenters who were engaged in furniture making and repairing. The study may be extended for the carpentry workers who are involved in construction work. The working conditions of the construction workers (carpentry) are different from that of workers engaged in furniture making. An ergonomic evaluation of the carpentry work at construction site is required. Emphasis may be given to study the work posture, physiological response and man –machine interface.

The carpenters use different kinds of hand handled tools. In this study only carpenters' chisel was evaluated and redesigned. There are enough scopes for ergonomic evaluation and redesigning of other hand tools, e.g., saw, drilling machine, carpenter plane, claw hammer, screwdriver etc. Modification of those tools may enhance the work efficiency of the carpenters. Furthermore, a carpenters' kit may be designed, which may contain essential tools for the carpentry work. An extensive study is required for designing the kit.

In the present study the height of the working table has been optimized. Here the working table of fixed height was considered. However, there is a scope for designing a working surface of adjustable height which may be helpful for accommodating the carpenters with different anthropometric measures. There would a better fit between the carpenter and the workstation.

Wood dust is a major problem in carpenters' workshop. Usually the carpenters do not use any personal protective devices to prevent the health hazards of dust pollution. Low cost personal protective equipment can be devised on the basis of ergonomic principle and human factors.

The restructured carpenters chisel was assessed for relatively short period of time. The workers should be skilled for a long-time basis. Therefore, a long-term operation of restructured chisel may be studied efforts may be made for recognizing the advantages and disadvantages of working with newly designed chisel. In accordance with response of the chisel users, it may be further improved. There are huge possibilities for more studies in the carpentry workshop.

As a part of the work some of the carpenters required to do some fine tasks. Excellence and extent of the creation may be determined by the level of illumination in the workshop, particularly where fine task is performed. Therefore, to progress in productivity and to maintain the quality, it is essential to explore the ideal level of illumination in the workshop of different tasks. The placement of illuminating source and eliminating glaring source in the workstation is important. A further research may be planned for evaluating the current illumination status and for determining the optimum amount of natural light and artificial light in the carpenters' workplace.

6.5. Recommendation:

Some recommendations may be supportive for the workers to diminish some of the work-related health hazards of the carpenters:

i. Workers should tend to adopt a suitable posture at the time of task execution to lessen the incidence of musculoskeletal hazards. To evade fatigue and work related pain / discomfort it is suggested for alteration of work posture, as much as possible without hampering the work output, within the work shift. Squatting posture should be avoided by the workers, as far as practicable, as it is a strenuous posture. The practice of job rotation may be followed, wherever possible.

ii. As the carpenters showed chronic energy deficiency (CED) a low-price balanced diet may be recommended for them. Consumption of easily accessible nutriment may defend themselves from dietary insufficiencies. Considering their socioeconomic condition, efforts may be taken so that they can get some free medicines like, multivitamin or calcium tablets, which are available in the primary health centers.

iii. The work rest cycle of the carpenters' job may be modified depending on their work load in a particular task. This will be a helpful measure for diminishing postural

stress, fatigue, and cardiovascular stress. It is recommended to modify the work rest cycle by adding more numbers of small breaks instead of a break of long duration.

iv. An awareness program for the carpenters may be arranged for educating them about the proper nutrition, adoption of appropriate work posture, and proper use of hand tools etc. Such programmes may enhance the productivity as well as earnings of the carpenters. Further, the workers who are habituated to smoking should be aware about the adverse effects of smoking on their health, especially on respiratory efficiency and they should be advised to give up smoking to prevent the occurrence of COPD.

v. In addition to the awareness programme, some training module may be prepared for the carpenters. The training module may include work safety, manual material handling, work method and use of personal protective equipment in relation to the carpentry task.

vi. The carpenters suffer from task related aches and pain / discomfort in different body segments. Discomfort / pain in the lower back of the body is awfully predominant in carpenters. The carpenters may be advised to perform some physical exercise, especially yogic exercise, which may be helpful for them to get relief from those problems.

vii. To diminish the ill-effects of dust exposure and consequently the occurrence of COPD of carpenters it is suggested to use of special protecting mask. The protective mask should be of low cost and durable. It would be better to devise a suitable mask for the carpenters, on the basis of ergonomics and human factors, to protect them from the wood dust in the workshop.