© FEB 2022 | IRE Journals | Volume 5 Issue 8 | ISSN: 2456-8880

A Case Study on Industrial Ergonomics

PUNEETH KUMAR
Assistant Professor, Department of Civil Engineering, Guru Nanak Dev Engineering College Bidar

Abstract- Ergonomics is the study of how working conditions, machines and equipment can be arranged in order that people can work with them more efficiently. The general approach for designing the work place for the positive outcome of the worker and the corresponding factors. Industrial Ergonomics is a science on how to fit the task and working environment the worker using scientific data drawn from a variety of disciplines. In Industrial System, the science of ergonomics seeks to adapt the job and workplace to the worker by designing tasks within the workers capabilities and limitations. The term ergonomics is neutral, takes no sides, neither of employers nor of employees. The various applications of industrial ergonomics which indirectly plays a vital role in the output of the respective industry. When the ergonomic is set right there is increase in the worker efficiency as well as the output. There is drastic reduction in the injuries to workers when the ergonomics is set up in the right way

Indexed Terms- Ergonomics, Designing tasks, etc.

I. INTRODUCTION

- ERGONOMICS

Ergonomics is the study of how working conditions, machines and equipment can be arranged in order that people can work with them more efficiently. As computers are probably the most ubiquitous type of machine in today’s work and learning environments, the issue of ergonomically sound interaction with them has come to the fore. In general, computers are clean, quiet and safe to use. However, poor interaction with and positioning of computer equipment can lead to health problems such as eyestrain, swollen wrists and backache.

Problems can be avoided by good workplace design and by good working practices. Prevention is easiest if action is taken early through effective analysis of each workstation. There are a number of practical steps that can be taken to achieve an ergonomically positive environment and, furthermore, to promote a safer learning environment. These are:

- positioning of the person and equipment
- arranging a safe learning environment
- Taking regular breaks

For students with disabilities, it is advisable to consult with an occupational therapist in relation to ergonomics.

1.1 Positioning

Body positioning and the positioning of equipment are fundamental to ensuring a comfortable and healthy interaction with computers. The following recommendations can help to reduce the risk of health problems:

- Sit up straight rather than slouch forward
- Use supports such as foot rests, wrist rests and adjustable chairs
- Adjust equipment to the correct height, distance and angle

The diagrams show highlight some positive and negative body and workstation positioning.

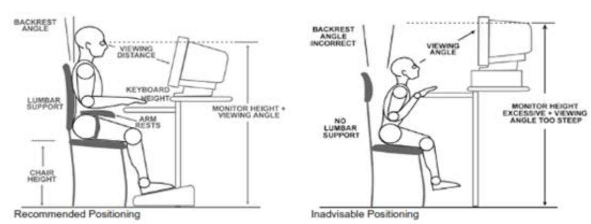

Figure 1: Working station positioning

1.2 Arranging a Safe Learning Environment

The term ‘workstation’ refers collectively to the computer, the monitor, the keyboard, the desk, the chair and the space provided for doing work. Workstations should be comfortable and have sufficient space to allow for freedom of movement. A minimum of 4.65 square metres of floor space for adults is recommended for office or similar environments. Adequate space between workstations should be provided for students both in a classroom and computer suite context. This should exclude space taken up by fixtures such as presses and filing cabinets. As computers can generate heat, a well-ventilated room is an important consideration. Coiled cables also give off heat and may need to be rerouted. In addition, securing and covering trailing cables is necessary if hazards are to be avoided. The following table identifies how specific aspects of our environment can be organised to create the right ergonomic conditions for a safer learning environment.

1.3 Regular Breaks

Computer users, both in workplaces and in schools, should be encouraged to take regular breaks if working for protracted periods on a computer. This may mean leaving the workstation for a few minutes every hour to avail of a work-break or to engage briefly in some other work-related activity. Not only will this allow eye muscles to readjust, it will also refresh all of the body's muscles, promoting personal health and a safe learning environment. By encouraging such practices in schools, teachers are reinforcing the importance of human– computer interaction, allowing students to form positive habits at an early stage in their development, ones that they can take with them into the world of work.

Environment	Health and safety considerations	Ergonomic Recommendations
VDU (visual display unit)	• Avoid discomfort caused by reflective glare and eyestrain • Protect eyes against moisture loss	• Take adequate breaks regularly • Adjust contrast and brightness • Focus on distant object regularly • Use an anti-glare screen with older monitors • Adjust height so that the top of the screen is at eye level • Position in a downwards viewing angle • Make sure the screen surface is clean
Keyboards	• Prevent wrist strain which can develop into RSI (repetitive strain injury)	• Use a wrist rest • Type with wrists floating above the keyboard • Keep elbows relaxed • Keep mouse at the same height as keyboard • Tilt the keyboard to the most comfortable position
Chair	• Prevent back problems	• Adjust chair to a suitable height • Tilt seat for lumbar support • Allow adequate knee clearance under the desk • Do not sit in the same position for long periods
Light	• Prevent visual fatigue • Avoid reflective glare	• Provide natural light if possible • Position monitors at right angles to windows, otherwise use blinds • Avoid strong artificial lighting
Noise	• Minimise distraction caused by noise	• Use headphones for software containing audio • Position printers or photocopiers away from workstations
Heat	• Prevent discomfort caused by heat	• Ventilate rooms but avoid creating draughts • Turn off equipment when not in use • Consider air conditioning
Electrical Safety	• Prevent accidents	• Leave technical repairs to experts • Reroute, secure and cover stray leads • Replace frayed leads and damaged plugs • Avoid overloading extension leads • Be aware of coiled cables overheating

Table1: Ergonomic recommendation based on different environment

II. INDUSTRIAL ERGONOMIC

Industrial Ergonomics is a science on how to fit the task and working environment the worker using scientific data drawn from a variety of disciplines. "Ergonomic" is derived from the Greek terms ERGON, indicating work and effort, and NOMOS, law or surroundings

In Industrial System, the science of ergonomics seeks to adapt the job and workplace to the worker by designing tasks within the workers capabilities and limitations. The term ergonomics is neutral, takes no sides, neither of employers nor of employees.

2.1 Goal of Ergonomics

The fundamental goal of ergonomics is to generate "tolerable" working conditions that are not hazardous to human health. Next, is to generate "acceptable" conditions upon which the people involved can voluntarily agree according to current scientific knowledge and under given sociological technological and organizational circumstances. The final characteristics, capabilities and desires that physical, mental and social well-being is achieved.

Its fundamental aim is that all manmade tools, devices, equipment, machines and environment should advance, directly or indirectly, the safety, well-being and performance of human.

2.2 Industrial Workplace Design And Anthropometry

The workplace is a location where a worker or workers perform tasks for a relatively long period of time. The workstation is one of a series of workplaces which may be used sequentially by the same person to perform a task. Workplaces should be designed so that workers can safely and effectively perform the required tasks. Reach, size, muscle strength, visual capabilities have to be considered when developing design criteria for a workplace.

Anthropometery is the study of human dimensions. It deals with the measurement of the dimensions and certain other physical characteristics of the body such as volumes, centres of gravity, inertial properties and masses of body segments. Anthropometric data should be used in the design of workplaces. Poor design of the workplace contributes to innumerable back injuries and musculo-skeletal problems each year. Poorly designed or mismatched chairs and workbenches may cause fatigue and discomfort, circulation problems and pressure on nerves. The dimension of a workplace are determined by the dimensions of the worker. The problem is that people vary greatly. There is an enormous variation in body size between individuals, the two sexes, ethnic origins and with age. These basic facts cannot be changed. It is therefore important to use data that is relevant. There has been a lot of anthropometric data derived from measurements taken from Caucasian populations and those in the military services. There is almost no data taken of the Malaysia population, except that made on a sample of university students (see Table 18.1). It is useless to use data derived from a different populations e.g. US airforce personnel, to provide design criteria for machinery to be used primarily by Malaysia females.

Let us take this example. Many manufacturing plants in Malaysia are built with no real considerations of the female workers who form a large percentage of our labour force. Some of the machinery or equipment are imported directly from the western world; the designs of which reflect the much bigger Caucasian male-dominated working populations of the West. These equipment, tools and general plant layouts were designed for the average American male (50th percentile) whose height is 1750mm (69 in). The tallest 95th percentile) Malaysia female is at 1660mm (65 in) which definitely falls short of the average American. The average Malaysia female (50th percentile) at 1560mm (52 in) in height is dramatically affected by existing workplace reach distances and work heights. Further, scaling down dimensions of western products does not give the answer.

Table 2: Anthropometric Data of University Students*

		Male (mm)			Female (mm)		
No.	Dimension	5th % tile	50th % tile	95th % tile	5th % tile	50th % tile	95th % tile
1.	Standing height	1578	1670	1789	1463	1557	1660
2.	Eye height	1467	1560	1669	1207	1440	1546
3.	Shoulder height	1119	1380	1460	1078	1292	1377
4.	Elbow height	961	1050	1200	809	982	1060
5.	Knuckle height	681	710	798	557	660	716
6.	Sitting height	760	855	940	743	811	870
7.	Sitting eye height	662	750	822	628	708	773
8.	Sitting shoulder height	529	588	658	498	549	606
9.	Sitting elbow height	170	230	281	175	238	274
10.	Knee height	427	499	562	372	460	509
11.	Popliteal height	397	448	499	295	400	458
12.	Buttock-Popliteal length	409	457	529	392	465	530
13.	Foot length	231	249	271	209	228	244
14.	Foot breadth	79	95	108	77	88	93

* Sample size : 207 males
89 females
Age : 19-26 years
19-23 years
Weight : 35.1-100 kg.
35.1-89.0 kg.

Asian workers being generally of smaller size have to stand on makeshift platforms or boxes to be able to reach some of these controls. Reaching up with the arms extended reduces force capability and endurance, and increases energy expenditure. This results in unnecessary strain and fatigue. Elevating the standing surface by s distance D, about the equivalent to the difference in eye heights between the average American and Asian, facilitated operation of the high control but simultaneously removes low controls from easy reach.

The wrong way to design a workplace is for it to suit an average person. There is no person who is average for every dimension. If you designed a door for the average height, then 50% of the population would bang their heads.

2.3 Core of Ergonomic Knowledge

There are four major applied sciences that make the core of ergonomics. These include primarily,

- Anthropometry: The measuring and description of the physical dimensions of the human body.
- Bio-mechanics: Describing the physical behavior of the body in mechanical term.
- Work Physiology: Applying physiology knowledge and measuring techniques to the body of work.
- Industrial Psychology: Worker attitude and behavior at work.

2.4 Basic Ergonomic Model

In any given operation, there are three important elements to be considered; the work capacity considerations, task demands and working environment.

2.4.1 WORKING CAPACITY

Some of the important factors to consider are the body dimension, weight, strength, gender, skill, handedness, age, physical work capacity and psychological factors. All of these factors affect the ability of the workers to perform their task.

2.4.2 TASK DEMANDS

Depending on the nature of work, task demands can vary accordingly. Examples of the task demands are accuracy, complexity, force required, duration, vibration and others.

2.4.3 WORKING ENVIRONMENT

The place where the workers perform their operation is called their working environment which consists of factors like the temperature, humidity, air flow and ventilation, workplace configuration, noise and others.

2.5 Application of Ergonomics in Industry

Design/evaluation in workstation

1. Working height.
2. Working envelope (Clearance, reach)
3. Arrangement of equipment, tools, bin, computer

2.5.1 Working Height

The working height is of critical importance in the design of any industrial workplace. If the work is raised too high, the shoulders must be lifted up to compensate. This way lead to painful cramps at the level of the shoulder blades, and in the neck and shoulders. If the working height is to low, the back will be excessively bowed which often causes backache. Hence the working height should relaxed and in their natural position.

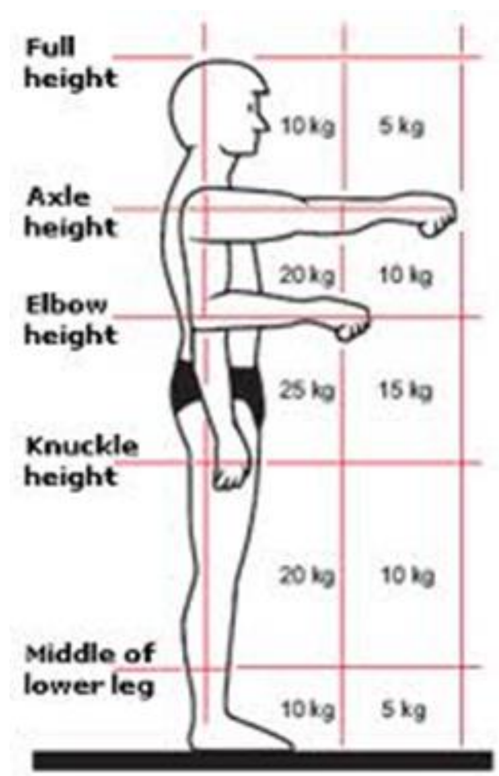

Figure 2: Working height.

The worksurface height must be at such a height whether the operator stands or sits at his work. The general rule is that the height of worksurface should be such that work can be conducted with forearms approximately horizontal or sloping slightly downwards. The work should be done at a natural arm position as close to the body as possible.

2.5.2 Workspace Envelopes

The normal worksurface is considered to be the function arm reach area that can be swept by the forearm as the arm moves in an aoutward direction form the fornt of the body to a full abduction. Such a movement includes full extension at the elbow with some abduction at the shoulder. The workstation, however, includesmore than the worksurface and requires consideration of working activitites, reach, storage requirement, etc. As the workers does his work.

The width and depth of the work surface should be sufficient to provide clearance for the largest operators. The placement of the tasks, control and work pieces should be designed to allow the smallest operator to reach easily. These dimensions are determined by the reach envelope that specifies the normal and maximal reach distances for the small (5% percentile) female and the large (95th percentile) male. The normal and macimal reach distances should be used for the following purpose.

Any tool, control or work piece that is contacted in every job cycle should be in the normal work envelope. All important control, especially those provided for safety reasons, should be included within the normal reach envelope. All tools, controls and work pieces that are contacted frequently, but not in every job cycle, should be within the maximal reach envelope. Only those things that are used infrequently should be located outside the maximal reach envelope.

2.6 Design Selection Of Hand Tools, Equipment, Devices

1. Vibration
2. Handle size
3. Grip type
4. Handedness
5. Usability

2.6.1 Exposure To Vibration, Noise And Cold

Vibratory power tools are common in today's automated manufacturing plant. Certain power tools such as pneumatic drills are noisy (-90 dBA) and kvibrate at 60 – 90 Hz. This requency in combinations with the amplitude can aggravate circulatory problems in the hands of susceptible operators inducing vibrations in the finger. Furthermore, the weight of the tool itself contributes to the vibraion injury since the tool has to be gripped tightly to support it.

Other environmental factors such as heat, cold and dampness will also affect biomechanical performance, particularly of the hands. Elevated heat will increase perspiration, and reduce gripping friction and increase fatigue. Cold will decrease sensation and constrict flow resulting in decreased performance. Exposure to temperature below (16ºC (50ºF) have been associated with significant increase in CTD incidence. Worst conditions of surfaces will reduce gripping friction and increase potential for skin irritation. Another factor to consider is tool handedness. Most hand tools are designed for right-hand use. However, approximately 10% of the population is left-handed. The handles of tools and the position of controls in a power tool should make the tool applicable to both left and right-handed persons

2.6.2 Hand Tool Design

Hand tools are used throughout the manufacturing system to operate, assemble or repair equipment. Their design can affect the productivity and health of the operator if they do not fit the person or task. Many occupational risk factors associated with musculo-skeletal problemss of CTD are directly related to hand tool design. Proper tool design and selection are integral to reducing direct or indirect costs associated with CTD, as well as to increasing productivity, quality and efficiency. Hand tools must fit the employee, not just the work.

Figure 3: Hand tool design.

A tool should be designed to extend and reinforce, range, strength and effectiveness of the limb(s) engaged in the performance of a given task. The major purpose of most tools however is to transmit forces generated within the human body onto the material or work piece.

There are five major risks which can affect the health and performance of hand tool users and contribute to CTD. These are static loading of the upper extremeties resulting in soreness and fatigue, awkward and position, excessivepressure on soft tissues of palm and fingers, repetition, and exposure to physical factors of noise, vibration and cold with power tool use.

2.7 Design/ Evaluation of Job/Task Procedures.

1. Manual Handling
2. Mechanical aids
3. Fatigue and stress (shift work)
4. Task demands
5. Errors
6. Working efficiency
7. Sitting/Standing
8. Visual work

2.7.1 Standing Workstation

Ideally, the most favourable working height for work while standing is 5-10 cm below elbow height. But considerations must be made for the nature of the work. Comfortable working height varies with the type of work being done. The elbow height is referred to because of the great variation in worker's heights. For delicate work which demands precision and for which vision is important, it is desirable to support the elbow to help reduce static loads on the muscles of the back. A good working height is about 5-10 cm above elbow height. During manual work, the worker needs space for tools, material and containers of various kinds. A suitable height for these is 10-15 cm below elbow height.

For heavy work which involves much effort and makes use of the weight of the upper part of the body (e.g., woodworking or heavy assembly work), the working surface height needs to be lowered; 15-40 cm below elbow height adequate.

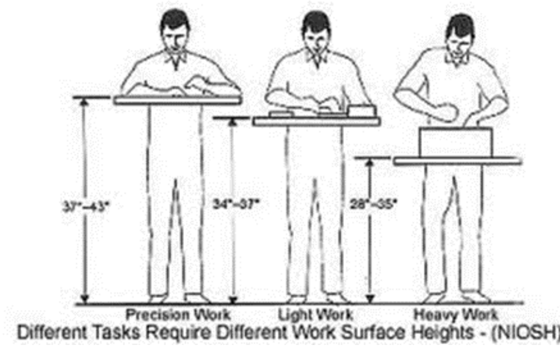

Figure 4: Standing workstation.

2.7.2 Seated Workstation

Preferably an industrial operation should be performed in a seated position to improve worker productivity by maximizing effective motions, reducing worker fatigue and increasing worker stability and equilibrium. A seated position has a number of advantages over a standing position, such as lower physiological load when sitting, reduced muscular load required to maintain body posture and improved blood circulation.

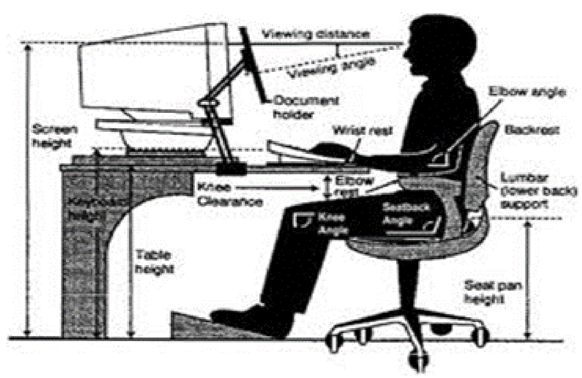

Figure 5: Seated workstation.

2.7.3 Seating

Despite a long history, seats are frequently poorly designed and uncomfortable. The main purpose of a seat is not just to take the weight off the feet. It is also to support the sitter so that can maintain a stable posture while he works and relax those muscles which are not required.

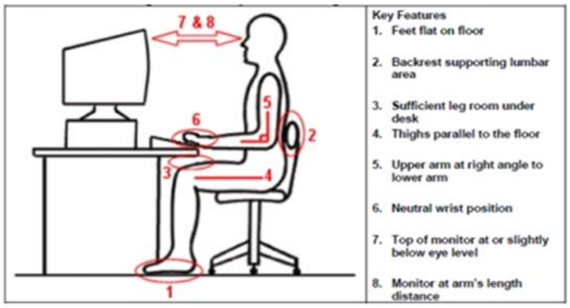

Figure 6: Factors of ergonomic design.

For most industrial tasks, workers are seated at a worksurface, bench, consoleor steering wheeel. Therefore, the seat should be seen and designed in realtion to the work site as a whole. The industrial work chair should satisfy certain basic requirements. The chair should be suitable for the job being done and the height of the work table. Because people vary in size, the seat height, depth and back rest height should be made easily adjustable. Here are some points:

- Seat area should be large enought to allow movement to relieve pressure points. Coushioning is desirable;
- Seat depth must not be too deep or too shallow. If it is too deep, it can result in pressure behind the knee, causing slouching and loss of thigh and back support. It should also have a front edge which is curved (waterfall front);
- Seat height should be adjustable. Best posture is to have both feet placed flat on the floor. There should be sufficient leg room to allow free change of leg positions, such as crossing of legs. Space for sufficient thigh clearance below worksurface should be permitted. If the seat height is too high, legs will dangle, thus increasing pressure on the underside of the thighs. If the seat is too low, knees will be raised, putting leg muscles under tension and creating leg space problems. It is preferable to give foor rest to shorter people than to restrict leg space;
- Back support is important and should maintain the natural vertical curvature of the lower spine as well as the horizontal curvature of the back. Back support should be adjustable both horizontally and vertically. If the back rest does not fit agains the lumbar curve, then the back will not be adequately supported and will result in extreme postures and muscular fatigue from the lack of external support for the weight of the body;
- Arm support is often unnecessary in iudustrial situations because the arms can be supported on the worksurface. If used, arm rests should accommodate broad people and be wide enough to support the whole arm. They should be made adjustable in height so that slouching or huncehd shoulders can be avoided.

2.7.4 Static Muscle Loading

When using a hand tool, the total force is a combination of the force used to position and manipulate the tool (i.e. grip the tool to perform the task), as it is used repeatedly throughout the workshift, and the force to overcome the weight of the tool itself. Therefore when tools are used in situations with arms elevated or the tools have to be at arm's length for extended periods (during gripping operation), the muscles of the shoulder, arm and hand may be loaded statically. This loading can result in fatigue and reduced capacity to continue the work.j It may produce soreness in the muscles within a day. The situation may be aggravated by the need to used forceful highly repetitive exertions at awkward hand, wristand arm postures. It may manifest in the long run as CTD problems in susceptible people.

One solution is to support the tool with a balance or aids for holding e.g. weight compensated slings for heavy air wrench or overhead suspension with counterbalances and/or retractable linkage. Another solution would be to reduce the length of the lower arm by supporting the forearm or wrist. This not only reduces the fatigue but also the tremor, permitting a more accurate use of the tool.

2.7.5 Awkward Hand Postures

Tools should be designed to minimize awkward postures required to operate the tool. One of the most common complaints about tools relates to the location of the handle which forces the worker to bend the wrist when using the tool.

Awkward hand positions may result in wrist soreness and difficulty in sustaining a grip on a tool. If the tool is used repetitively with a bent wrist, the tendons in the wrist are stained and an inflammatory condition –

carpal tunnel syndrome – is induced that can cause significant hand pain.

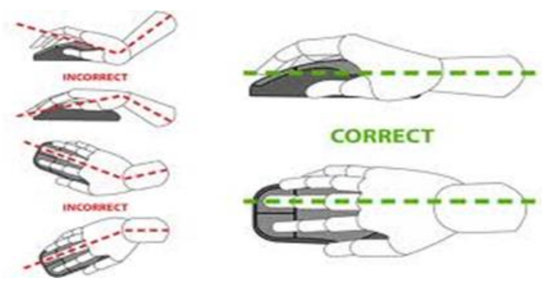

Figure 7: Awkard hand posture.

To reduce this problem the warkplace needs to be designed and potitioned so that wrist deviations are minimized during assembly or maintenance operations. Alternatively, the tool should be redesigned by "bending the tool, and not the wrist"

The tip of the original soldering iron is straight and had to be held at an angle. This requires the operator to lift his elbow by moving the arm away from the body. This action causes fatigue of the shoulder muscles. The improved design has the tip bent at a 90o angle. This eliminates the need to lift his elbow. Also shown is a pair of pliers which required the user to cock the wrist. Strength is also lost as the wrist is moved from its neutral position. The improved design avoids the awkward posture.

2.7.6 Pressure On Soft Tissues Or Joints

When large forces are exerted during the use of hand tools, pressure can be transmitted to both the palm and fingers. The tool can press into the palm at the base of the thumb where blood vessels and nerves pass through the hand. This situation may result in some pain and swelling of the hand. To reduce this potential for injury, handles for tools should be long enough so that they do not end poking into the palm. This is especially for tools such as pliers and rivets where high force applications are required. Forces exerted by the fingers, e.g. holding a trigger or activating a slide switch, may put high pressure on the skin dan joint.

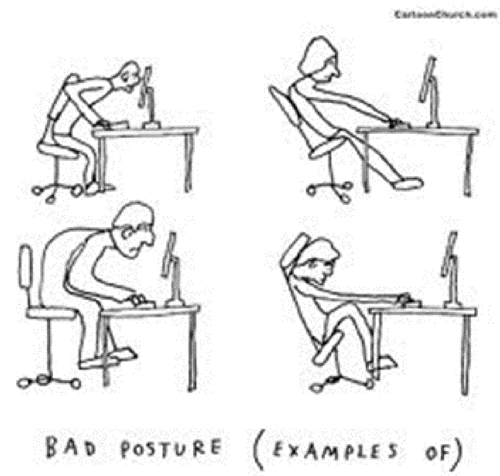

Figure 8: Pressure on joints.

The most approprite way to improvise the situation and solve the problem is to keep the forces low. If the area over the force applied is increased, the force per unit of area will be reduced.

2.7.7 Repetition

Repetitions are defined as movements or exertions made by a major joint. The combination of repetition and excessive force can contribute to the onset of CTD. The body has a natural limit to the amount of repetitive movements it can withstand. Mechanical and physiological problems arise when these limits are exceeded. Many jobs such as assembly, packing, sewing, typing involve manipulation and repetition. Althoughthe hand and arm evolved as highly efficient grasping tools, they are not designed to withstand the stresses imposed upon them by many industrial tasks. High rates of repetition, unnatural ranges of movement, and overloading of muscles and joints can lead to CTD.

After exertion, muscles require recorvery time. The heavier the exertion, more recovery time is required. If adequate recovery is not allowed within the total cycle time of a repetitive job, then this lack of rest will result in a state of cumulative fatigue at the end of the workshift. Carpal Tunnerl Syndrome is a CTD which is induced by repetitiveness of the task and the force levels.

The situation ca be resolved by using automatic tools to do repetitious work such as driving screws: reducing the required force and allow adequate recovery time without changing cycle time or repetitions; maintaining force requirement and allowing more recovery time by reducing repetitions, increasing the cycle time or allowing self-pacing of the work; or alternating between differeng task to use a variety of muscle groups.

2.7.8 Manual Materials Handling

Despite an increasing amount of manual work being done by machines due to increased mechanization and automation, there are still many jobs that must be done manually which result in heavy physical stress. Poor design of the workplace contributes to innumerable back injuries each year. Back injuries are one of the leading causes of job related disabilities. In contrast, a survey of injuries reported by SOCSO in Malaysia in 1992 sowed that back injuries only constituted 6.7% of the reported cases of injuries amongst industrial workers. Back injuries are usually caused by working or lifting with a bent spine.

Figure 9: Manual material handling.

The most hazardous task involving the back is lifting.However, stretching, stooping and twisting also represent potential injury risks.All these maneuvers are prevalent in the workplace and the gravity of how hazardous the maneuver is to the back must be considered in relation to factors, such as loading body position, and individual physical variations (twisting with a 36kg (80lb) load is a significant risk).The back is vulnerable to cumulative trauma. Although the back may sustain these and other stresses for extended periods of time with no apparent difficulties, the trauma and damage to the back structures often tend to be cumulative. This explains the fact that the person who routinely lift 45kg (100lbs) packages can injure his back when bending to pick up a pencil; "the straw that broke the camel back!". The cumulative effect underscores the importance of understanding and utilizing proper lifting and material handling techniques.

Lifting of moderate weights can also result in severe and debilitating injury if the legs and head are not positioned correctly in relation to the trunk and torso. When the body bends at an angle so that back is roughly parallel to the floor, the musculature of the back is not generally capable of sustaining this static loading especially when it is repeated loading as well. In this position, the vertebral column is suspended from the hip joint in the same manner as a crane boom is suspended from its fulcrum. According to the Laws of Physics, the closer the back to the horizontal, the more severe the stress and loading on the back.

Risk to the back can be minimized by following good ergonomic practices:

- Proper lifting posture to avoid back injuries.
- Reduce the amount of manual product handling; use mechanical or automatic transfer devices e.g. hoists, trolleys, adjustable platforms.
- Restrict lifting to between shoulder and knuckle height.
- Avoid awkward postures such as twisting, high lifts, constricted spaces.
- Redesign the workplace and containers with handles or hand grips on loads respectively.
- Select people for specific tasks according to their strength and endurance.

2.8 Design/ Evaluation of Working Environment

1. Lighting
2. Noise
3. Temperature
4. Comfort

2.9 The Need of Ergonomic Intervention for Industries

The design of jobs, Work environment and workstation using ergonomics principles which focus on human capabilities and limitations is neither still nor very widespread in industry. There are a number of possible reasons for this:

1. A lack of recognition of how poorly designed jobs can reduce productivity or affect worker health and safety.
2. A lack of practical guidelines that can be applied to job design.
3. A lack of awareness of the information available and how to apply it.
4. The unavailability of documented studies demonstrating the impact of the ergonomic redesign of jobs on productivity, accident rate, quality of performance and so on.

Primary reasons for industry to incorporate ergonomic principles into job of workplace design are:

1. To improve health and safety.
2. To improve productivity.
3. To increase work quality
4. To improve ability to do work.
5. Job satisfaction.

III. CASE STUDY

3.1 Case Study 1

A Case Study evaluating the ergonomic and productivity impacts of partial automation strategies in the electronic industry

A case study is presented that evaluates the impact of partial automation strategies on productivity and ergonomics. A company partially automated its assembly and transportation functions while moving from a parallel batch to a serial line-based production system. Data obtained from the company records and key informants were combined with detailed video analysis, biomechanical modelling data and field observation of the system. The new line system was observed to have 51% higher production volumes with 21% less per product labour input and lower work-in-progress levels than the old batch cart system. Partial automation of assembly operations was seen to reduce the total repetitive assembly work at the system level by 34%. Automation of transportation reduced transport labour by 63%. The strategic decision to implement line-transportation was found to increase movement repetitiveness for operators at manual assembly stations, even though workstations were constructed with considerations to ergonomics. Average shoulder elevations at these stations increased 30% and average shoulder moment increased 14%. It is concluded that strategic decisions made by designers and managers early in the production system design phase have considerable impact on ergonomics conditions resulting system. Automation of assembly and transport both lead to increased productivity, but only elements related to automatic line system also increased mechanical loads on operators and hence increased the risk for work related- disorders. Suggestions for integrating the consideration of ergonomics into production system design are made.

- Case Study: 1 Conclusion

The automation of repetitive assembly work reduced system-operated exposed to manual assembly work, and thus system-level WMSD risk. It also is increased productivity. However, the remaining manual assembly work increased in intensity and monotony due to the automation of transportation functions, which simultaneously increased in both productivity and WMSD risk. The early selection of technological solutions reduced biomechanical exposure latitude and could not be overcome by adjustments to the workstation layout. Production system designers and senior decision-makers have decisive influences on the ergonomic quality of their production systems.

3.2 Case Study: 2

Scientific approaches for the industrial workstation ergonomic design.

Over the last years ergonomic problems have received growing attention due to their effects on industrial plants efficiency and productivity. Many theories, principles, methods and data relevant to the workstation design have been generated through ergonomics research. However, no general frameworks have been suggested, yet. The time seems to be right for presenting a review paper on the scientific studies whose aim is to achieve the ergonomic design of industrial workstations. To this end, it is the intent of the authors to provide the readers with an accurate overview on the main scientific approaches proposed (during the last two decades) by researchers and scientists working in this specific area. In particular, two main scientific approaches have been identified.

The first approach is based on the direct analysis of the real workstations, while the second one uses computerized models to design workstations ergonomically. Each scientific approach will be presented through a detailed description of the research works it involves. The initial search identifies a huge number of articles which were reduced to about 60 studies based on content and quality. Note that the research works description represents the core part of this literature review.

- Case Study: 2 Conclusion

The main objective of the paper is to present a literature review concerning ergonomic effective design of industrial work station. The initial search identifies a huge number of articles which were reduced to 60 case studies based on content and quality. Such studies have been identified by means of Google scholar, Scopus and Scirus as research engines. The first run is made by typing the keywords “industrial workstation” , “industrial design” , “workstation design”, “ergonomic standards”, “modelling & simulation” and “computerised model”. At the second stage, the abstract of the peer-reviewed and of the specific-interest groups’ publication outcomes have been read, to evaluate the actual pertinence of the abstracts to the research issue. At a later stage, starting from evaluation of the abstracts only the more relevant papers have been read and classified/considered in the literature review. The researches were clustered according to the scientific approach they propose. In this regard, the author identifies two different scientific approach based on different principles, methods and tools. The approach is based on the direct analysis of the real workstations, while the second one used computerized models to design the work station ergonomically. Finally, the literature review with the identification of some gap and a brief description of ongoing research activities that give significant contribution to the actual state of art. To this end three different application examples in three different manufacturing areas are briefly presented and discussed.

CONCLUSION

In conclusion, manufacturing industries should apply the principles of ergonomics to the design of equipment, tools and systems in order to reduce risk factors of CTD. In summary, all tasks should be reviewed systematically and ergonomic controls should be utilized to reduce exposure to risk factors.

The risk factors of CTD may be summarized as follows:

- Repetition - The number of motions made per day by a particular part of the body.
- Force- The exertion required to make these motions.
- Awkward postures- The positions of the body that deviate from the neutral in making these motions (especially bending wrists, elbows away from normal at side of body, and a bent or twisted lower back)
- Excessive pressure - Excessive contract between sensitive body tissues and sharp edges, on nerves or soft or surfaces on a tool or an equipment.
- Vibration- Exposure to vibrating tools or equipment whether hand held tool or whole-body vibration.
- Temperature - Exposure to excessive cold or heat.

REFERENCES

[1] Swedish National Board of Occupational Safety and Health, 1998, Ergonomics for the prevention of Musculoskeletal Disorders (translation), AFS 1998:1. ISSN 0348-2138, Stockholm.

[2] Hendrick, H. W., 1996, *Good ergonomics is Good Ergonomics* (Santa Monica, CA: Human Factors and Ergonomic Society).

[3] Andersson, E.R., 1992, *Ergonomic evaluation of ergonomics: Part I-Guidelines for the Practitioner.* International Journal of Industrial Ergonomics, 10, 161-171.

[4] Wilson J., 1997. *Virtual Environments and ergonomics*: need and opportunities. Ergonomics, 40, 1057-1077.

[5] Nayar N., 1995. *Deneb/ERGO: a simulation based human factors tool*. Winter Simulation Conference Proceedings 1995, 427-431.

[6] Jung E.S., Kee D., 1996. *Man-machine interface model with improved visibility and reach functions*. Comp. Ind.Eng.30 (3), 475-486.

[7] Das B. and Sengupta A.K., 1996. *Industrial workstation design*: a systematic ergonomics approach. Applied Ergonomics, 27, 157-163.

[8] Resnick M.L. and Zanotti A., 1997. *Using ergonomics to target productivity improvements*. Computers and Industrial Engineering, 33, 185-188.

[9] Deros B.M., Khamis N.K. (2011) "An *ergonomics study on assembly line* workstation design". American Journal of Applied Sciences 8(11):1995-1201.

[10] Mavrikios D., (2006), "*An approach to human motion analysis and modelling*". International Journal of Industrial Ergonomics, Vol.36 No.11, (979-989).

[11] Ulin S.S., Keyserling W.M., (2004), "*Case Studies of Ergonomic Interventions in Automotive Parts Distribution Operations*". Journal of Occupational Rehabilitation, Vol.14, No.4.

[12] Kumar K.S (2011), "*Jig design, assembly line design and work station design and their effect to productivity*". Jordan Journal of Mechanical and Industrial Engineering Vol.5, No.1 (9-16).