Ergonomics Investigations across Durable Goods Manufacturing Sector In India: An Insight

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ABSTRACT

In Indian scenario, ignorance towards ergonomics, the science of human-machine compatibility is prominent across all industries. Very limited efforts have been taken to investigate physical ergonomics aspects of manufacturing shop floor and implementation of research outcome. Present paper which is an attempt to collect essential information on physical ergonomics research and development in durable goods (brick, steel, lock, automobile parts, glass etc.) manufacturing sector in India, will help to understand ergonomics methodology adopted, manner in which issues have been addressed and also to know current state of affairs of ergonomics research in these sectors. Literatures from various sources were studied to achieve intended goal of present review. Research efforts mainly relate to workstation/workspace evaluation and design; manufacturing activities; material handling; anthropometry; working postures; occupational health of workers and physical work environment. It is highly apparent that physical ergonomics aspects were not given much thought in India while installing and commissioning majority of production units (large, medium, small, and micro). As a result, durable goods manufacturing industries in this country are affecting workers wellbeing and are far from being human centric or user friendly. Research and educational institutions, both at regional and national level should take initiatives to address the issue regarding deficiency of worker friendly manufacturing activities. Government, industry, academia collaborations should compulsorily be initiated for further strengthening research and application of ergonomics. Benefits brought forth by application of ergonomics should be made aware to all concerned, so that investigations from ergonomics perspective are not treated with suspicion and discouraged, but encouraged positively.

Key words: durable good, manufacturing sectors, physical ergonomics, research, India

INTRODUCTION

Manufacturing denotes the process of converting raw materials, components, or parts into finished goods to meet customer's expectations or specifications. Durable goods manufacturing sector is predominantly characterized by presence of man-machine/equipment/tools and space allocation in workplaces. India is taking various efforts to improve its manufacturing sector through various initiatives. Such initiatives are expected to increase employment in manufacturing sector to 100 million workers by year 2025 [1] and this forecast deserves to be taken notice by ergonomics community in India. It is very much understandable that labor intensive industries in a country like India where focus is on increasing employment opportunities of a mammoth population, discipline of ergonomics should be gladly received and applied for optimizing human machine interaction for enhanced safety, comfort and wellbeing of workers in durable goods manufacturing sector and for increasing efficiency and productivity of work system. Ignorance towards ergonomics, the science of human-machine compatibility is noticeable across all industries in Indian scenario. Very limited efforts have been taken to investigate physical ergonomics aspects of manufacturing shopfloor and implementation of research outcome. Present paper which is an attempt to collect essential information on physical ergonomics research and development in durable goods manufacturing sectors in India will help to understand ergonomics methodology adopted, manner in which issues have been addressed and also to know current state of affairs of ergonomics research. Sufficient information in a consolidated form will surely help novice researchers in developing their own research design/framework quickly; foresee problems likely to be encountered besides encouraging out of the box thinking.

METHODS

Literature from various sources was reviewed to achieve intended goal of present manuscript.

EXAMPLES OF PHYSICAL ERGONOMICS RESEARCH IN DURABLE GOODS MANUFACTURING SECTOR

The following tabulation (table 1) represents collection of case studies/research related to durable goods manufacturing sector in Indian scenario from physical ergonomics perspective. Essential factors considered, important methodology/tools employed, significant problems identified along with major solutions recommended are described to give a wholesome picture of the subject matter under consideration.

DISCUSSION AND CONCLUSION

Ergonomics in factory layouts, workstations, work methods, physical work environments were not given much importance while installing and commissioning vast majority of Indian durable goods manufacturing industries. Research efforts mainly relate to workstation/ workspace design and evaluation, manufacturing activities, material handling, anthropometry, working postures, occupational health of workers and physical work environment. If industrial workplaces are not made human centric, working population will be subjected to severe occupational health problems in near future affecting all stakeholders. It should be made obligatory by law on part of industries to allow ergonomics related investigations/ research which is mostly viewed with suspicion and discouraged by many factory managements. A mutually beneficial and workable mechanism involving Government Industry Academia must be visualized to take ergonomics research forward and create a human centric manufacturing industry for benefit of all concerned.

Table 1 : Description of case studies/ research related to durable goods manufacturing sector in India

Industry	Vital factors considered	Important tool/methods used	Significant problems identified	Major solutions recommended	Ref.
Small scale casting	manufacturing process	video recording, snapshots, Ovako Work Analysis System (OWAS), Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA)	high risk of musculoskeletal disorders (MSDs)	elimination of awkward postures, reduction of material handling distances, implementation of well-defined layout, proper ergonomics training of workers	[2]
Copper and copper alloy foundry shop	production systems, variety and sizes of products manufactured, cycle times	process flow diagram, cycle times, operator movement	existence of manual operations required high man power	new layout proposed and implemented resulting in decrease of cycle time, man power and reduction in operator movements	[3]
Brick manufacturing	self-reported work-related musculoskeletal disorders, work activities	Nordic Questionnaire, Chi square analysis	awkward postures for a longer period of time resulted in discomfort and pain in different parts of body	--	[4]
Assembly workstation in a welding shop	cycle times, factory layout and its associated activities	motion study aided by video recording, line diagram of workstation design and workplace layout, flow chart of assembly process	work tool and parts were not found suitable for gripping and easy operation, occupational health issues (back pain, shoulder pain, wrist pain, neck pain etc.) were observed	training of workers in order to make them aware of standard work procedure, adoption of proper body postures and motion sequences, implementation of standard procedure for handling tools, modification of workstation layout and design for enabling worker to adopt good body postures and also enable good contact between tool and work piece, reduction of fatigue by implementing suitable mechanical automation assistance incurring less expenditure, enhancing worker's comfort by providing good air supply/circulation system and lightning system	[5]
Welding work station in a small scale tractor trolley manufacturing	prevalence of musculoskeletal disorders, angle of body segments for different posture	RULA, photography	workers performing their work in kneeling and forward bending postures were found to be more affected with problems of MSDs as compared to those who were performing the same work in standing posture, number of musculoskeletal pain regions increased with increase in length of exposure time	urgent changes needed in workstation design, occurrence of pain due to prolonged working period may be reduced with suitable change in posture after evaluation of existing working posture	[6]
Small scale forging firms	Work activities and working posture	video recording, OWAS, RULA and REBA	lack of ergonomics planning and methods was evident and as a result significant proportions of workers were found to be working in very bad postures, workers were under moderate to high risk of developing Musculoskeletal disorders (MSDs)	implementation of ergonomics interventions should be given high priority and proper awareness regarding ergonomics among workers was deemed to be urgent	[7]
Foundries	handling of heavy objects such as molds or castings, anthropometric data of worker, work posture and load conditions	Rapid Upper Limb Assessment (RULA)-based biomechanics evaluation module of CATIA-V5	excessive stress intensity in workers' current work posture and load-carrying condition, musculoskeletal disorders are prone to occur due to improper work postures	alternative work postures were studied to find a good working posture from ergonomics perspective	[8]
Cast house operations	awkward working postures, anthropometric measurements of workers	photographic examination, line diagram techniques, OWAS	computer–aided ergonomics assessment platform with virtual workers	design of an ergonomic work system specifying changes in work procedures, work norms and ergonomics interventions, new control board with sit stand chair was suggested to improve comfort of operators	[9]
Soaking pit in slabbing mill of steel plant	quality, environment, occupational health and safety management systems	inspectional survey of work area, individual discomfort rating, five years data relating to accidents and incidents, biomechanical study	adverse head postures, head rotations, frequent neck movements, vibration exposure from moving soaker crane, high demand on job attention, inappropriate seat design, disorder in neck region of the operators	need for redesign of workstation	[10]
Electroplating of automobile parts	working posture, musculoskeletal disorders	survey of workplace	workers working in sitting and standing posture had lower and upper back pain	--	[11]

Industry	Vital factors considered	Important tool/methods used	Significant problems identified	Major solutions recommended	Ref.
Foundry	working environment, work procedure, impact of work, illumination, sound, humidity, average temperature, dust particle in air, vibration, dimensions of equipment, work space area, workers' age, weight, average heart rate, average blood pressure, anthropometric measurements, cycle time	working postures, general study of process	cleaning of mixing chamber and ports was found to be very tedious and difficult for regular maintenance staff	procedural changes effected by design to easily perform regular hard maintenance tasks	[12]
Lock manufacturing	manual load lifting	performance of the operator recorded in terms of muscle fatigue measured in EMG units, two factor ANOVA statistical analysis	height of lift and lifting load have an impact on performance of workers/operators, workers are able to lift more loads with less strenuous if load is lifted from knee level rather than from ground level, increase in muscular fatigue with increase in amount of load	general guidelines regarding lifting load, lifting height etc. were given	[13]
Structural shop in steel factory	musculoskeletal disorders, body mass index, workplace layout, anthropometry	questionnaire, free body diagram, goniometer, spine load calculation with the help of a mathematical model	ectomorph welders more prone to back pain, workers were found having MDSs, sitting posture with support caused less spine load followed by standing and sitting without supports, low back ache caused on account of welding operations (prolonged static posture, working in confined space) and poor postural training	need to consider anthropometric measurements for appointment of welders, regular medical checkup, proper training, back extension exercise, provision of low height, flexible and movable sitting arrangement	[14]
Welding work (Ironworks, steel industries etc.)	welding gases and fumes, musculoskeletal injuries, occupational exposure limits	photography, review of literature, workplace survey	welders mostly suffer from some kind of respiratory illness or pulmonary infection, prolonged exposure to fumes cause asthenia, vomiting, weakness, dry throat and cough, fatigue, fever, lower back pain, mental confusion, metal fume fever, paralysis and tightness in chest	use of downdraft worktables was recommended in order to direct welding fumes downwards and away from welder's breathing space, substituting less hazardous flux materials in welding rods, using proper enclosures and improving ventilation, implementing suitable work-rest schedules and safe-work practices, provision of proper ventilation systems (should include hoods, roof vents and high-speed intake and exhaust fans which can capture and remove toxic fumes and gases)	[15]
Steel plant	anthropometry of crane operators	survey of manually-operated Electrical Overhead Travelling (EOT) crave cabin work system	poor ergonomics design of chair and controls, awkward work postures, and insufficient vision angle resulting in musculoskeletal disorders (MSDs)	minimization of anthropometric mismatch, ways of improving layout of components and controls within enclosed workspace, and methods to improve work posture minimizing risk of MSDs were learnt	[16]
Steel plant	pace/speed of work, fatigue allowances, lifting of weights, force required to push or pull objects, movements of human body, visual environment in workplace, thermal environment in workplace, workers complaints about physical environment, repetitive motions, hand tools, information overload, physical fitness, knowledge of training, anthropometry, auditory environment	Ergonomic Performance Indicator (EPI)	ergonomics factors, design and performance factors needed for design and development of ergonomic performance indicator	design and implementation of ergonomic performance indicator	[17]

Industry	Vital factors considered	Important tool/methods used	Significant problems identified	Major solutions recommended	Ref.
Hot metal and glass factories	thermal data of workplaces, accidents, workers' physiological responses	objective assessments, subjective assessments in the form of questionnaires	need for reducing heat stress, accident risks and physiological costs	ergonomics centered and designed (low-cost, washable, ventilated, vapor permeable, flame-retardant, radiant-heat-reflecting) special work clothing recommended to be adorned by workers	[18]
Compatibility of controls in electric overhead cranes heavy engineering factory	layout of controls, population motion stereotypes	questionnaire, direct observation of daily tasks, detailed study of photographs of different activities, compatibility study for machine controls and resultant movements performed	less attention being paid to ergonomics during design of cranes, variation from one crane to another with regard to layout of controls groups and orientations of each of individual controls with respect to operators' seats(as cranes were procured from different manufacturers), operators committing mistakes while operating controls as they had to move from one crane to another every week as a part of their job requirements	significant numbers of low-cost ergonomic solutions were recommended to minimize these problems	[19]
Small scale aluminum casting works	physiological evaluation (cardiac strain assessed in actual work situation) of workload	working heart rate, net cardiac cost, relative cardiac cost and recovery heart rates	strain job found to be moderate, recovery patterns inadequate, prevailing thermal stress higher than recommended level, workers exposed to cumulative circulatory stress	interventions are a must to restructure ergonomic stressors	[20]
Casting industry	Respirable Suspended Particulate Matter (RSPM) and respiratory symptom, weight, smoking and drinking habits, amount of work exposure, level of dust exposure, overtime, diseases contracted	self-designed comprehensive questionnaire, personal interview	grinding section was found with highest dust concentration, dust concentration was lowest in lathe section (machining section), majority of workers were uneducated and unaware of benefits of using Personal Protective Equipment (PPE) and health hazards, less importance accorded to worker's safety	properly designed bulk material handling components necessary (to reduce dust generation, emission, and dispersion), complete isolation to protect workers from exposure to harmful dust. workers need to be educated regarding health and safety measures at work place	[21]
Glass manufacturing unit	workplace air pollution and heat exposure	evaluation of workplace air quality at eight locations, heat exposure parameters including air temperature, wet bulb temperature and globe temperature, manufacturing process analysis	investigations related to heat stress studies continues to be most neglected occupational hazard in tropical and subtropical countries like India, Wet Bulb Globe Temperature (WBGT) (an indicator of heat) exceeded recommended limits most of time at all workplace locations	to avoid heat stress problems established recommendations should be taken as indicative of stress areas, continual medical supervision necessary for workers	[22]
Electronic component manufacturing	anthropometry	survey	south Indian men are smaller when compared with men in other regions (central, western, and northern) of India, south Indian men were also found to be smaller than men in other countries (America, Germany, Japan, Africa), difference in body dimensions should be strictly considered while buying or using imported equipment for electronics industry in south India, anthropometric difference affect workers posture and cause fatigue when working with industrial equipment imported from places where this equipment has been designed to suit local working populations	application of anthropometric information should be utilized for designing all industrial equipment's to suit large diversity of different populations and not necessarily for designing to specific localized norms giving little consideration for easy adjustments	[23]
Small scale steel manufacturing	concentration and impact of occupational health hazards (environmental and physical) on worker's health	physical health check–up, survey of workplace	highlevels of suspended particulate matter and ambient air temperature respectively above mandatory limits, very limited use of personal protective equipment's by workers, workers suffered from obstructive breathing, prolonged cough, dermatitis and eye infections which were significantly higher than control group	--	[24]
Pedestal oil-lamp manufacturing	occupational health risks and hazards	questionnaire survey, direct observation, chi-square and Pearson correlation techniques	strong association between musculoskeletal discomfort and type of work engaged, safety measures (protective clothes, gloves, shoes, goggles, ear muffs and mask) were not adopted by most workers, psychological stress was strongly associated with family status, long hours of work in a day, age of workers, economic conditions, physical position during work and over time	first aid box to be kept ready for use, regular records on health checkup must be maintained, provision and training to use fire extinguisher, working environment should be modified (for best handling of tools and proper ventilation), health awareness programs must be conducted, PPEs (helmet, mask, goggles, ear muffs, proper dressing and safety shoes) should be provided to workers	[25]
Glass manufacturing	work heat exposure	wet Bulb Globe Temperature (WBGT), Corrected Effective Temperature (CET) and Mean Radiant Temperature (MRT)	WBGT values exceeded recommended limits	revision of standards to suit tropical and subtropical conditions	[26]

STATEMENT OF RELEVANCE

Manufacturing sector in India is projected to witness increased levels of employment. Review of present state of affairs is essential for future research initiatives and directions. Hence, current review which highlights lack of human centeredness in durable goods manufacturing sector in India is crucial for ergonomics research community.

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