Model Development Using Soft Computing Techniques to Assess Musculoskeletal Disorders among Workers of Brick Kilns Industry: An Indian Prospective

Vikash Agarwal[1], Rajeev Kumar Upadhyay[2]

Department of Mechanical Engineering, R.B.S Engineering College Technical Campus Bichpuri, Agra, India[1]

Department of Mechanical Engineering, Faculty of Engineering Dayalbagh Educational Institute, Dayalbagh Agra, India[2]

Abstract: In this paper study of musculoskeletal disorders of workers in brick kiln industry has been carried out. This study shows the relationship between Occupational Health Hazard (OHH) and Expected Earnings. Four parameters namely rest break (RB), working hours (WH), switching over for alternate job (SOAJ) and working hours between two consecutive breaks (WHBTCB) were considered. In the present study 10 brick kilns industry of medium and small scale were selected in the adjacent areas of Etawah (Uttar Pradesh), India for physiological assessment. The data related to musculoskeletal disorders in different muscles of human body were obtained and is optimized by using artificial neural network (ANN) and genetic algorithm (GA).

Keywords: Musculoskeletal Disorders (MSD), Occupational Health Hazard (OHH), Artificial Neural Network (ANN), Genetic algorithm (GA)

I. INTRODUCTION

Complaints originating in the musculoskeletal system are one of the most common categories of illness among industrial workers. Musculoskeletal complaints account for 30% of time loss through sick, increase in musculoskeletal illness. The musculo-skeletal disorders may manifest in the form of stiffness, fatigue, weakness and power loss etc. It may occur in various parts of body (neck, shoulder, arms, wrist, elbow etc.) and with varying frequency for each individual/ operational worker. Many jobs and activities require manual material handling such as loading and unloading, removing material from conveyor belt, storing items in ware houses etc. Manual material handling activities affect primarily the musculoskeletal system. Overexertion appears to be the main reason for manual material handling problem. An industry which has the main aim of increasing its production inevitably has to work under such environment which undergoes continuous humanistic and mechanistic interactions with several not well defined classes of boundaries leading to imprecision.

In brick kilns industry large numbers of male and female workers do different type of work such as moulding of bricks, lifting bricks, etc. due to which they suffers from musculoskeletal disorders due to repetitive work under unfavorable conditions. Disorders are linked to jobs that are repetitive, require high forces, and require continuous or repeated extreme or awkward postures which may affect the body's soft tissues, including damage to the muscles and nerves of hand, elbows, wrist, shoulders, neck and back. Such disorders / pain in the neck, hand shoulders cause work disabilities among employees.

A repetitive task is defined as work requiring repeated performance of similar cycles of work activities. Cycles are considered similar if the developed muscle forces, time sequences and spatial characteristics of movements are similar [13, 14]. The prevalence of clinically verified cumulative disorders ranged from 1% to 25% in an industrial work population according to the force demands and repetitiveness of the work's tasks [1]. In brick industry workers do moulding work continuously up to 8 to 10 hours and their wrists are in continuous perceived exertion (PE) for this duration. They usually complain about wrist pain which is ignored by the supervisors and owners. The over PE causes reduction in the efficiency of workers, which in turn affects the production of further raw bricks adversely.

Genaidy *et al*. investigated the effect on discomfort of maintaining a fixed posture about various joints and investigated the effects of posture on discomfort seen as precursor of injury if work is continued. Tanaka *et al*. recommended that the wrist angle be defined as sum of proportions of measured wrist angles while performing the tasks in relation to the ROM (range of motion) in each direction of wrist bending. Moore et al. found in their study that musculoskeletal disorders are related to repetitive tasks and led to the development of a model that makes it possible to express incidence of disorders as a function of exerted force and time sequences of load and recovery. Kahn *et al*. also focused on the problem of maintaining load for an 'infinite' time. They proved that the maximum force maintained for 4 min decreased hyperbolically. Lin *et al.* established equal discomfort levels for the wrist is relation to exertion level, movement, frequency and flexion only, for 1 h of work. Kee derived regression equations for the Joint Angles of Discomfort (JAI) where subjects maintained static pressures at 0%, 25%, 50%, 75%, 100% of the range of motion for 60 sec but there was no dynamic activity studied.

II.   RESEARCH METHODOLOGY

For physiological assessment of existing and improved tasks/ postures/ conditions following methodology were used.
- Visit to selected organizations.
- Selection of Workers.
- Study of existing postures/tasks/conditions.
- Suggest improved postures/tasks/conditions.
- On line experimentation on existing and improved postures/tasks/conditions.

To study the physiological assessment, visit of the brick kilns in the adjacent areas of ETAWAH (Uttar Pradesh) that has a concentrate of kilns, has been done. Formal as well as informal procedures were adopted for this purpose since different policies were followed by different organizations. It was not possible to have the exactly similar study. Few organizations allowed the videography and rest permitted only still photography; however some industrial organization were not ready for any type of photography and on site physiological assessment. They were not considered as part of the study.

 The initial visits to the brick kilns had to be organized with the help of the local Brick kiln owner. Number of visits had to be made to the kilns to finally make the owners agree to allow us to meet the workers Initially very minute and detailed studies of different workers about existing Postures/tasks/conditions were observed and only those workers were selected, who had some complaints of musculoskeletal nature due to their job profile and work environment. The following triggering question were posed to workers to identify the most important postures/tasks due to which they feel that they were suffering from musculoskeletal disorders and back pain."Which of the task/ posture according to you has the greatest potential on your musculoskeletal disorders and back pain?" "After how long do you feel the pain in different muscles?" etc.

In brick kiln industry generally seven types of tasks were done. Table -1 shows a list of different tasks.

Table I
Category of Workers with Their Earnings

S.NO	Category	Terms of payment
1.	Moulder	Rs.160 Per thousand bricks
2.	Loader	Rs.90 Per thousand bricks
3.	Stacker	Rs.90 Per thousand bricks
4.	Firer	Rs.6000 Per month
5.	Accountant	Rs.7000 Per month
6.	Guard	Rs.5600 Per month
7.	Technical Supervisor	Rs.8000 Per month

In moulding work we intended to investigate the wrist discomfort levels of workers involved in brick moulding work with variation in following parameters.
- RB: Rest break: It is defined as time interval taken by workers after they get tired because of doing continuous work.
- WH: Working Hours: Working Time taken by the workers during the whole day.

➢ SOAJ: Switching Over for Alternate Job: This is done in order to reduce health hazards pertaining to one type of job for long working hours.
➢ WHBTCB: Working hours between two consecutive breaks: It means that after how much time rest break was provided.
In this context we took the real life data from different Brick Kiln Industry near Etawah with the permission of owners. The discomfort levels would be measured based on perceived exertion by the workers on different working parameters as mentioned below.
 Workers: Following three workers were considered in this project.

Worker	Age
W1	24
W2	37
W3	46

Workers were doing continuous work for four hours. They took one hour rest for lunch break (unavoidable) and then do continuous work. Four working hours were divided into three sessions 80 min. each.
The following table II depicts perceived exertion (PE) of work by workers and their corresponding value on 1 to 10 scale.

Table II
Range of Perceived Exertion

Perceived Exertion	Corresponding value on 1 to 10 scale.
1	Negligibly Strained
3	Lightly Strained
5	Moderately Strained
7	Highly Strained
9	Extremely Strained

In analysis workers were suggested three options, first is to work with different rest break to determine level of stress in wrist. Table III shows discomfort level based on perceived exertion of workers by taking different rest breaks. It has been found that increasing the rest break reduces the stress in wrist of workers.

Table III
Determination of Discomfort Level with Rest Breaks

Workers	Before lunch			After lunch			Before lunch (10 min rest break)			After lunch (10 min rest break)			Before lunch (20 min rest break)			After lunch (20 min rest break)		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
W1	3	5	7	5	7	7	3	5	5	3	5	5	3	5	5	5	5	5
W2	5	5	7	7	7	9	5	5	7	7	7	7	5	5	5	7	7	7
W3	5	7	9	7	7	9	5	5	7	7	7	7	5	5	7	7	7	7

Second option is to reduce the session time. Table IV shows discomfort level based on perceived exertion of workers by reducing session time with taking same time of rest breaks. It has been found that reducing the session time with increasing the rest break reduces the stress in wrist of workers.

Table IV
Determination of Discomfort Level with Reducing Session Time

Workers	Before lunch (session time 60min with10 min rest break)				After lunch (session time 60min with10 min rest break)				Before lunch (session time 40min with10 min rest break)					After lunch (session time 40min with10 min rest break)				
	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	5
W1	3	3	5	5	3	5	5	5	3	3	3	3	5	3	3	3	3	5
W2	3	5	5	5	5	7	9	9	3	3	5	5	5	3	5	5	5	7
W3	3	5	7	7	7	7	9	9	3	5	5	5	7	5	5	7	7	9

In analysis it has been found that increasing the rest break and reducing the session time reduces the stress level in wrist but earning also get affected, so another option is suggested to workers to switch over another job during the day to minimize the stress in wrist without reducing their earning,. It has been suggested to do lifting work after the moulding work for some part of day. Data collected is shown in table V.

Table V
Determination of Discomfort Level with Switching Over Alternate Job

Workers	Combined work (for 5 days)	Combined work (for 10 days)	Combined work (for 15 days)
W1	7	5	3
W2	7	5	5
W3	9	7	5

It has been found in analysis (shown in Table V) that stress level reduces in case of alternating their jobs without reducing their earning.
On the basis of third option (switching over alternate jobs) data has been collected and trained in artificial neural network (ANN). This data consist of numbers of inputs and outputs. ANN trained the data and calculated different outputs for the different inputs, which were difficult to obtain from original data. In this system inputs are rest break, working hours and session time and outputs are occupational health hazard and earning of worker. The data for training ANN is shown in table VI.and trained figure obtained from ANN is shown in Fig. I and II.

Table VI

Input Data for Training Ann

| INPUTS						OUTPUTS	
RB(MO)	WH(MO)	wh (mo)	RB(LI)	WH(LI)	wh(li)	OHH	EARNING
0	480	80	0	0	0	9	190
0	400	80	0	80	80	9	194
0	320	80	0	160	80	7	198
0	240	80	0	240	80	5	202
0	160	80	0	320	80	5	208
0	80	80	0	400	80	3	210
0	0	0	0	480	80	3	215
10	480	80	0	0	0	9	165
10	400	80	10	80	80	7	169
10	320	80	10	160	80	7	173
10	240	80	10	240	80	5	177
10	160	80	10	320	80	5	182
10	80	80	10	400	80	3	185
0	0	0	10	480	80	3	190
20	480	80	0	0	0	7	140
20	400	80	20	80	80	7	145
20	320	80	20	160	80	5	148
20	240	80	20	240	80	5	152
20	160	80	20	320	80	5	157
20	80	80	20	400	80	3	160
0	0	0	20	480	80	1	165
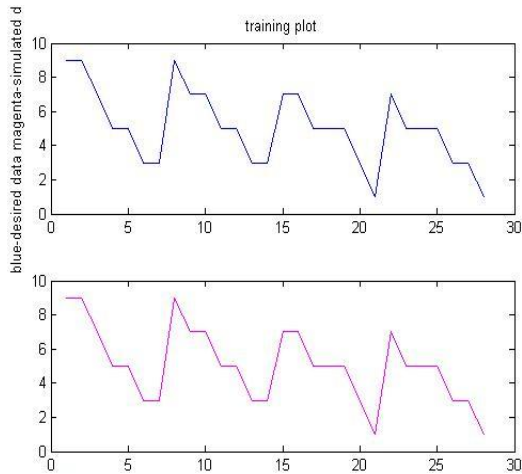
Fig I. Trained figure of OHH from ANN
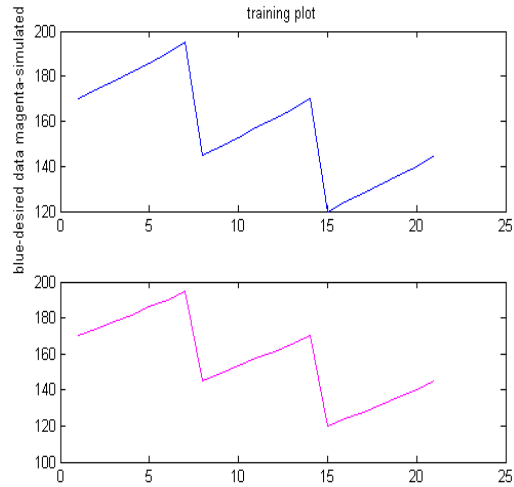
Fig II. Trained figure of earning from ANN

After the training genetic algorithm (GA) was used which generated number of random solutions after interacting with ANN in MATLAB, and found the optimal solutions and tried to get good combination between earnings and occupational health hazards. GA calculated optimum results which have been shown from Fig III to VI. Fig III to Fig V shows the better solution and Fig VI shows the best solution between OHH and Earning.
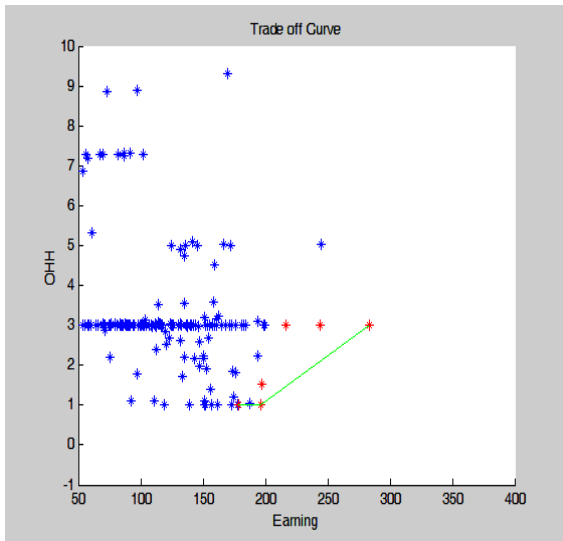
Fig III. Trade off curve between OHH and Earning (stage 1)
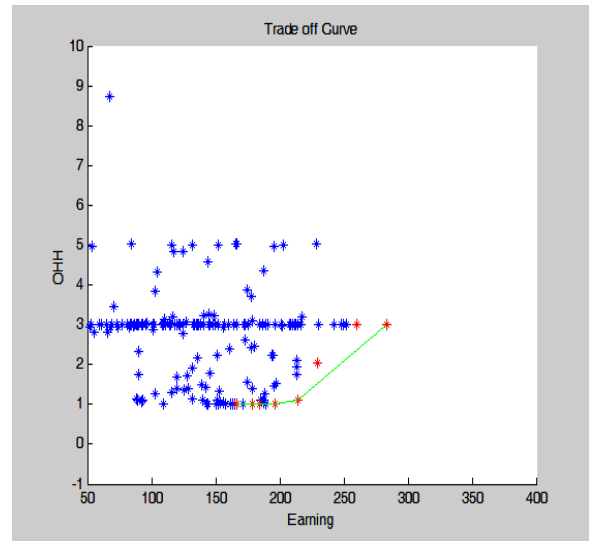
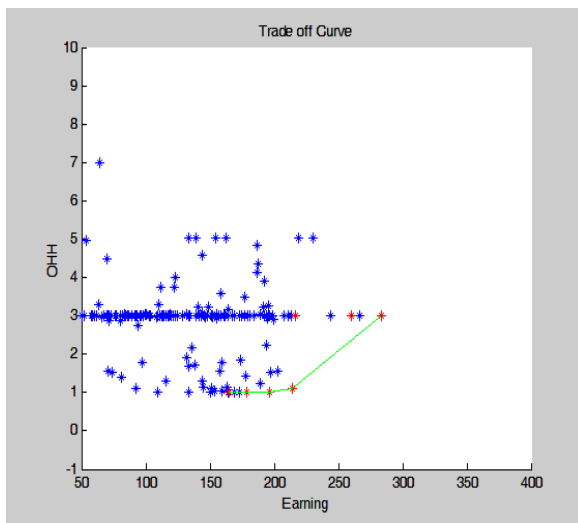Fig IV. Trade off curve between OHH and Earning (stage 2)

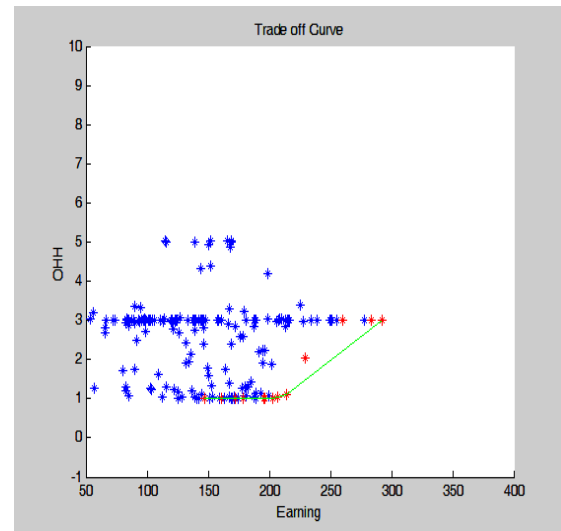**Fig V** Trade off curve between OHH and Earning (stage 3)

Fig VI Trade off curve between OHH and Earning (Final stage)

III.   RESULTS AND CONCLUSION

Trade off curve (shown in fig III, IV, V, VI) shows optimum results between occupational health hazard and earning which can be summarized by giving some suggestions to workers for reducing the stresses in wrist and can increase the efficiency without reducing their earnings.

- In industry different types of tasks are done, so moulding worker have an option to change their job for few duration. This change will affect the wrist in fewer amounts as compared to moulding work and earning will be not affected.
- Worker can increase their working hours with increasing rest breaks. Rest breaks will provide more rest to workers and stresses will be reduced.
- Workers do their jobs in drastic environment without having medical facility. Stresses level can be reduced by providing good environment with good medical facility with routine checkup.

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