AN EXPLORATORY STUDY OF ERGONOMIC WORK PRACTICES IN SELECTED SMALL MANUFACTURING ENGINEERS.

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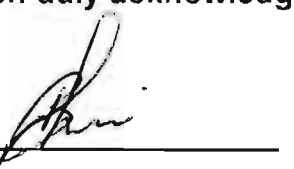
DECLARATION

I declare that that the dissertation hereby submitted for the Master of Commerce Degree at the University of Kwa-Zulu Natal has not previously been submitted for a degree at this or any other institute, and that it is my own work in design and execution and all reference material contained therein has been duly acknowledged.

Signature of Student: 

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A HUMBLE OFFERING AT THE DUST OF THE LOTUS FEET

OF MY SPIRITUAL MASTER:

HIS HOLINESS KRISHNA DAS SWAMI MAHARAJ ·

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ABSTRACT

Many organizations are using ergonomic principles and its applications to improve and optimize the current levels of productivity, safety and health. This can be achieved by carefully examining the current management and work practices with the view of finding alternative ways to perform these tasks.

In view of the above this research examines the current management and work practices of three small manufacturing engineers, with the purpose of providing inputs, to improve their current status through the application of ergonomic principles.

The study is divided into three parts. The first part focuses on the review of current literature on ergonomics and specifically discusses issues such as anthropometry, cumulative trauma disorders, manual material handling, and ergonomic based management systems. The second part focuses on an assessment and identification of existing problems and areas of weaknesses in the workplace. This was accomplished through in depth interviews, observation and questionnaires. The final part presents the research findings followed by the discussion and proposed recommendations.

The study has revealed that there is a fundamental lack of knowledge of ergonomics and its relationship to productivity, safety and health. Currently most work practices are guided by what has been learnt and internalized over the years.

The researcher proposes that in order to successfully implement an ergonomics programme, ergonomic awareness, training and education, self help training, management commitment and work force participation are essential.

CHAPTER ONE – INTRODUCTION

1.1 Introduction

The demands imposed by today's turbulent business environment leaves no room for poor performance. It is important therefore to consider all methods, factors and techniques that contribute to the efficiency and productiveness of a system. There are different tools through which the productiveness of a system can be evaluated. One such vital tool is ergonomics (Simpson 1988).

In order to survive or grow a business there has to be a system in place where coming up with pro-active and be active solutions to problems becomes the expected norm, and where these are translated into a culture of continuous improvements in aspects of work (Womack et al, 1999). Herein lies the true value of ergonomics.

For profit to be maximized employers must invest in both technology and workers to enhance productivity and competitiveness (Ntuli, 2000). There must be a shift from the traditional view of labour is a cost to be minimized, to a resource that has to be maximized for success (Vally, 1997). In view of this an understanding of ergonomics is therefore necessary.

For management it is imperative that maximum value must be extracted from their workforce. However in realizing this, health and safety of the worker must not be compromised. Workplaces should be designed to be human friendly as employees spend approximately one third of their lives at the workplace (Haslegrave, 1990).

Ergonomics once a speciality left to experts must now be understood by general management in order to understand essential elements in a job of work and by relating it to factors such as human factors in design, labour effectiveness, productivity, safety and health. In this respect, ergonomics, when applied correctly, is a win-win proposition.

Proper work standards are often a necessary part of ensuring that employees are able to give of their best. Jobs with high energy expenditure and whole-body fatigue are the primary cause of increased costs and loss of productivity (Kaudewitz, 1988).

A productive workforce is a vital source of productivity growth. People are important resources and should be valued by their companies. Herein lies the importance of an ergonomic intervention (http://www.ergonomics.org.uk).

The way forward is to make ergonomics an integral part of an organization. This will create an organization with a balanced set of values and place employee well-being on the same level as fiscal values for increasing wealth and productivity.

1.2 Problem Statement

There are two major problems with the current orientated approach to ergonomics. Firstly it is reactive rather than proactive thereby severely limiting the ergonomic potential for enhancing total performance of an organization. Secondly, history has shown this approach to lead to the sub optimization of work system design, including poor utilization of human capabilities (Hendrick, 1999).

The single greatest weakness in the application of the current ergonomic knowledge base is that well over half of the world's population does not benefit from it, or does so in a very limited way (Hendrick, 1999).
Focussing on South Africa, the major problem facing small manufacturing businesses are many unique challenges that are not generally faced by similar businesses in developed countries. Although ergonomics interventions are common practice in developed countries, these types of interventions are severely lacking in industrially developing countries (IDCs) such as South Africa (Christie 2001). Industries in IDCs have been acknowledged to be "a complex array of problems" receiving little or no ergonomic benefits (Scott and Shahnavaz, 1997). These factors largely limit the application of the current ergonomic knowledge base in South Africa.

As many workers in IDCs are poorly educated, South Africa being no exception, workers are willing to do any type of work and put up with abhorrent working conditions to earn a living (Christie,2001). Furthermore, too many small businesses in South Africa have sub- optimal working conditions which breed ill health and/or are unsafe. A predictable outcome is that workers suffer, productivity is compromised and ultimately the profitability of the company is decreased. This in turn will have a profound effect on the country's economy as a whole.

The consequences of technological change have not always been foreseen for many types of work. Despite the exponential development of technology

and automation, people remain the most valuable resource of any country and in particular in IDCs such as South Africa. It is important for management to ensure that the increasing rapid pace of change created by new technology does not exceed human capability either mentally or physically, while at the same time ensuring that productivity is not compromised. Man in his working environment has certain assets and liabilities, and certain capacities and limitations. The assets and capacities must be utilized to their best advantage and the liabilities and limitations require compensation.

South African small manufacturing companies have yet to recognize the substantial impact that ergonomics can have in improving worker efficiency thereby increasing productivity while at the same time reducing physical and mental demands placed on the worker (Christie, 2001).

1.3 Significance of Study

The effort of organizations such as the South African Ergonomics Society in supporting ergonomic growth and awareness in South Africa is admirable. However this represents a minute percentage of effort needed in the optimization and development of the human potential.
It is imperative that for ergonomics to significantly contribute to improving health, safety and ultimately productivity a concerted effort is needed at all levels viz: national, regional, organizational.

Workforce strikes have revealed that it did not revolve around pay packet issues only, but also on better working conditions (Erasmus, 1995).
According to the Growth Economic and Redistribution strategy document (GEAR), studies into economic growth suggest that growth is strongly affected by human capital (http://Ananzi.com).

The DTI/Nedlac Fund for Research into Industrial Development Growth and Equity (known as Fridge) commissioned a research study in 2002 to examine the reasons for job losses, turnover and low productivity in the metal and

engineering industry and to identify and propose implementable outcomes which will benefit the industry as whole, and lead to sustainable development and job creation and development (www.seifsa.co.za).

This study is significant in that it can serve as discussion/study platform in the research process. This study will significantly contribute in the process to help improve the prospects of the metal and engineering industry and its employees in the years ahead.

1.4 Why is the Study Important?

It is increasingly becoming evident that we must proactively adopt a human centered approach to management practice. This approach transforms the role of management to serve as a proactive change agent, resulting in a more productive and humanized work systems.

South African managers face several stumbling blocks in implementing a proactive approach to reducing health and safety costs. Some of these problems can be attributed to management's current trend of viewing any investment from a short term profit perspective.

Today's managers' face increased pressure to improve performance within their organizations. In order to accomplish this objective with a smaller workforce; managers need to empower employees to take responsibility on productivity and performance. To create a workplace that is conducive to achieve this performance, health, safety, work design and productivity has to be considered.

A random survey of annual reports from a cross section of major companies listed at the Johannesburg Stock Exchange indicated that less than 20 percent included in their mission statement a commitment to employee health and safety. Nowhere in any of these reports can be found evidence to suggest how these companies support these principles. A survey conducted in South Africa revealed that South African managers do not rank health and safety issues as major management priorities (MacKinnon and Negash, 1998).

While it is necessary that workers must perform their job in the most efficient manner possible, they must also be protected against undue physical, biological, and physiological strain that may occur as a result of performing a task.

It is time that all facets of the occupational environment are investigated and addressed, so that all hazards that may have an effect on a person's health at work are assessed and controlled using sound fundamental principles of engineering, management and administrative controls and not the "quick fix" route as is so common in South Africa.

1.5 Contribution of Study

The researcher proposes that through the systematic application of principles, guidelines and recommendations proposed in this study, this research will potentially contribute to the following:

- A new tool for management problem-solving: Both the workplace and processes will be viewed from a new perspective thereby providing fresh insights. Problems that are often overlooked will spotted and corrective action taken and new ways will be found to accomplish goals.

- Enable management to respond proactively to human resource problems: Costs associated with the following trends can be addressed:
    - higher workers' compensation costs
    - rising health care costs
    - aging work force
    - increasing expectations of work

1.6 Purpose of this Study

- To analyse different ergonomic models, concepts and management principles from relevant literature and adapt it specifically to the work processes under study.

- To propose recommendations in conjunction with global ergonomic and management best practices.
- To suggest possible guidelines for implementation in order to obtain optimum benefit and efficiency of the proposed recommendations.

1.7 Expected Outcome of Study

Issues of productivity safety and health has become an increasingly topical subject as management experiments with new and innovative ways to optimize these against a backdrop of legislation, financial constraints, high cost of labor and advent of technological advances. The expected outcomes of this research endeavor can be summarized as given below:

- At an organizational level, the targeted outcome will be to see the proposed recommendations and changes help the organization realize the goals to optimize productivity safety and health. In the process of doing so growing successfully and become a model for other small manufacturing engineers and other small companies.
- At a national level, the research will provide a case study that will help small scale manufacturing industries identify similar problems and thereby increase their contribution to economic and social development in South Africa.

1.8 Future Value of Study

- This study could serve as a pilot study for future studies with a larger sample and geographic spread.
- To develop and test hypothesis and feasibility of the proposed ergonomic recommendations through an actual intervention. This can be done through a longitudinal study.

1.9 The Context of the Research

The organisation is considered as a holistic system as any proposed changes or recommendations would influence the entire organization. Thus, in this research the organization is taken as a whole system.

1.10 Limitation of Study

This is an exploratory study of just three companies. The findings, however valid it may be to the companies under study, cannot be generalized to all small scale manufacturing engineers. In view of this the present study does not make any attempt to generalize.

1.11 Definition of Concepts

"Ergonomics may be defined as the study of the relation between man and his occupation, equipment, and environment, with respect to the application of anatomical, physiological, and psychological knowledge – or, put another way, (The *Concise Oxford Dictionary),* the 'study of efficiency of persons in their working environment", (Buchanan, 1983: 5).

The following definition on small business is best suited for this study. "A business in which one or two persons are required to make all the critical management decisions: finance, accounting, personnel, purchasing, processing or servicing, marketing, selling, without the aid of internal specialist and with specific knowledge in only one or two functional areas", (Watson and Everett,1997: 65).

"*Management* is the planning and controlling of the various functions (i.e. activities) of an enterprise so that the procedures and duties carried out by the employees maximise the resources of the enterprise in order to achieve the stated goal of that enterprise", (Buchanan, 1983:1).

"*Production* is the gathering or resources and the process of transforming them into finished goods", (Buchanan, 1983: 1).

"*Productivity* is defined as 'the state or quality of producing something, or the state of effectiveness of a productive effort", (The Concise Oxford Dictionary, 1999: 1141).

The small manufacturing engineers generally fabricate and manufacture small components, on a subcontract basis to large scale industries. These components are used in the assembly of final products such as a drive train, mountings etc. Common work processes are cutting, welding, machining of castings into parts and assembly of components.

1.12 Conclusion

The introductory summation sets the scene for a detailed analysis of the significance and importance of ergonomics in relation to the survival or growth of a business. We now have a preview of the role of ergonomics in the manufacturing environment. The interdependence of factors further illustrates the need for a careful study as identified in the purpose of the study.

CHAPTER TWO - LITERATURE REVIEW

This chapter is divided into three parts. The first part is the conceptual background to the study followed by the theoretical framework and finally the third part reviews related research findings. These three sections will be used as a basis to conduct the research as in identifying and understanding the real issues of the organization. Since the variables under study are not fully understood this section strives to provide a comprehensive review of all possible variables. This chapter will form the basis for discussion, design, recommendations and intervention necessary for the optimization of safety, health and productivity of the organizations under study.

2.1 Introduction

The manufacturing process adopted by the small manufacturing engineers under study can be classified as a human-machine system of production and work. It is therefore imperative that management elicit and maintain human capacity to its limit, and to also retain and provide the maximum optimum conditions for the efficient functioning of this human-machine system.

To successfully achieve this, it is important to understand that the human-machine interaction does not take place in a vacuum. It is affected by the physical workplace, the physical work environment and by the organization of the job or work.

Ergonomic interventions including redesign and proper adjustment of workstations, use of ergonomically designed seating, training in low-risk methods and postures provides the inputs for management to maintain a perfect balance in the human-machine system.

While many of these interventions have the potential to improve comfort, safety, and production efficiency, new ergonomic issues can appear with their introduction (Burke, 1992).

Integrating ergonomics into a workforce culture can have a positive effect by reducing workers compensation costs, reduce lost time, and improve productivity and quality.

Ergonomics has numerous positive inputs to improve such conditions. The best way to make ergonomics an integral part of the workforce culture is to develop a company wide programme.
The researcher stresses that ergonomics and its application plays a pivotal role in creating a win win situation among all stakeholders.

2.2 Conceptual Background to Study

This section focuses on issues concerning ergonomic disorders, safety, health, productivity, quality and worker participation, organizational culture and values, communication.

2.2.1 Characteristics of Small Industries

Implementing an ergonomics programme and evolving a process are difficult for small industries as they have unique characteristics which carry associated constraints. These constraints impact on the decisions that are required to develop the best ergonomics programme model to fit the culture and business needs of the organization.

Small industries often have the following characteristics (Stuart- Buttle, 1993).

- Less formality. Procedures and communication methods are informal and often have minimal documentation. Teams or task forces are often used but are loosely and formed ad hoc.
- Responsibility for several positions. Personnel perform several job functions, and therefore ergonomics is often included at the same time as addressing other issues thereby reducing team input because there

are fewer people in different positions, although the range of perspective remains.

- Greater responsiveness. The company tends to be project based. Therefore it gives focus to issues and brings them to conclusion.
- Less specific knowledge. Having personnel with several job positions means that less time can be spent focused on one specific area such as ergonomics. Therefore the degree of in house expertness usually limited.
- More management involvement. Management tends to be involved with the details of plant activities and shows their responsiveness to projects by making decisions and coordinating project efforts. However, the culture of the company also affects the extent of management commitment and employee involvement.
- Less data orientated approach. Once the company has decided on a course of action and is convinced that the approach is a good one, qualification is typically downplayed. This reduces the data available for prioritizing problem areas, cost benefit decisions, and determining project effectiveness.

2.2.2 Ergonomics Costs and Rewards

A full cost benefit equation of an ergonomics programme is extremely difficult to devise since many factors, some of them 'invisible', are involved when assessing the value of the programme.

Those that are important include, on the benefit side, the value of all goods and services produced by the system, and the values which accrue from any incidental or 'spin off' products. The negative side of the equation includes equipment costs, costs of replacement or the maintenance of parts, operating costs, the costs of job aids and the social costs of implementing the system (Ossler, 1984:19-25).

Any manager who contemplates to implement a system designed on ergonomic principles must be able to justify the cost in relation to the rewards. Many of these factors can be expressed in tangible monetary terms while others are less quantifiable. Nevertheless they make important contributions to reducing the efficiency and productiveness of a system and must be taken into account.

2.2.3 Productivity and Quality Enhancements

Improving the fit between humans and their workplace in conjunction with tools and machinery means a more effective match. Good ergonomic improvements often result in better ways of performing a task. The neck aches, backaches, eyestrain, and hand-wrist problems that results from poor workplace design can take away 15% to 30% of expected productivity. This can be changed by proper ergonomic workplace design (Pulat and Alexander, 1991).

Ergonomically conscious management's goal is to reduce human scrap and to maximize the operator's safety, efficiency and performance reliability. In turn this should result in reduced time lost through accidents and a corresponding increase in efficiency. Good ergonomic design can enhance productivity and quality, resulting in cost savings for organizations.

Many ergonomics programmes are initiated primary due to injury loss. This is an economically and socially post facto reactive approach which seems to overlook the fact that and human factors have their roots in human performance (Kogi, 1985).

Enhanced performance improves productivity, and ultimately has an impact on operating costs and profits. It is important to justify ergonomics also on the basis of productivity. Since the workforce size is relatively small, they are likely to have few or no compensation losses. Ergonomics based on productivity will help convince managers about the true value of ergonomics.

2.2.4 Participatory Ergonomics

Ergonomics, like any other technology, cannot exist independently of organizational and management considerations. Therefore, when introducing ergonomics we need to consider the organizational culture, management system, communication patterns, rewards, and a host of other variables that support ergonomics as a technology (Kuorinka and Patry, 1995).

Participation, however, recognises the worker as a valuable resource for solving problems. Participation allows workers a higher level of control and autonomy over their lives in the workplace. In doing so management seeks to increase motivation, efficiency and productivity. In a study done by Maller (1987) it was found that more South African companies using work study which a related discipline of ergonomics is to increase worker participation.

There are at least three compelling reasons which argue for involving people in the development of the ergonomic technology:

- Ergonomics in itself is an intuitive science. In many cases it simply provides names and labels for ideas, principles, or practices that workers are already using. In one sense it legitimizes the ideas and experiences that workers have accumulated in the process of doing their jobs.
- Ownership in ideas enhances the likelihood of implementing ergonomics successfully.
- End-user participation in developing technology creates a flexible problem-solving tool. That is, if people implement the technology, they will be able to modify it to solve future problems (Noro 1991:12-27).

People are more likely to support projects for which they feel ownership. In the long run, this has implications for a more involved and dedicated work-force committed to problem solving.

Listed below are suggestions for the general process of participatory ergonomics. (Kourinka 1995)

1. Clarify the essence of the problem and establish a goal.
2. Generalize and prioritize the measures.
3. Implement the measures.
4. Follow up.

A step by step approach according to Vink (1995) would be to

1. Prepare (decide the objective and the framework of the project)
2. Analyze work and health
3. Select measures
4. Implement the measures
5. Evaluate.

2.2.5 Employee Involvement

Employees are a valuable source of information and ideas. Involving employees in the process to accomplish effective ergonomics demonstrates the respect and expectations management has for employees. In small companies management is likely to be involved, therefore providing decision-making authority. Management support is necessary for effective implementation of administrative control.

Benefits of employee involvement are:

- Knowledge about the mechanical aspects of the production system and the environment helps when determining the workplace redesign potentials and the related costs.
- Personnel overseeing production and quality contribute information that helps to identify problem areas. Their perspective is useful in problem solving and assessing potential solutions.
- Involvement of the purchasing department ensures that the products are purchased based on function, quality and cost (Render and Heizer, 2001).

Many ergonomic issues are addressed through the active participation of employees and this is achieved through sufficient training to increase competency in making decisions. Teaching people about ergonomics will enable them to apply concepts in all aspects of their lives, which is a valuable asset in our rapidly changing technological environment (Joyce, 1994).

Programmes already in place that involve the workforce can be enhanced and used as a basis for ergonomic improvements.
The concepts are relatively simple and result in direct benefit to the employees themselves, which serves as positive reinforcement to employees for contributing ideas (Macleod, 1995).

2.2.6 Improved Morale and Employee Relations

Motivation plays a major role in efficiency and productivity. Concern for employees and their well being produces a payoff in improved morale.
This produces an environment that is conducive to work being done efficiently, and can be a major asset, but cannot be measured in monetary terms (Robbins, 1995).

2.2.7 Organizational Culture and Values

"Culture is defined as the set of key values, guiding beliefs and understandings that are shared by most members of an organization. The culture defines the basic organizational values. Culture represents the feeling part of the organization", (Johnson and Scholes, 1998: 230).

When culture is shared and accepted by the members of an organization it generates a commitment to support the beliefs and values that are essential to sustain the performance of the organization (Johnson and Scholes, 1998).
Ergonomics can help transform an organization from a fiscally based value system to a value-focused thinking and "ergo friendly" organization.

With value focused thinking, the values that are important to the organization become the principal measure against which alternatives and their consequences are evaluated (Huse, 1980).The" ergo friendly" concept of an organization clearly indicates that it is essentially important as a function of good business. It helps to make choices if conflicts, for example between worker safety and other business priorities arise.

Some common benchmark values of an "ergo friendly" organization (Buchanan, 1983, Chaffin, 1984 and Martin, 1987):

- Nearly all work-related injuries and illnesses are preventable.
- Management is responsible for creating a safe and healthy environment.
- Safety is an integral part of the business plan.
- All workplace safety and health exposures can be controlled.

In small companies the culture comes from management. The culture generally reflects their personal value and beliefs.

2.2.8 Management Commitment

Management commitment is fundamental to the success of an ergonomics programme. *A* lack of management commitment undermines any ergonomics programme; however well that programme may have been conceived and initiated. Small companies have an advantage, as management is more involved in the details of the production or service and have closer alliances, (Dodge, 1992).

Key expectations from management for success:

- Demonstrate commitment to the ergonomics process by presenting a positive attitude. Management attitude indicates the true priorities of the company to the employees.

- Commitment also affects whether a programme matures to become a way of doing business.
- If a culture change is required for the success of the programme, then vision, expertise, and exemplary management skills are essential (Churchill, 1983:27-45).

2.2.9 Communication

To enhance communication management must consider the following points.

- Verbally communicate the importance of ergonomics as the means to a safe, healthy and efficient workplace.
- Express interest to give a message that the programme is important and to instill energy, pride, and quality work in employees.
- Reinforce the commitment by an ergonomics policy or including the statement in the overall company policy and mission statement.
- State the programme objectives clearly to ensure that employees understand the reasons for changes (Wilson, 1988:13-19).

The advantage of small companies is that communication between management and the workforce is informal and very fast. They can see each other everyday and can talk or emphasize any points they wish to. This can speed up any change to be implemented or response time to important any issues.

2.2.10 Role Model

The behavior of management impacts more than a written statement (Robbins and Coulter 1999). The actions required by management to positively influence an ergonomics programme are: (ILO, 1985, Laing, 1992).

- Set an example by displaying an active interest in how the work is performed by the employee and whether the job demands are

reasonable.

- Closely monitor the injuries and illnesses records and follow safety requirements when in the work areas, such as donning personal protective equipment.
- Convey the importance of ergonomics in productivity by showing concern for the best environment and methods when looking to improve the process and production.

2.2.11 Compliance

Compliance to government regulations should not be the sole reason for implementing an ergonomics programme. If the workplace is designed well for people to perform their jobs effectively on a long term basis the workplace will be safe and healthy.

In Sweden, for instance, the working environment of workers is protected by ordinances and companies are legally bound to improve harmful working conditions. In contrast, if Japanese workers want an improvement in their working environment, they must submit a proposal that shows how this improvement will benefit the company. This proposal is then reviewed and approved by the manager. This unlegislated approach may lead one to conclude that Japanese companies may be considered inferior to their European counterparts. However, as a result of participation, the working environments in Japanese factories are among the best in the world (Imada, 1982).

2.2.12 Health and Safety Regulations

Workplaces and products have to be designed with health and safety regulations in mind.

In particular, ergonomics has proven to be effective in preventing a class of injuries known as cumulative trauma disorders, which result from damage to joints and surrounding tissue because of overuse from strenuous or highly repetitive tasks (Pulat and Alexander, 1991).

2.2.13 Worker's Compensation Claim Costs

This directly affects the bottom line profitability of any organization.
Costs are divided into two categories (Ossler, 1984 and Render and Heizer, 2001).

2.2.13.1 Direct quantifiable costs

Job related injuries and illnesses can result in workers filing for compensation. Compensation costs may include immediate and long-term medical expenses resulting from injury or illness, as well as payment of loss of income benefits if an employee is not able to work. In serious cases, there may be payments for permanent or partial, full or temporary, disability.

2.2.13.2 Indirect costs

These costs are difficult to capture and quantify and are often ignored although they have an equal negative impact on an organization's bottom line just as direct costs do. These include:

- Time lost by personnel who were not injured but may be called in to assist the injured employee
- Time lost in seeking medical help or to investigate the occurrence
- Cost of damaged material that resulted from the accident
- Cost of lower productivity while replacement workers learn new job skills
- Costs to make up lost productivity through overtime.

2.2.14 Meeting Competition

Large organizations compete successfully by providing improved services, innovation, and quality. Smaller companies can compete by taking full advantage of human capital to improve market advantage against competitors. This alternative, however, is not always sufficiently pursued.
Ergonomics can assist small businesses in this effort, by maximizing the use

of present human resources (Schoeman and Schroder, 1994). Despite the fact that the competitive landscape continually changes, in small manufacturing engineers the one variable that is sure to always be present is the human factor.

2.2.15 Job Design (ergonomics)

The ergonomic approach in designing the job to fit the capabilities of the worker has received greater attention in recent years. Statistics indicate a direct relationship between certain job activities and postures to the incidence of compensable low back pain.
These activities and postures include manual handling tasks, certain body movements, excessive loads, prolonged sitting and vibration (Grandjean, 1988).

2.2.16 Employee Well-Being

A good starting point for describing benefits of workplace ergonomics is employee well-being. Reduced injuries, fatigue, and mental stress are sufficient reasons in themselves for applying ergonomics, independent of any associated cost savings (MacLeod, 1995).

2.2.17 Ergonomic Problems

Fernberg points out that studies conducted in the 1970s and 1980s by ergonomists Marvin Dainoff, Michael Brill, Stephen Margulis, Tim Springer and others, focused on workstations and indicated a definite relationship between worker performance and working conditions. They found that the problems with most workstations are centered on two design-related problems — the physical components of the workstation and the nature of the job or job design (Rowan and Wright, 1994).

2.2.18 Ergonomic Related Diseases

"Occupational illness is defined as any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to factors associated with employment", (Figura, 1996: 51).

In order to develop preventive strategies, one must first look to medical science to determine possible musculoskeletal disorders that can occur in the workforce, what causes these disorders, and how they can be prevented.

2.2.18.1 Cumulative Trauma Disorders

"Work related musculoskeletal disorders of the neck, shoulder and upper limb can be collectively known as repetitive strain injuries (RSI). These disorders can be defined as physically orientated injuries that have developed over a period of time as a result of repeated biomechanical or physiological stresses on a specific body part. Cumulative trauma disorders(C.T.D.) is a collective term for syndromes characterized by discomfort, impairment, disability, or persistent pain in joints, muscles, tendons and other soft tissues", (Pheasant, 1991: 77).

According to Chaffin (1984) during the working years (ages 18 to 64) more people are disabled from musculoskeletal problems than from any other category of disorder. According to medical scientists, the majorities of these musculoskeletal injuries are not the result of accidents or sudden injuries, but rather develop gradually as a result of repeated micro trauma.
Trauma refers to the bodily injury from mechanical stresses, and often is only a micro trauma initially (Rowe, 1985).

On evaluation of CTD's, some of the reasons for the increase in the number of people suffering from this disease could be attributed to the following issues which include among others:

- Change in technology.

- An aging workforce.
- Decreased physical capacities of aged workers.
- Lower worker turnover.
- Increased awareness.

Putz-Anderson (1988) summarizes research in the area of CTDs, where it is emphasized that there are basically four occupational risk factors associated with the development of CTDs:

- Awkward postures.
- Excessive manual force.
- High rates of manual repetition.
- Task duration (or inadequate rest).

In addition, as the mean age of the working population increases, strength and flexibility decrements are visible. These are also important factors which can contribute to the development of CTDs.

2.2.19 Medical Research Relating to Musculo – Skeletal Disorders

Several studies (e.g. Frank 1983), have highlighted the occurrence of various musculo – skeletal symptoms among workforces across a broad spectrum of industries. The musculo – skeletal pain may be of various types (stiffness, fatigue, weakness and power loss, swelling or the sensation of swelling, numbness, tingling, etc.); it may occur in various parts of the body (neck, shoulder, arm, wrist, hands etc.) and with varying frequency for each worker, (daily, occasionally or seldom).

Bridger (1991) conducted research jointly with the University of Cape Town, Medical school on musculoskeletal pain in a cross section of industries on the prevalence of body area pain. This study revealed the following:

Table No. One ~ Prevalence of body area pain

Body Area	Prevalence
Low back	26%
Trapezius	1%
Pectoralis	12%
Intercostals	5%
Shoulder Girdle	3%
Forearm, Wrist and Hand	1%
Digit and Thumb	1%

In industries surveyed, standing appears to be the posture of choice for many tasks but workspace and job design factors can increase postural stress. The study cites the most commonly observed design faults as:

- Lack of space for feet.
- Lack of clearance for feet under the work surface.
- Inappropriate work surface heights.

2.3 Theoretical Framework

This section presents a framework that can serve as a backdrop to guidelines that can assist small manufacturing engineers. The key areas of focus are anthropometry, standing/standing considerations, workplace design, the physical work environment and manual materials handling.

2.3.1 Workstation Design

A strong relationship exists between the comfort of workers and their productivity. Unfortunately, this fact has not yet been accepted by many manufacturing organizations, where management expects productivity of the organization and the quality of its product to be a function of pay rate (Erasmus, 1995).

Management should understand that worker discomfort due to long stan instead of sitting, for example, puts additional energy demands on the employee that by no means contribute to the workers productivity (Kroemer,1994).

In addition to fatigue and the resulting deteriorated worker's performance, an awkward workplace design can result in development of occupational injuries (e.g. cumulative trauma disorders) to the worker.

2.3.2 Anthropometry

"Anthropometry is defined as the science of measuring the human body", (Roebuck, 1975:8).Factors that influence anthropometry are gender, ethnic, occupation, clothing and genetic differences. In the industrial environment there are fewer constraints.

People can move around freely and there is not a great need for very sophisticated modelling. Anthropometric design can usually be accomplished in a couple of hours with paper and pen (Helander, 1995).

Anthropometric data for different regions of the world differ. The basic philosophy of ergonomics is to design workstations that are comfortable, convenient and productive to work (Helander, 1995).

Unfortunately no anthropometric data are available for South Africa.

As a guide anthropometric data for twenty regions of the earth is included (see appendix B)

"In manufacturing the use of the hand reference point is recommended. The ideal location of the hands depends on the task. For heavy manual jobs the hands should be about 20cm below the elbow height, but for precision tasks with supported under-arms the hands should be about 5cm below the elbow height", (Roebuck, 1975:287).

Since no anthropometric data are available for South Africa, U.S. civilian body dimension of industrial relevance are included as guide (see appendix C).

2.3.3 Sitting

There is less need to hold things when one is sitting down than standing, on the other hand sitting causes many aches and pains which can be relieved by standing.

Standing and sitting impose stresses upon different muscles. Each changeover relaxes some muscles and stresses the other. Standing requires an outlay of static muscular effort to keep the joints of the feet, knees and hips in fixed positions; this muscular effort ceases when the person sits down (Astrand and Rodahl, 1977).

2.3.3.1 Advantages of Sitting:

- Taking the weight off the legs
- Ability to avoid unnatural body postures
- Reduced energy consumption
- Fewer demands on the blood system .

2.3.3.2 Recommendations for Seated Workstation

- All items needed during the routine task cycle can be easily supplied and handled within the seated section.
- The job being performed does not require reaches more that 40 cm forward or higher that 15 cm above the work surface.
- The job does not require large forces, such as handling objects heavier that 4.5 kg.
- The job involves writing or light assembly for a major part of the shift.
- The job requires precision or fine manipulative movements that need a level of stability.
- The job includes foot control operation, which is performed easily and safely while sitting and maintaining good postures (Nag, 1996:311-312).

2.3.3.3 Recommendations for Sitting Postures

- The upper arms and lower legs are vertical.
- The forearms and thighs are horizontal.
- The feet are flat on the floor.
- The seat backrest supports the inward curvature of the lumbar region of the spine.
- The weight of the upper body is evenly distributed between the large area of the buttocks and the thighs (Tayyari, 2002:241).

2.3.3.4 Design of Seated Workstations

The main two objectives of ergonomic seating in the workplace are:

- increase individual efficiency and reduce fatigue;
- facilitate proper posture.

The following are common principles for design of seated workstations (Tayyari, 2002:247).

- Everything workers need while performing their task must be accessible and easy to handle in the seated position.
- The sitting workstation design should not require the hands to work at more than 15 cm above the work-surface.
- Provide mechanical assists or eliminate the requirement of large forces. The worker should not handle objects weighing more than 10 kg manually.
- Provide an ergonomically correct chair. The chair should allow users to keep their spine and head upright to prevent back and neck strain.
- Eliminate lifting from the floor.

Table No. Two ~ Critical Dimensions Required for Proper Seat Design

Horizontal knee room	300x 650mm
Height of working field above seat	300-600mm
Height of working field above floor	1000-1200mm
Range of adjustment of seat	800-1000mm

Source: (Clark and Corlett, 1984:204).

2.3.3.5 The Advantages of Sitting over Standing

- Sitting requires less muscular activity, delaying fatigue. An individual can sit for approximately one hour but stand for approximately only half an hour before fatigue sets in.
- Sitting has more stability, which is needed for precision or fine tasks.
- A worker can operate a foot control more easily while maintaining a good posture (Rowan and Wright, 1994).

2.3.3.6 Seat Design

An appropriate match between the dimensions of the seat and those of its user is a basic prerequisite both for comfort and good posture.

As a guide some anthropometric aspects of seat design are given included (see appendix D).

2.3.3.7 Important Considerations in Seating

- The height of a seat should not exceed the popliteal height of its user (i.e. the height of the underside of the knees). For a resting chair, where the user may wish to stretch out his legs, a lower seat is preferable.

- If the seat height is greater than popliteal height, the user will be unable to rest his feet firmly on the floor without undue pressure on the underside of his thighs. This rapidly becomes a source of discomfort.
- The height of a non-adjustable chair should not exceed 400mm or 425mm at the most
- As a rough guide, the upholstery of a chair should be compressed by 2.5cm when you press down hard on it with your hands. Upholstery materials should be porous as plastic and wooden chairs may become unpleasantly clammy in hot weather
- The seat depth of about 380 mm is recommended.
- The backrest should be high enough to support the lumbar region (the small of the back), which extends from about 125mm to about 200mm above the compressed seat surface. Lumbar supports are often shaped so as to induce a curve in the spine that encourages good posture and minimizes fatigue.
- The seat width is determined by the need to accommodate the hips and lower trunk. A width of 410mm will fit all but the broadest person, although 50mm should be added to this to allow for clothing and the contents of the pockets (Oborne, 1982, Sommerich, 1997, Pheasant, 1991, Galer 1995).

2.3.3.8 Recommendations for Working at a Seated Workstation:

- Sit as close to the work as possible.
- Lower the seat height enough (but not too low) to place the feet flat on the floor. If this is inappropriate, the use of a footrest is recommended;
- Support the lower back and avoiding sitting slumped.
- Avoid forward and downward leaning over the task.
- Avoid prolonged sitting, even in good postures; (Clark and Corlett 1984).

2.3.4 Standing Workstations

As stated previously standing and sitting impose stresses upon different muscles. Each changeover relaxes some muscles and stresses the other. In addition to this fact there are other instances when standing is favourably suited to perform certain tasks.

Standing workstations are recommended in the following instances:

- The workstation does not have knee clearance (suitable leg-room) for a seated operation.
- The job involves handling objects weighing more than 4.5 kg.
- The job requires frequent movement from one station to another.
- The job requires high, low, or extended reaches frequently.
- The job requires the exertion of downward forces (Burke, 1992, Haslegrave, 1990, and Kroemer, 1994).

2.3.4.1 Recommendations for Working at a Standing Workstation:

- place work at a comfortable height;
- change positions frequently;
- place one foot up, for example, on a foot-rail and alternate the feet frequently in prolonged standing;
- Avoid standing on hard (e.g., concrete) floors. Cushioned mats should be used for standing;
- Avoid bending forward at the waist during prolonged standing. The requirements for working at low heights should be eliminated;
- Avoid standing with swayed back and relaxed stomach muscles, and knees locked (Bailey, 1982, Oborne, 1982, and Tayyari, 2002).

2.3.4.2 Techniques to Minimize Pressure on the Legs and Feet

- Change the workstation layout to eliminate leaning against the table edge, machine, or any other obstacles.
- Reduce the size of the workbench/table to avoid over-reach and leaning against the table edge.
- Round and pad the edge of the worktable.
- Change the work-surface height.
- Wear cushioned shoe inserts (insoles).
- Stand on floor mats.
- Redesign the job (Hagberg, 1982, Kroemer, 1994).

2.3.5 General Rule for Working at Workstation

Human work, in principle, consists of repetitive body movements and is dynamic in nature. This places constant strain on the body.
Listed below are some workstation rules that are of prime importance:

- Hand grips, operating levers, tools, and materials should be arranged around the workplace in such a way that the most frequent movements are carried out with elbows bent and near to the body.
- Hand-work can be raised by using supports under the elbows, forearms or hands.
- Use rubber or padded strips to cover sharp edges or corners of work tables and benches with which the body may come in contact.
- Torso twisting action should be prevented. Twisting is especially dangerous when performed in conjunction with lifting.
- The combination of stretching and lifting or placing objects at a distance which will significantly increase the load on the back should be avoided. Hooks or similar devices should be used to pull the object as close to the body as possible, before lifting it.
- Lifting heavy or bulky objects above shoulder height should be prevented. Such objects can generate large torque loads on the lower back.

- Wrist bending in repetitive tasks should be prevented. For example, a container can be tilted so that when objects are repetitively removed from or placed into it, the hand is aligned with the long axis of the forearm. It is especially important to avoid bent wrists when the application of large forces if required (Grandjean, 1988, Pheasant, 1991 and Waters et al, 1994).

2.3.6 Good Working Postures

- Align the ears, shoulders, and hips.
- Align the elbows, wrists, and hands to maintain the wrists in a neutral position, with the hands slightly below the elbows.
- Keep the elbows as close to the body as possible.
- Keep feet flat on floor/footrest with the thighs horizontal when sitting.
- Support one foot during standing on a footrest and alternating the feet periodically to reduce strain in the low back region, and to allow for frequent, easy postural changes (Oborne, 1982).

2.3.7 Good Work Habits

According to Tayyari (2002) the following is a summary of good work habits:

- using whole hand grasps, but avoiding pinch grips;
- holding an object at about its centre of gravity to balance its weight;
- Tilting the work surface or containers may help maintain the wrists in a straight posture and bring the task within an easier reach.

2.3.8 Back-Injury

Back injuries are seldom caused by single incidents. They are usually developed by long-term wear and tear. This is why they are often classified as CTD's.

Listed below are common causes of back injuries, (Chaffin, 1984, Kroemer, 1994, Nag, 1996)

- Overexertion in manual material handling, e.g., lifting, lowering, pulling, pushing, and carrying activities
- Poor lifting techniques such as
  - sudden or jerky movement (to create inertia), instead of smooth lifting
  - extreme twisting instead of pivoting
  - lifting objects too far away from the body
  - lifting with the back flexed
  - using weak back muscles instead of the leg muscles, which are stronger than back muscles
- Reaching above shoulders, especially when lifting an object
- Awkward workstation design, at which
  - work is too low;
  - work is too high, requiring reaching;
  - work is far away from the body;
  - the back is unsupported;
- Poor postures in sitting and standing.

2.3.8.1 Back Injury Prevention Techniques

There is no magic pill or formula to eliminate back injuries. With careful application of engineering and administrative controls, exposure and injuries should both be reduced. In order to have a successful back injury-reduction programme, the workers must become involved in the programme.

The old safety posters reminding workers to "keep your back straight and lift with your legs" are not an adequate solution to the problem of increased back injuries. In its place there must be awareness and training principles that instruct employees in the following techniques of back-injury prevention.

Listed below are back injury prevention techniques (Taylor, 1987:32):

- Keep the spine in a neutral posture during sitting.
- Get support for the lower back by using the seat backrest or a pillow in sitting.
- Adjust the seat height so the thighs are horizontal and feet flat on the floor. If the seat is not adjustable, a footrest should be used.
- Get up and stretch for a few moments every 15—20 minutes of work.
- Tuck the stomach in and fill the lungs during physical work and exertions.
- Choose a workstation that allows you to alternate between sitting and standing.
- If the work is only performed in a standing posture, a footrest or box should be used to raise one foot over the other. The feet should he alternated when the person feels like it.
- Stand on a mat or carpet rather than on a bare concrete floor;
- Avoid bending over the task.
- Keep the task in front of the body, not on the sides.
- Warm up before starting the work

2.3.9 Guidelines to Prevent Awkward Postures

The general rule of thumb for preventing awkward shoulder posture is:
"The lower the reach target, the better the posture".
Maximum shoulder height occurs when the trunk is perfectly upright (Putz and Anderson, 1988).
In many work situations, awkward posture is caused by the excessive reach requirements of a specific task.

- Avoid reaching for an object that is lower than the height of the hands when the arms are fully flexed (i.e., hanging vertically at the side if the body).
- Avoid reaching for an object that is too far in front of the body (Putz and Anderson, 1988)

It must be noted that recommendations for preventing awkward shoulder and trunk posture must be treated with extreme caution, particularly when working at the limits of the reach envelope. Repetitive reaches to the limits of the envelope can result in excessive fatigue and/or soft tissue injury (Rowe, 1985).

2.3.10 Work-Tools

The essence of ergonomics is about understanding human beings and in doing so tools have to be designed to fit and suit human requirements.

- *Hand tools:* Hand tools are non-powered and include files, hammers, screwdrivers, hand saws, pliers, etc.
- *Power tools*: There are several different types of power tools, based on the power source they use. They include electric, pneumatic, liquid fuel, hydraulic, and power actuated tools.

The greatest hazards posed by work-tools result from their misuse and improper maintenance. Even when tool design is correct, a tool can still produce a disorder by used too frequently in a unit in time over a period of time (Greenberg and Chaffin 1975).

2.3.10.1 Good Tool Use

To ensure ease and efficient tool usage the user's capabilities, comfort and limitations must be evaluated.

The following are pre requisites for easy and efficient use of tools (Greenberg and Chaffin, 1975).

- Use tools with the right grip size for the hand
- Use tools with the right handle lengths for the hand
- Use tools with textured or cushioned handles for better grip
- Maintain work tools in good repair for easier use.

2.3.11 The Physical Environment

This aspect of manufacturing is often never paid much attention to in the manufacturing processes. Management tends to place a greater emphasis on direct factors such as machinery, raw materials and labor costs etc. Often regarded as the "soft" inputs of production they still do however have a direct impact on productivity, safety and health.

Any cost benefit analysis in manufacturing that fail to include this factor is sure to face serious shortcomings. The goal of an "ergo friendly" organization is to maximize output whilst reducing costs. Ergonomics and the physical environment factors are so interdependent that it is impossible for either of them to independently maximize safety, health and productivity. The following are key factors to evaluate.

2.3.11.1 Lighting

Artificial light is commonly used in buildings during daytime to provide additional local lighting on the task, or to illuminate surfaces inaccessible to the daylight. It may be necessary to consider the use of artificial light as a permanent supplement to the daylight.

There are three points to consider, as follows:

- The artificial lighting must be planned for continuous integration with the daylight and not for use solely after dark.
- The amount of supplementary light should raise the level of illumination at least to that necessary for the visual tasks involved, and areas so lit should compare favourably with areas receiving maximum daylight.
- The colour of the supplementary should be of a sufficiently good match to daylight to prevent any noticeable difference in the colour.

Good integration of artificial light with daylight can increase the use of available floor space by eliminating dark areas and minimising shadows (Clark and Corlett, 1984).

Different tasks require varying levels of illumination. Appendix E provides a guide on this aspect.

2.3.11.2 Air Temperature

For individuals doing light work the optimum air temperature is 22^0C, and the comfort zone (over which not more than 1 person in 7 complains of actual discomfort) ranges from 20 to 24^0C. For more active tasks the temperature should be lower and for really heavy work 16 to18^0C is a suitable range. The air temperature should be also lower if the individual is exposed to sources of radiant heat (Galer, 1995:66-68).
Appendix F provides a guide to maximum work times without a break.

2.3.11.3 Air Humidity

Humidity has relatively little effect on thermal comfort at ordinary temperatures, but extremes are to be avoided, especially if the task in hand involves heavy physical work.

Humidity is usually measured as a percentage of the moisture that would completely saturate the air existing temperature. Very low humidity may cause discomfort through drying of the nose and throat, particularly if the air temperature is very high. As the air temperature rises above the comfort zone excessive humidity limits the rate at which sweat can be evaporated making it more difficult for the body to regulate its heat (Astrand and Rodahl, 1977).

2.3.11.4 Rate of Air Movement

Provided the air and radiant temperatures are correct, the ideal level of air movement is around 0.15 m/s. This is just about the point at which the movement is perceptible. Above 0.51 m/s is regarded as 'very draughty', and much below 0.1 m/s as 'airless' (Helander, 1995:283).

2.3.11.5 Noise

Noise is any acoustic phenomenon that annoys the listener. Thus noise is subjective. At many workplaces the noise created by machines can affect the

health of workers. High levels of noise can cause accidents and affect production, as warning and other signals cannot be heard (Laing, 1992). Common sources of noise from machines are due to poor maintenance or loosely fastened parts.

Methods to reduce noise include the following:

- Enclose entire machines that produce excessive levels of noise. If this is not possible enclose noisy parts of machines;
- Install screens or partitions to isolate noisy areas of work;
- Relocate noisy work so that it is at a distance from the place where most of the workers are working;
- Workers operating machines that emit noises must use earmuffs;
- Establish a rule for servicing tools and machines regularly to keep them in good condition and thereby reduce noise (Nag, 1996, Laing, 1992).

The current acceptable sound level is 85 decibels at maximum or 16 hours exposure, 90 dBA at 8 hours and 4 hours at 95dba, unlimited exposure at 75 dBA (O.S.H.A., 1992:11).

2.3.12 Manual Materials Handling

Manual materials handling is still an activity frequently required at work. Both in the industrially developed and developing world, manual material handling tasks (e.g. lifting, lowering, holding, pushing, pulling, carrying, and turning of weights) have been recognized as the major causes of overexertion musculoskeletal injuries such as back disorders (Nag, 1996). Appendix G summarizes the guidelines for handling loads by an individual.

2.3.12.1 Manual materials handling techniques to prevent overexertion:

Waters, (1994) and NIOSH, (1981) emphasize the importance to develop the following as the essence of a proactive ergonomics approach.

- Avoid lifting as much as possible;

- Use carts, lift trucks or other mechanical assists;
- Push instead of pull as pushing allows the spine to remain neutral posture;
- Get help from fellow employees;
- Know the destination or where the load is to he placed in advance;
- Know the shortest and safest routes to get to the destination of loads carried;
- Get a good grip of the object being lifted;
- Keep the object being handled as close to the body as possible;
- Tuck the stomach in.

2.4 Significant Empirical Research Findings

This section reviews research findings of other researchers which are of relevance and significance to this study.

2.4.1 Postural Study

A study was conducted by Putz-Anderson and Galinsky (1993) on physiological responses associated with controlled postures and loading of shoulder muscles. The study group consisted of 72 healthy subjects with assembly work experience. The task involved the simulation of repetitive assembly by a work simulator, consisting of lowering of a tool handle and striking a metal pointer to a plate. The duration of the work was given until a perceived muscle discomfort was reached. The findings revealed main areas of muscle discomfort were in the muscles of the neck, shoulder and upper arm. This drastically reduced the work duration and repetition period.

2.4.2 Epidemiological Study on Upper Limb Disorder

A cross sectional study industry of 52 subjects involved in packaging industry revealed the prevalence of neck and shoulder stiffness and pain, pain in joint motion and muscle tenderness in the neck and shoulder. The findings attribute the higher prevalence of pain in activities which has a higher pace of

work and awkward work heights (Sakakibara et al., 1995).

2.4.3 Ergonomic Controls

Kim et al., (1994) conducted a study on use of floor mats and control conditions in which subjects stood on concrete. The researchers observed muscle fatigue as determined by electromyography readings. The employees rated their comfort in several body regions, including the upper leg, lower leg, ankle and back. A scale of 0(no discomfort at all) to 10 (extreme discomfort) was used. The ratings showed significant changes in discomfort due to a variation of floor coverings. The researchers reported a strong correlation between the floor surface coverings and discomfort.

2.4.4 Whole Body Vibration: Potential Solutions and Preventative Measures Relevant to South African Conditions

This research proposes that in order to effectively control and eliminate whole body vibration adequate control measures are needed. These include control solutions that must take into account all risk factors, and should be based on sound scientific knowledge, ergonomic and occupational health and safety practice and principles.

The writer states;

"In order for any programme of many components to be successful, a full management programme needs to be drafted and implemented that will ensure commitment from all involved, from top management to the employees, as well as the eradication of ambiguity, so everyone knows their responsibilities and they can be evaluated and measured to ensure success. Such a programme would contain components such written policies and operating procedures, organizational responsibilities, equipment selection and maintenance, risk assessment and evaluation of vibration exposure areas, implementation and evaluation of control measures, and ongoing programme evaluation component to assess the effectiveness of the programme against set norms and standards", (Joubert,1999:44).

2.4.5 High- Risk Lifting Tasks in Industry ~ a Case Study

This research examined and analyzed thirty two positions in eighteen potentially high-risk lifting tasks in a major South African manufacturing concern. This was carried out with the help of the computer aided system called liftRISK. Of the thirty positions, twenty one were deemed to carry high or excessive risk. Attenuating risk factors such as excessive carry, obstacles in the carry phase, rotation, and poor underfoot stability was noted. In view of the high incidence of absenteeism due to backache, the researcher strongly recommends an educative programme emphasizing correct lifting techniques and prevention must be implemented. It is further reported that almost all intervention strategies are cheap and easy to implement such as stacking of additional pallets to reduce stooping whilst lifting (Olivier 1997).

2.4.6 Sedentary Work

Epidemiological evidence presented by Videman et al., (1990) documented the increased risk of lower back problems for those who perform jobs characterized by sitting. Known mechanical changes associated with seated posture include the increase in intradiscal pressure when compared to standing postures. This study has motivated occupational biochemists to consider the duration of sitting as a risk factor when designing seated work in the interest of reducing the risk of injury. In a related study by Mc Gill and Brown, (1992) it has been proposed that the maximum sitting limit without a break should not exceed fifty minutes.

2.4.7 Heavy Physical Work

Behrens et al., (1994) found the highest rates of back strains among workers who perform physically heavy work. In this cross sectional study it was found that unskilled workers had the highest prevalence rate for disc prolapse and lumbago. The manual exertion requirements were determined using various muscle stress indices. Musculoskeletal problems were twice as common if lumbar disc forces exceeded 6,800N. Back problems were about 2, 5 times

higher in tasks with high physical requirements.

2.4.8 Psychological and Psychosocial Work Factors

In a study of attitudes, beliefs and absenteeism among workers in a biscuit manufacturing factory, Symonds et al (1996) showed that workers who had taken in excess of one weeks absence due to lower back trouble had significantly more negative attitudes and beliefs (when compared with workers who had taken shorter absences, or with those who reported no history of back trouble). Beliefs about the inevitability of back pain, fears of hurting or harming, and perceived disability were significantly associated with absenteeism. In an associated study, an introduction of a psychosocial pamphlet, designed to correct mistaken beliefs about back pain (e.g., confusing hurting and harming) and reduce avoidance behaviour, successfully reduced extended sickness absence resulting from low back trouble. Since this study is retrospective it is difficult to determine whether psychological factors are antecedents or consequences of pain.

2.4.9 Justifying Ergonomic Initiatives ~ a Case Study

The study was analyzed and reported by Alexander (1995). What follows is a précis of the actual report.

This case study took place in a vehicle subassembly manufacturing plant. As the operation began to grow so did the incidence of cumulative trauma disorders. Local management saw ergonomics as an area of importance and decided to address issues using a quality management approach. An ergonomic problem-solving team was developed. Soon after the team formation each member received 2, 5 days of training. The teams initially focused on reactive problem solving using loss analysis as a guide to direct them to problem areas. Specific solutions at this stage included:

- Work tables
- Carts

- Platforms
- Floor mats

Two months later the team began to use proactive techniques to address ergonomic issues by identifying problem tasks through observation of risk factors, conducting task analyses and requesting employee feedback. Through this process the team determined that supervisory training is needed. A training plan was created and implemented. After the supervisory training, employee feedback was incorporated into the problem solving efforts. The ergonomics processes were now integrated into the business operation. Administrative controls were considered in those though areas where engineering controls were not completely addressing issues. In the paint department, for instance, a job rotation process was piloted and implemented. Through continuous training more strides to involve employees were made. Job rotation was embraced and initial rotation strategies were expanded to include 85% of the production area. By the end of two years over 90% of all repetitive bending, heavy lifting and twisting were eliminated.

Measured Results (at the end of two years):

- Back injuries were reduced from 85 to 11
- Upper extremity CTDs were reduced from 105 to 54
- Lost work hours reduced from 1402 to 476 (per year)

Other Tangible and Intangible benefits which were Cited but not Quantified

- Increased quality
- Decreased inventory levels
- Decreased scrap
- Decreased turnover/absenteeism
- Increased morale

Keys to Success

- Strong management support and TQM culture facilitated problem solving
- Ergonomics teams were multidisciplinary
- Necessary resources were provided to execute improvements

- Appropriate training undertaken and bias towards worker participation
- Effective communication at all levels.

2.4.10 Psychological and Psychosocial Work Factors in Relation to Pain

Several psychological work factors, including monotony of work, work dissatisfaction and poor relationships at work have found to increase the risk of worker illness. Middle aged workers had an increased prevalence of back pain if they performed physically heavy work and the association of pain increased further when the workers were dissatisfied with the nature of work or working environment or conditions (Battie 1992).

2.5 Conclusion

The literature review strongly suggests that the concepts and principles of ergonomics have to be embraced to optimize productivity, safety and health. Any job or work design which fails to address one or more of the ergonomic concepts or theories, reviewed in this chapter, will have a high probability of being the major cause of sub optimal performance. This would depend on the severity of each factor.

CHAPTER THREE – METHODOLOGY

3.1 Introduction

This chapter discusses the aim of the study and provides the description of the methodology, research design and data collection techniques. Qualitative research methodology provides the broad paradigm, whilst the philosophy of the approach lies within the exploratory method. The basis of this choice lies not within a particular bias towards this approach, but rather in the suitability of a structured qualitative approach for exploratory studies.

3.2 Rationale and Aim of study

Employee efficiency is one of the key ingredients of success. One of the greatest assets of a small business is a highly efficient workforce. It has been noted that management is constantly trying to find ways to improve the bottom line profit of their organizations. Employees in the small manufacturing sector have the ability to the success or failure of the organization and it is therefore important that studies on maximizing worker efficiency and improving worker safety and health are undertaken.

The study aims for the following:

- To gain some initial insight and understanding of the important variables and factors of ergonomics and management that can positively influence productivity, safety, health and absenteeism in the workplace.
- To create awareness among management about the importance of the application of ergonomic principles and its positive impact, thus enabling management to empower the workforce in the application of ergonomic principles.

This will be achieved through the analysis of different ergonomic models, concepts and principles from relevant literature and adapt it specifically to the work processes under study at selected small manufacturing engineers.

3.3 Research Design

Of the two broad categories of research methodology, qualitative and quantitative, the researcher has selected the qualitative methodology for the study. Qualitative research is described as an "Inquiry process of understanding a social or human problem, based on building a complex holistic picture, formed with words, reporting detailed views of informants, and conducted in an natural setting", (Leedy,1997;165). This understanding substantiates the use of this method.

Exploration is particularly useful when researchers lack a clear idea of the research problem. The objectives of exploration can be accomplished through both qualitative and quantitative techniques but exploration lies more heavily on qualitative techniques. Through exploration researchers develop concepts more clearly and gain a broader understanding of the research problem (Cooper and Schindler 1998).

In the context of this research this method is suited as the important variables are not fully known or thoroughly understood. An exploratory study is undertaken to learn and analyze the current situation of the organizations under study.

3.4 Method of Data Collection

Qualitative research requires qualitative information, that is, information that needs to be analyzed through methods other than mechanical tools. The data collection methods used for this research include secondary and primary data collection methods, and is explained below.

3.4.1 Secondary Data

In explaining the importance of secondary data, Ghauri (1995:96) says, "Do not bypass secondary data: begin with secondary data and only when the

secondary data are exhausted or show diminishing return, proceed to primary data." Secondary data provides an enormous saving in time and money. That is, researchers only need to go to the resource centre, and locate and utilize the resources. This can suggest suitable methods or data to handle a particular research problem. It also provides a comparison instrument with which we can easily interpret and understand our primary data.

The secondary data used for the research include texts, journals, research articles and publications.

3.4.2 Primary Data

Primary data collection will include a number of techniques discussed below.

3.4.2.1 Research Instrument

The instruments used in this study to collect primary information include qualitative semi structured in-depth interviews, observations, questionnaires and company records as the primary data-collection strategy. This method seemed to be the most appropriate in terms of gaining insight and exploration into the companies' management structures, styles and knowledge and understanding of role of ergonomics and views of worker participation and skills needed to implement change. Observations afforded the researcher the opportunity to observe and capture the dynamics of the work processes and to uncover emerging themes. Once the emerging themes were uncovered a questionnaire was designed and administered to the remaining members. The data obtained from the questionnaires was used to confirm and further analyze issues of health, safety and productivity identified by the observation. Company records were utilized to collect data on absenteeism. A pilot study was carried out to ensure validity and reliability of research instruments.

3.4.2.2 Interviews

This study made use of semi structured interviews. This allowed the researcher opportunity to probe and clarify issues. Dowsett (in Nunan 1992:149) says that semi structured interviews can elicit evidence that is not possible with questionnaires or structured interviews. The respondents were encouraged to as much as possible to" paint their own pictures" within the guidance areas set by the interview questions. This resulted in a large amount of data. The pilot study helped narrow down and identify the most important issues and themes. For the purpose of this research extracts which relate to aim of the study will be the main focus for review and discussion.

A five minute introductory period during each interview was intended. The purpose was to as much as possible neutralize any preconceptions of the interview or the researcher. This also helps to create a climate conducive to truthful, unrestricted, unpressurized and thoughtful responses. All interviews were conducted at the interviewee's office or workplace where it was hoped that the familiar atmosphere contributes to honest and reliable responses. An interpreter assisted the researcher in the interview process. This was necessary as some of the respondents where not fully conversant in English.

- **Recording**

Recording of interviews was done by the way of note taking. This was the only possible method due to noise emitted from machinery whilst in operation. The writing activity sometimes detracted the spontaneity of the discussion. Aspects such as body language could also not be carefully observed. Care was taken to record the responses as much as possible in the interviewee's own words.

The research seeks to remain close to the original responses and wherever possible include the actual wording and language in the findings. This would help the research issues and themes to be as accurate as possible and increase the validity of the research.

3.4.2.3 Observation

It is listening and watching other people's behavior in a way that allows some type of analytical interpretation. Non participant observation is an observation where the researcher observes a natural setting but is not directly involved in the situation (Ghauri, 1995:57). This method is chosen for the following reasons:

- The researcher was afforded the opportunity to capture the dynamics of the work processes which was not possible through the interview or questionnaire method.
- The naturalness of the setting was optimized and this enabled the researcher to collect first hand information and translate these into meaningful information.

3.4.2.4 Questionnaires

Sekaran (1992) defines a questionnaire as pre-formulated written questions to which respondents record their answers, usually within rather closely defined alternatives. The purpose of the questionnaires is to confirm the existence and accuracy of themes and issues uncovered the observations and to facilitate further analysis. The criteria for assessing the ergonomic work practices of the subjects were drawn from a review of the literature covering these aspects. The questionnaires were personally administered by the researcher. An interpreter assisted in providing clarity and understanding to respondents who were not fully conversant in English.

3.5 Data Analysis

Even though there is a high possibility of getting large amounts of information through the qualitative method, the technique demands special talent and effort in gathering and analyzing those data. The main reason, as given by Ghauri (1995:96) is that data collection and analyses are done simultaneously

and sometimes the research objectives is formulated and reformulated at the same time. This often leads to new questions and new data collection, and there is no definite phase of data analysis.

The data analysis in this study highlights the assimilation of the primary and secondary data with the relevant theories and current practices of ergonomics and its application to identify the real problem of the organization, to understand the causes of these problems, and to design and decide the intervention for the success of the organization. Situation analyses that include sensing, understanding, deciding and acting is also properly considered.

3.6. Preparatory Work

A large amount of preparatory work was done within this study in order to ensure not only reliability and validity but also that the output was of value, at least, to the companies under study. The first step was to identify the potential companies to be studied. The researcher through his work experience in similar industry contacted companies with whom the researcher was acquainted with. This was done telephonically. The conversation entailed a brief overview of the proposed research. Seventeen companies were contacted. Nine companies showed some initial interest. Subsequently a meeting was arranged with the owners/managers. The meeting entailed a casual general discussion and if they had any intent on embarking on a human capital investment initiative. Five companies stated that they were looking at alternative ways of maximizing profits other than a huge capital injection or expanding capacity. Three companies agreed to have the research carried out. These companies were selected for the study.

3.7 Pilot Interviews

The process of pre-testing is intended to measure the effectiveness of the instrument in relation to such aspects as its length, wording and validity while the pilot study is the preliminary small study (Treece and Treece 1986).

Although it had been the researcher's initial intention to use an in-depth unstructured interviews in order to encourage the respondents as much as possible to "paint their own picture" – so as to avoid leading responses in any way, after the first two discussions it became evident that specific questions were needed to be asked in order to prompt responses . Only in this way, was it possible for any kind of insight to be gleaned from their responses. Definite questions were needed to probe specific issues, as it was noted that often there was reluctance to engage in any in – depth unguided exploration of the issues. Issues were frequently "sidestepped" and there was a tendency to become engrossed in relating problems/experiences that was of importance, but which were unrelated to the issues under study. Changes had to be made which included a "fleshing out" of the original questions into more specific "pointed" questions.

The pilot interviews comprised of one member from each category in the three companies under study.

- owner/manager
- supervisor
- skilled worker
- semi-skilled worker
- unskilled worker

3.8 Composition of Respondents

The entire workforce of the three firms was listed. The number of owner/managers and supervisors were small, thus it was possible to interview them all. Due to time constraints and large number it was only possible to

conduct interviews with twenty percent of the workforce. Respondents for data collection are composed as follows;

Interviews - 100% of owner/managers
100% of supervisors
20% of skilled workers
20% of semi skilled workers
20% of unskilled workers
Questionnaires – 80% of skilled workers
80% of semi skilled workers
80% of unskilled workers

3.9 Validity and Reliability

Fink (1995) argues that validity is a more important criterion than reliability in exploratory studies. A high reliability may exist with no validity. This study addresses these aspects as follows:

3.9.1 Content Validity

Content validity accounts for the researcher's ability to make use of the research content in questions, check lists and other types of tools. Validity of instruments used in this study is established by:

- Utilizing theory developed from secondary data.
- Findings of the pilot study to guide interviews and in questionnaires construction.

All prescriptive recommendations are based on internationally accepted ergonomic principles and theories as set out in the literature review.

The proposed guidelines for implementing an ergonomic process are based on a theoretical model for intervention as proposed by Shanavaz (1990).

The theory developed in the literature review is used the basis to compare the findings of the study. This is known as analytical generalization as the purpose is to generalize the findings to theory and not to the entire population

population or universe of small manufacturing engineers.

3.9.2 External Validity

Altheide and Johnson (1994) define external validity as the extent to which the study findings can be generalized beyond the sample used in the study.

The study is limited to three companies. The findings, however valid it may be, to the companies under study, cannot be generalized. This is an exploratory study of just three companies that can stimulate further research of both a qualitative and quantitative nature that provides information on replicability.

3.9.3 Interpretive Validity

Altheide and Johnson discuss usefulness as a type of "interpretative validity" that can be used to ensure that a research is valid. Usefulness in this study refers to whether when the report is read by the organizations studied, are they enlightened or moved to action by the contents.

3.9.4 Face Validity

Face validity is defined as," that quality of an indicator that makes it seems a reasonable measure of some variable" (Babbie and Mouton, 2001; 642). In this study the questionnaires and interview questions are designed to give an indication of issues of health, safety, worker participation etc. Thus we can say it has face validity.

3.10 Ethics

- It has agreed upon, at the request of the companies, that there identity be withheld, for reasons best known to them.
- The researcher will seek management permission prior to every visit to the workplace.

- The questionnaire concerning the workforce must first meet management's approval.
- All information obtained, must first be presented to management of that specific company, obtain their consent and then further processed.
- The researcher will seek the workforce consent prior to observations.

3.11 Triangulation

Triangulation is a research strategy that aims to enhance the research process by using multiple approaches. It is claimed that by using multiple approaches, the strengths of one will compensate for the weakness of another, therefore improving the quality of data – particularly its validity and reliability (Sim and Sharp 1998).

This study makes use of the "within – method" of triangulation. This refers to more than one data collection technique within a particular methodological approach. The interview method enabled the researcher to gather in–depth qualitative data on certain aspects of the findings of the pilot interviews, whilst observation afforded the researcher the opportunity to collect information in the natural setting of the workplace on the ergonomic issues revealed in the pilot study. The questionnaires were then administered to further validate issues generated by the researcher during the observations. This also helped to rule out any bias that may have crept in on the researcher's part during the observation .The data was then compared to identify any meaningful common themes and issues.

3.12 Reporting

The information generated from the interviews, observations and questionnaires is pooled across the three companies. The results are analyzed discussed and presented as pooled data.

3.13 Problems Encountered

It was difficult to complete each of the interviews in the allotted times. Very often there were work interruptions and the interviews had to be stopped and continued on another day. This posed a problem as the researcher had to commence again with an introductory period.

Another problem the researcher encountered was that although management was eager to express their views,they required a fair amount of probing and encouragement. The researcher had to consciously constantly avoid leading and over prompting.

The main operational difficulty encountered was in completing the questionnaire. The complaint from management was that the questionnaires took up much of valuable production time. It was suggested that the questionnaire be completed during breaks, however the workforce were reluctant to complete the questionnaire in their official break time. Due to the high rate of absenteeism, more than the planned number of visits had to be undertaken to ensure a 100% response rate was achieved. This posed a great problem for the researcher in terms of time management.

Management also feared that results of the questionnaire will trigger new ideas in the workforce and this can be as a basis for frivolous compensation claims. There was also a fear that the findings can pose a potential threat of a strike by the workforce.

CHAPTER FOUR - THE FINDINGS

This chapter aims to evaluate the work environment through the use of the interview, direct observation and questionnaire methods. The proposed recommendations and guidelines made herein are in conjunction with literature review in chapter two.

4.1 Brief Overview of the Companies Under Study

All three companies fall under the category of light engineering industries. For the purpose of anonymity the three companies will be called company A, B, C.

Company A

The company was formed in 1991 and is presently owned by the same two owners since inception. The company is located in Jacobs, an industrial suburb south of Durban. The present complement of staff consists of 29 employees. Currently all work carried out are on a subcontract basis and have a customer base of approximately fifteen. The main activity is the manufacture of heavy plant, machinery and equipment components which is then supplied to manufacturers and repairers of such equipment.

Since its inception the company has doubled its size due to a large capital input from a family inheritance. The company has to date purchased seven new machines. The owners are qualified fitters and turners by trade and have followed a course general office practice.

Company B

This company is in existence since 1973. The present three owners acquired the company in 1994 as the previous owner left South Africa prior to the historically first democratic elections. The company is located in Umbilo, an industrial sector of central Durban. The present owners were supervisors and acquired the company on a work on pay basis. There has been no expansion

or additional equipment since then. The staff complement is presently 33. The main activity is the fabrication of components for the conveyor industry. The work is of a highly specialized nature. The company has only two principal customers but occasionally take on work related to their field. None have the owners have any formal technical qualification, but collectively have 25 years of combined experience in this type of work.

Company C

This company is 65 years old and belongs to the same family for three generations. The present owners are the grandson of the founder. The company presently have 28 employees. There has no been updated equipment or expansion since the last owner. The present owners are two brothers; one is a landscaper and the other a welder by profession. The landscaper has little or no experience about the technical nature of work. The company is situated in Jacobs, an industrial suburb, south of Durban. The company is specialist component manufacturer to the heavy haulage trailer industry. Their large customer base includes trailer manufacturers, transport fleet operators, repairers and trailer spares retailers and wholesalers.

4.2 The Findings

This section presents the findings of the pilot study, interviews, observations and questionnaires.

4.2.1 Pilot Study

The pilot interviews revealed the following themes in line with the aims of the study.

- Varying perception of roles in the company
- Issues of worker participation
- Limited understanding of ergonomics and its role in productivity

- Indication that there is a lack of application of ergonomic principles in work procedures, design and layout.

4.2.2 Interviews

What do you see as a role of a manager/supervisor/worker in the company?

Management

Managers see their task as to ensure the survival of the company. This meant ensuring that the proper control procedures are in place and the cash flow is well managed so that staff could be paid on time and to ensure a continuous supply of materials for production. Put in another way means their responsibility is to keep the "wheels turning". In doing so they felt their staff would be happy as they are constantly employed. Of most importance was to see the company having a constant flow of work as in this is sure to ensure profitability.

In the words of one manager

> "I see my role as a link between the outside and the company. I have to see that we are able to get sufficient work and get paid on time to meet my running costs and staff overheads."

However two others felt differently

> "My prime responsibility was towards customers as they are my bosses. Without customers there would be no company."

One manager's view of his role:

> "My responsibility is to see to the welfare of all parties that make up the company. In the process of doing so profit will be realized."

Supervisors

The general view was that they are the middleman of the company. They see their primary role as the man who sees the job is getting done. In the process of achieving this they have to provide motivation to the workers so that they can work efficiently and effectively. It was evident that the supervisors embraced the values of management; the values of continually striving to increase productivity and profits. Most of the supervisors took pride in their responsibility of getting the job done.

In the words of one supervisor

> "I have a very responsible job in this company. My most important duty is to see that I fulfil my boss's instructions in that I have to get the job done with the least amount of rejects as this impact on the company's profits."

Two supervisors spoke strongly about the autocratic management styles of their respective company's. They felt that their authority is eroded and the existing top down management styles stunted the potential for work to be carried out efficiently. They further added that management set the goals without consultation and they have to meet these goals.

This is what one of them had to say

> "I do not see my role as of adding any value to the company or work processes. My role is merely to relay information back and forth between management. I am unable to make any decisions independently. All instructions come from the bosses. I have to just carry them out. I am sandwiched between the bosses and workers."

Workers

Workers felt their role was prime importance as they provide the vital link in production. They see themselves as the link between machinery and raw materials. Without their input both the machine and raw materials would be rendered useless. They further added that even if one considers automation the machines still have to be manned and machines are sure to breakdown and need repairs and maintenance. They also felt they are the wealth amassing tools of the company.

One worker had this to say

> "The company totally depends on us. Without us the company cannot make any money. All the steel is only useful by our efforts. We make it happen."

Question: What is your view of worker participation in organizational changes?

Management

Management was of the general view that they are not sure of their staff capabilities to be involved in organizational change processes. In the past change or improvements were always met with a great degree of resistance. Workers could not see the perceived benefits of such changes. Management believes that one of the prime causes for this phenomenon is poor communication between workers and themselves.

However they seemed open to ways of involving staff, so long as it does not increase costs and realizes more profits. There was also the thought that involving workers in process of change might lead to the workers feeling that the company cannot function without them and as a result of this place undue demands to management.

The words of one manager

> "I have no problem in getting anyone involved be it workers, outsiders or any other persons so as long as the company makes more" bucks". My past experiences in bringing about any changes were very bitter, but I am still hopeful. We seem to be operating on two different "wavelengths". I can't seem to understand them nor can they understand me. My fear is that the staff will become swollen headed and hold us to ransom for more wages."

Supervisors

All of the supervisors bar one were in favour worker participation for the following common reasons:

- This would lead to better communication and in turn lead to greater efficiency and productivity.
- The workforce will be able to value their contributions in the success of their respective companies.
- If workers are involved in change they will be more likely to abide by them and accept them.

The supervisor who felt differently held the following view:

The view is that policies, values and principles as the job of management. He believes that they have more knowledge and they should be responsible for change processes.

Workers

The first theme from the worker is that this is a strategy to motivate workers harder so that more profits will be made for the bosses. They see this as beneficial to the company only. They are on the brink of joining the union and this was a ploy to prevent them from joining and in the process create

divisions among the workers. Management will create a superficially direct relationship with their workers and together they can solve all problems and there is no need for trade unions. They felt if management genuinely valued this then would have introduced this a long time ago. They also felt their inputs were not valued as management always takes ages to implement them. Management always claim they have no money to do anything.

The other theme was that this would benefit both the company and workers The following reasons were given:

- Working conditions would be improved by making work more healthy and safe.
- Work will become a better place as they will be allowed to use their experience and skill to solve problems and thus save a lot of money.
- A strong team spirit will be created which is presently lacking.
- A channel will be created to raise and timeously solve problems.

> "Our ideas will save the company lots of money as we know the job best. There is no need of hiring costly consultants."

Question: <u>What do you understand of ergonomics and its role for success in your organization?</u>

<u>Management</u>

The overall understanding was fair. Management understood the role of ergonomics in design. Ergonomics was always viewed in mechanical terms. Management understood very little about ergonomics and its role of productivity, health and safety.

Supervisors

Supervisors and the workers had a very limited understanding of ergonomics and its application in a manufacturing environment. The view held was that ergonomics are issues linked with designing of aircrafts, cars etc. There was even some confusion between ergonomics and economics.

Question: Are there any other issues you think that are of concern that need to be addressed?

Due to the time consumed up until this point all respondents felt quite exhausted and briefly mentioned other issues of concern but did not want to pursue any in-depth discussions.

The following common themes were mentioned:

- Management raised issues of low productivity , absenteeism,
- Supervisors raised issues of lack of morale among the workforce
- Workers raised issues of health and safety and better salaries.

4.2.3 Observations

Selected Job Analysis

This section provides a summary of selected job analysis. This was achieved through the observation method. The purpose is not to provide comprehensive ergonomic evaluation, but to provide a brief synopsis of problem areas that will benefit through ergonomic interventions.

Work Description 1

In the machine finishing shop the worker has to use different hand tools to finish a work piece.

Problem Summary

Each time a different tool has to be handled, it involves turning and twisting his body or neck to get the tool. This twisting results in low performance and productivity and skewed body positions. The workers often use their maximum reach capability to obtain necessary tools.

Work description 2

The installation of mechanical seals on to motor pump housing requires the worker to apply a slip agent around the inner of the housing in which seal has to be inserted into. The slip agent is applied with the aid of a small hand brush. The seal is then picked up using the pinch grip of the thumb and four fingers and placed into the housing. Pounding of the seal is usually done by an open palm. A lock ring is then inserted with the aid of spring loaded spreader.

Problem summary

The skin is in direct contact with the slip agent. This reduces the gripping friction and requires additional force to insert seal. Excessive wrist flexion is experienced during the application of slip agent. Repetitive pounding the seal with the hand results in shock to the palm area. Several unnatural wrist and hand postures were noted as a result of using the spring loaded spreader.

Work description 3

Worker, whilst seated, has to pick up and place component on drill press base plate. Align the part onto template and drill holes on component as per template drilling guide.

Problem summary

The seated posture caused static load of neck and back muscles due to forward bending since there was no room for the legs underneath the workstation. The drill press lever was above elbow height, causing a static load on the shoulders and arm muscles. The chair had a wooden seat and was hard and uncomfortable. A loose pillow was often used as seat padding. The chair had a wooden back support which was hard and badly shaped. The back support could not be regulated back and forwards, and gave no support to the lumbar area of the back when bending forwards.

Work description 4

The production of components involves the movement of various work pieces through the various phases of production.

Problem summary

All the different work tables were of varying heights. All plants did not have a conveyor system. This necessitates the workers bending their backs in order to put pieces in the lower layers. The next phase also involved in the worker picking up the tools also incurred a lot of bending. This action presents a risk of lower back trauma and discomfort to the neck and shoulder areas and ultimately injury to these areas.

Work description 5

The installation of a hose onto a valve requires the worker to cut the specified length of hose using a conventional pair of cutters. The hose is twisted onto the valve by hand. A clamp is screwed on to secure the hose.

Problem summary

The use of the conventional pair of cutters requires force to be exerted with the front and back of the fingers and thumb to operate the cutters. The wrist is also deviated while applying the force required to operate the cutters. This produces contact forces, which can cause irritation and damage to the nerves and blood vessels. The action of twisting the hose onto the valve requires using a pinch grip with excessive flexing of the wrists and application of force with the wrist in a deviated position. Severe ulnar deviation is experienced whilst securing the clamp.

Work Description 6

Majority of the tasks required the workers to stand for long periods on a concrete floor.

Problem summary

Standing for long periods on hard surfaces can be associated with lower back pain and static pooling of blood in the lower extremities.

4.2.4 Questionnaires

4.2.4.1

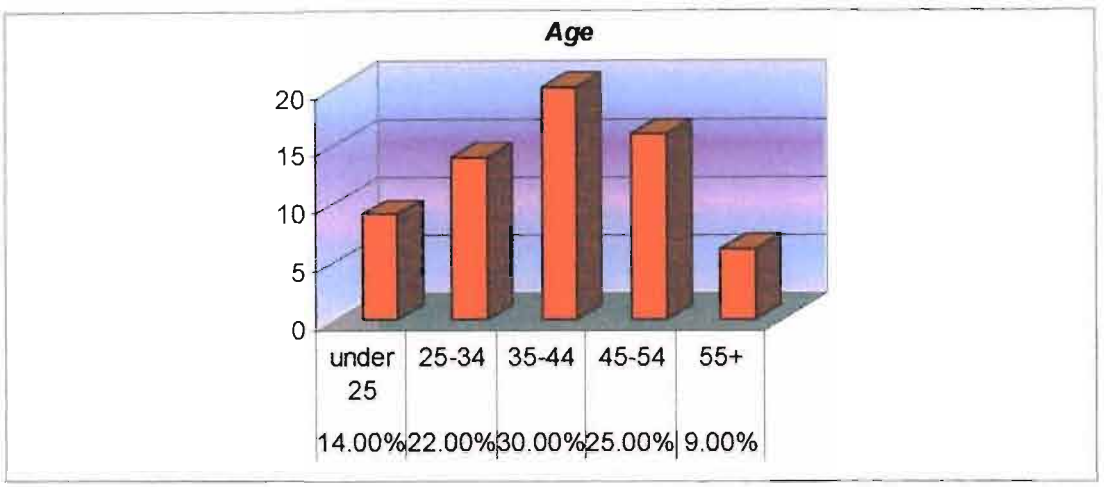

Figure 1: Age Categories

Most responses fall in the 35-44 age groups with 30% followed by the 45-54 age groups with twenty five percent. Third highest responses come from the 25-34 age group and other age groups come in the minority of responses. This is clearly indicative that employees are mostly thirty five years and older (sixty four percent).

4.2.4.2

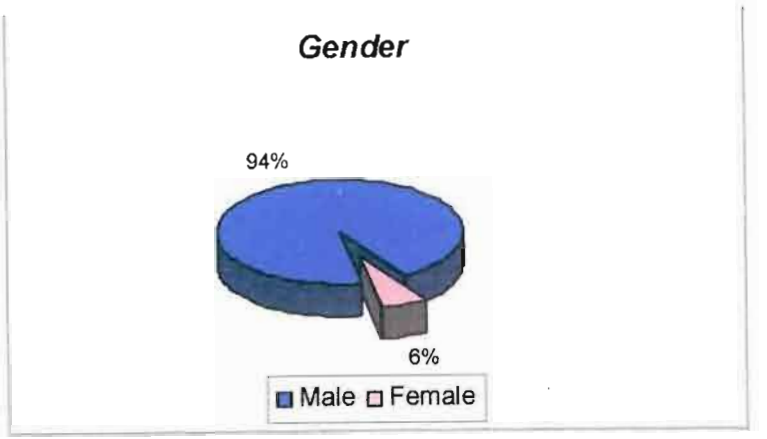

Figure 2: Gender

The majority of the employees are male with ninety four percent followed by females with six percent. This is in line with the current trends of employment in these industries. However this can change with time as a result of the Gender Equity Act and with the fact that more females are making inroads into traditionally male dominated jobs.

4.2.4.3

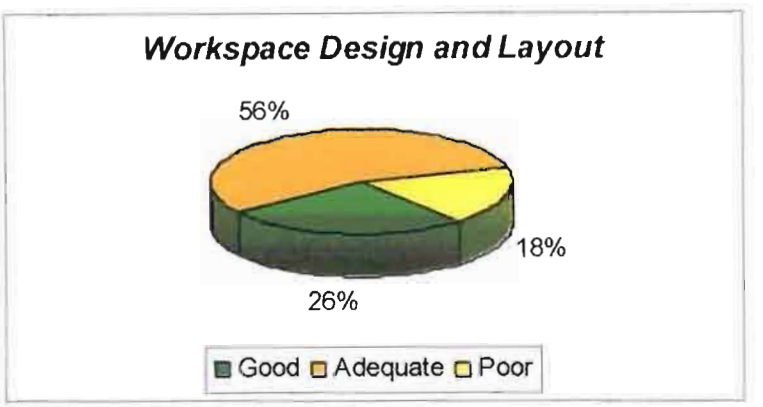

Figure 3: Workspace Design and Layout

Fifty six percent of the respondents find their workplace layout and design adequate. A further twenty six percent find this to be good. These findings reveal that most of the workforce is satisfied with this criterion. There is however a need for further improvement as eighteen percent finds the workplace design and layout poor.

4.2.4.4

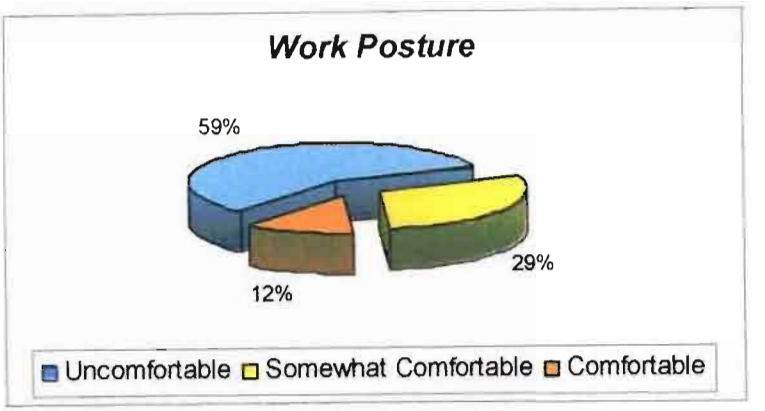

Figure 4: Work Posture

Fifty nine percent find their work posture uncomfortable followed by twenty nine percent who find their work posture somewhat comfortable. Only twelve percent find their work posture comfortable. This means the organizations under study must adjust work styles to improve this situation.

4.2.4.5

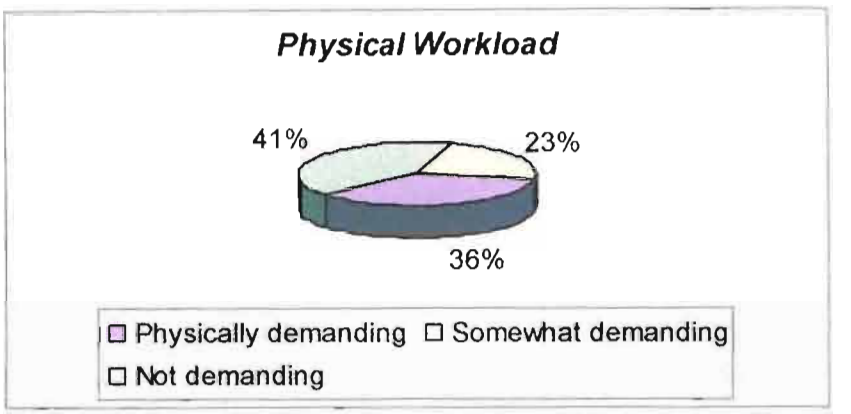

Figure 5: Physical Workload Ratings

Forty one percent of the total workforce finds the physical workload somewhat demanding and thirty six percent finds it physically demanding. Twenty three percent find their workload not demanding. These findings indicate that workers undergo strain and improvements in this area are a necessity as it directly affects productivity and worker health.

4.2.4.6

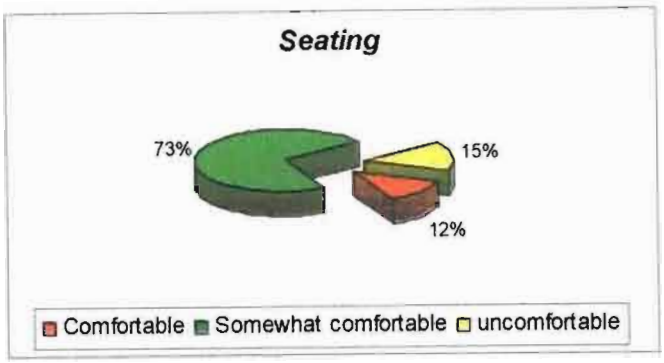

Figure 6: Seating

Seventy three percent of respondents that performed tasks whilst been seated find the seating somewhat comfortable. A further fifteen percent find the seating uncomfortable and twelve percent find it comfortable. This is due to the type of seating used, in some cases unpadded bases and others utilizing makeshift seating.

4.2.4.7

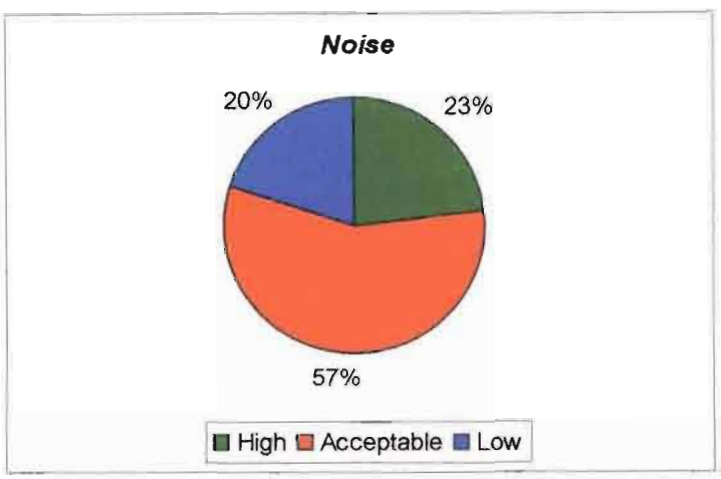

Figure 7: Noise Level

The majority of the respondents, fifty seven percent, did not have any complaints on the current level of noise. High levels of noise are experienced by twenty three percent probably due to specific nature of the job e.g. use of hand held grinders. Twenty percent find the noise level low probably due to their remote location from noisy tasks or noise generating machinery and equipment.

4.2.4.8

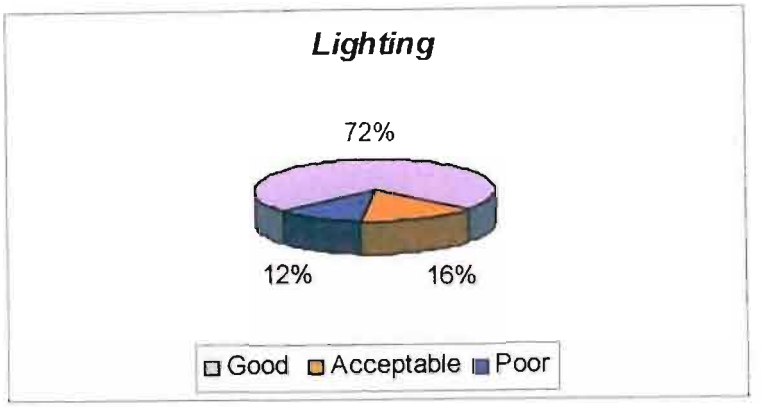

Figure 8: Lighting

The majority of the respondents find the lighting good, seventy two percent. Sixteen percent find the lighting acceptable but can be improved in the future. Twelve percent find the lighting poor.

4.2.4.9

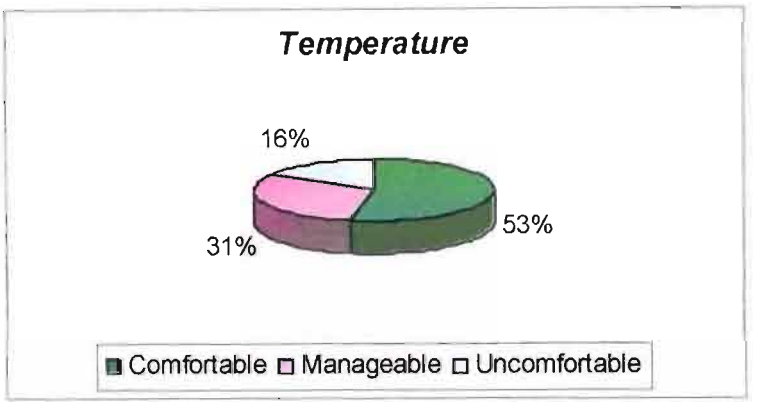

Figure 9: Workforce Rating of Temperature

Fifty three percent of the respondents find the temperature level comfortable. Thirty one percent said it was manageable and sixteen find it uncomfortable. Those that find the temperature uncomfortable are due to specific task related conditions e.g. welding, furnace work e.t.c. It is important that temperature must be kept to within the generally accepted comfort limits. Small departures from the ideal temperature can lead to decrements in both motor and cognitive performance thereby impacting on workers performance and safety.

4.2.4.10

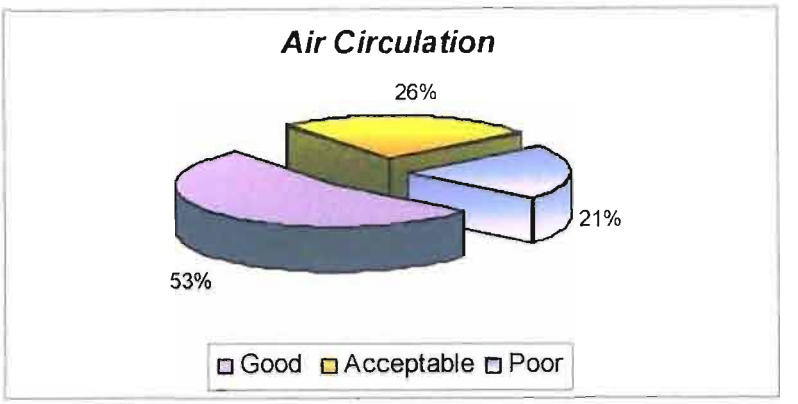

Figure 10: Rating of Air Circulation

The majority, fifty three percent of the respondents feel that the air circulation is good. Twenty six percent find the air circulation at an acceptable level with twenty one percent finding it poor.

Methods to improve air circulation must be investigated and implemented.

4.2.4.11

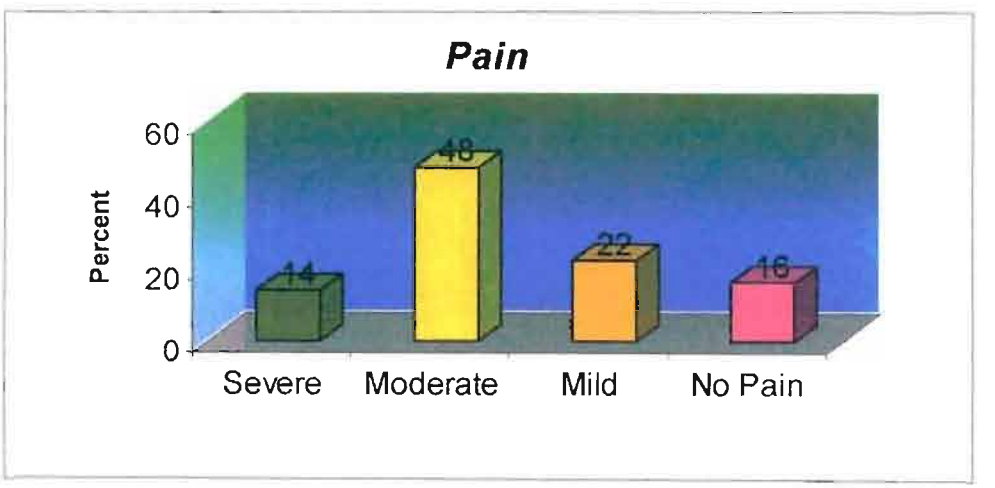

Figure 11: Intensity of Pain

The findings reveal that a total of eighty four percent of the workforce experience pain of varying intensities.

4.2.4.12

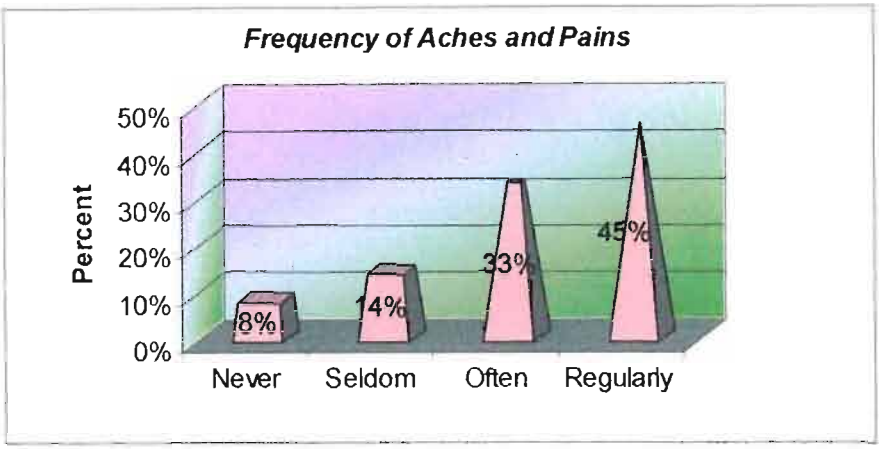

Figure 12: Frequency of Aches and Pains

These findings on pain concur with other studies in industries with a poor application of ergonomics. Eighty four percent of the workforce did experience some degree of pain. Contributing factors include musculo skeletal disorders, physical workload. These figures are indicative that the underlying causes must be further investigated as this directly impacts on productivity.

4.2.4.13

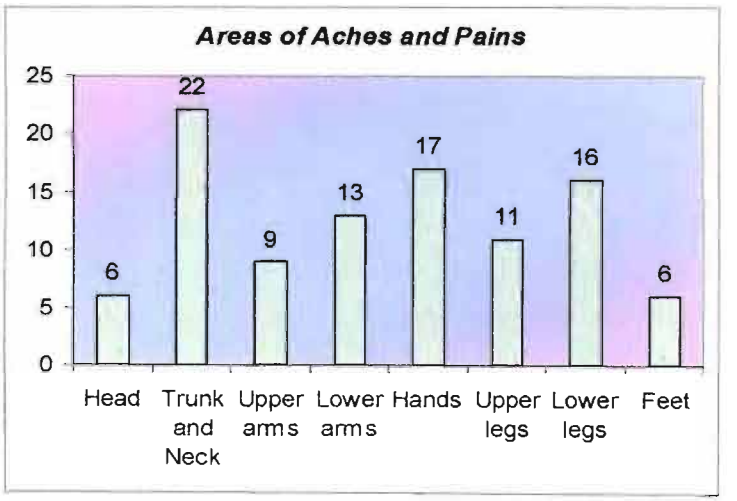

Figure 13: Areas of Aches and Pains

The areas and frequencies of pain identified above confirms the inherent risks of cumulative trauma disorders and other work related pains associated with work activities of the companies under study.

4.2.5 Company's Records

4.2.5.1

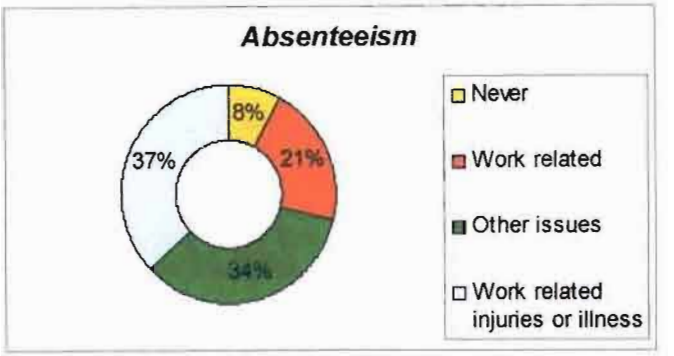

Figure 14: Absenteeism

Thirty seven percent of the staff stayed away due to work related injury or illness. Twenty one percent were absent for other work related issues. This represents a total of fifty eight percent of the workforce that are absent due to different aspects of work. Thirty four percent stayed away for other reasons followed by a meagre eight percent who never stayed away.

4.3 Conclusion

The findings of this chapter have elucidated factors which can help create a conducive environment to optimize safety health and productivity. Data trends in this chapter tend to indicate that compatibility of the physical dimension, pleasing aesthetics, work comfort, safety, worker participation and communication are the key factors in optimizing health, safety and productivity.

CHAPTER FIVE- DISCUSSIONS AND RECOMMENDATIONS

5.1 Introduction

Data obtained from the previous chapter are discussed in order to provide a holistic understanding. Discussion will be done with reference to the literature review of the study and where necessary with references to other studies of a similar nature.

5.2 Interviews

These results indicate that the organizations surveyed do not practice participative management styles. Without worker participation it is impossible to implement ergonomic changes at low costs. This is further illustrated in the selection phase that these companies were desirous of implementing changes but without huge financial injection or capacity expansion. This is further reinforced by Olivier (1997) who states that often ergonomic improvements and interventions can be implemented at little or no cost to the organization.

Without worker participation it is not possible to fully utilize the existing experience within the companies. Worker participation also makes the workforce interested in the organization. Management in the past were not so successful in implementing changes. Arguably if the past methods are followed, an ergonomic intervention will not be any exception. This is consistent with a study by Alexander (1995) which has shown that a bias towards worker participation was a key factor to success.

Management had fair knowledge of ergonomics. They viewed ergonomics singularly and not from a systems perspective. A wider systems perspective can help identify quick and obvious financial or motivational aspects which can be used to encourage managers. This perspective entails developing and implementing written policies, operating procedures etc. This wider

perspective should improve the likelihood of the employment of ergonomic principles and thus implementation of ergonomic solutions. There must be an initial agreement that there exists a weakness in the existing procedures. An ergonomic programme must then be initiated considering all aspects. This statement is supported by Joubert (1999) who recommends that for any programme consisting of many components to be successful a full management programme needs to be drafted and implemented.
It must be noted with caution that the relative importance of each ergonomic factor will vary from manager to manager.

The findings are also indicative management experienced difficulty in the past in bringing about change. There is definitely a need to follow a set of guidelines in the implementation of an ergonomic intervention. There is a need for all members of the organization to receive some training on ergonomics and its applications. It can be argued that little or incomplete knowledge of a concept is worse than no knowledge. Care should therefore be taken in teaching and training in the area of ergonomics, its applications and benefits. (http://www.iea.cc). The literature review in the study provides a good starting point. Much of this knowledge will also be acquired during the intervention process provided the participatory approach is adopted. As they are directly affected by any changes brought about in the working environment workers want more involvement but also speedier implementations. Financial support is also needed for improvements. Finally they request for improved communications in all spheres of the working environment. Communication is always top down and never bottom up. Alexander (1995) cites strong communication at all levels of the organization as one of the many key success factors. This further reinforces the need of effective communication.

Managers express the desire to improve communications. Blanche (1999) has emphasized the importance of communication in the intervention process as "the glue that holds this process together.....each side must continually work together, to talk out the problems before they become a crisis to make the best decision for the well- being of both the business and its employees."

5.3 Observations

The observation revealed many ergonomic mismatches. This certainly contributed to the high levels of discomfort experienced by respondents. It was evident that both the work and the equipment have not been designed or laid out with the workers in mind. The discomfort observed may be a precursor to more serious work-related musculoskeletal disorders. It would also be useful to consider shorter work cycles to reduce present discomfort levels. But this requires further study and a full cost benefit analysis has to be carried out. Workers certainly need training and encouragement to maintain more desirable work postures. To reduce the risk factors and to attempt to alleviate current levels of discomfort observed several work changes are needed.

5.3.1 Prescriptive Recommendations

Based on the findings of the observations, recommendations are made in conjunction with currently accepted ergonomic practices and theories reviewed in the theoretical framework section of chapter two.

Problem 1

Use adjustable hanging tools as the operations are repeated in the same place. Hanging tools can be grasped easily the tools should be mounted on a spring mechanism so that they return automatically to their place. Reduction in time needed to put the tool down and to pick it up again translates into enhanced productivity. This arrangement allows the body to maintain a symmetrical relationship as much as possible.

Problem 2

A glove should be worn to prevent skin contact with slip agent. The glove also decreases the finger grip force needed to hold the brush. A longer handled brush should be used to decrease wrist flexion. A small rubber mallet should be used to pound the seal. An alternate could be to use palm pads to reduce hand trauma. A long term solution would be to replace current seal with a pre-lubricated seal thereby eliminating the need for a slip agent. A specialized tool should be developed to insert the lock ring thereby minimizing unnatural wrist and hand postures.

Problem 3

In order to reduce the static muscle load when working with elevated arms the work table should be based on a hydraulic cylinder. This allows adjustment of height and slope of the table. Independent adjustment of height and slope of the table allows each worker to find his own optimal work posture depending on his height, thereby reducing the strain on the neck shoulders and lower back. The adjustable workbench allows the operator to alternate between sitting and standing.

A new chair should be introduced that has adjustable height, seat tilt, and adjustable backrest to minimize awkward postures. The back rest must be padded with rounded edges that support the lower back. The front edge must be gently sloped to help prevent the chair's edge from pressing into the back of the leg. The seat must be cushioned and contoured so that the body weight is distributed so no one body part gets all the pressure.

Problem 4

Minimize the height differences of the various worktables. Use a transport or stacking system whereby components can be lifted and placed without changing heights. An adjustable trolley, specialized cart or platform should be devised thereby reducing/eliminating the need of bending. Olivier (1997)

suggested in his study, to stack additional pallets to reduce stooping whilst lifting.

Problem 5

Provide an ergonomically designed pair of cutters. This may include a spring loaded cutter, which functions without pressure from the worker's hand, or an electric cutter. All cutters should be designed to be utilized with the wrist maintained in the neutral position. The workers should be educated on the importance of maintaining a neutral wrist position while performing repetitive motions and tasks. A tool needs to be designed where the hose and clamp can be secured with one smooth movement of a lever system.

Problem 6

An anti fatigue mat should be fitted at the workstation covering the range of motion of the worker. A sit/stand alternative should also be considered to reduce pressure on the workers legs. This recommendation is based on the findings by Kim et al (1994) who study on floor mats showed a strong correlation between floor surface coverings and discomfort.

5.4 Questionnaires

5.4.1 Age

In designing any operating system or actual physical design procedure age is an important consideration for optimal productivity, safety and health. As the workforce age their capacity, speed and ability also changes. It is therefore necessary to evaluate each specific procedure and adjust them accordingly. Majority of the respondents fell in the 35-44 age groups. The risk of developing cumulative trauma disorders is higher among individuals over 40 years of age.

Other factors influenced by age include response to thermal conditions, vision and muscle strength (http://www.ergonomics.hfes.org).

5.4.2 Anthropometric Data in Relation to the Workplace

Existing anthropometric databases often are not valid for specific population of workers. This may be especially true where job characteristics self-select for certain characteristics in the worker. The population of female workers (6%) in the companies were too small to warrant any significant changes in work procedures to accommodate them. The guidelines provided in section 2.3.2 covers a substantial range of dimensions; however this must be treated with some caution as it may not be valid for every ethnic group.

5.4.3 Workplace Design and Layout

The tendency of workers to adopt abnormal postures whilst performing their various tasks is clearly suggestive of conflict between the workplace design, layout and the worker. To compensate for these design and layout in adequacies workers leaned forward, adopted abnormal body positions and maintained asymmetrical positions in relation to the workstations.

Workstations are varied as industry itself. It is suggested that principles of anthropometry and work analysis be utilized to design an appropriate workstation for an employee or group of employees. Several guidelines are presented in sections 2.3.1 to 2.3.6. This should be able to design a workplace that allows the worker's capabilities and limitations to meet the demands of the job. However, not all details and data will be appropriate or applicable for all workstations.

Many guidelines are common sense, but unless the designer is reminded of them, they are very easy to forget. For example, in the design of a seated workstation, it is very easy to get caught up in the range of adjustability of a chair, the work-surface heights, clearances that it may be forgotten to provide a foot rest for shorter workers (http;//www.usernomics.com).

productivity. This is important as it is a general tendency to look at a particular improvement on a stand alone basis and expect immediate positive results.

5.4.6 Physical Discomfort

One primary risk factor for the development of pain is the frequencies with which motions are repeated. On the basis of observation and the interviews the jobs can be classified as requiring both high and low amounts of repetitive manual manipulation. These findings correlate with research by Putz-Anderson and Galinsky (1993), Behrens et al (1994) and Bridger (1991) in which there is a direct relation between nature of work and pain. It is arguable that the nature of the physical work activity is not the sole cause of pain. Important to note is the study by Battie (1992) which has revealed psychological variables such as monotony of work, work dissatisfaction and poor relationships have found to increase the risk of worker illness and pain.

However it must be further stated that these findings must be treated with some caution as it is important not to draw conclusions from subjective information. Littlejohn (1986) points out that "repetitive activities are the very function of the musculo-skeletal system and, in the normal course of daily events, we often experience aches and pains." With this in mind further investigation into the cognitive, psychosocial and psychological aspects of pain must be fully investigated.

5.4.7 Lighting

It must be noted that even small departures from the ideal levels of lighting as set out in section 2.3.11.1 can lead to fairly large reductions in performance. The greater the level of precision of the job the more strenuous is this on the eye. Poor lighting forces the worker to adopt a cramped position. The age of the worker must also be taken into consideration, as twenty five percent are in the 45-54 age groups.

The human eye deteriorates with increasing age; the lens loses elasticity and a result the focal point moves further from the eye.

5.4.4 Work Posture

Much of the reported discomfort in the back and neck can be attributed static muscle load on these areas. The prime cause of this is due to reach requirements of the tasks. Such postures have been cited as a factor in muscle fatigue and discomfort as highlighted in section 2.3.6. The findings concur with the research of conducted by University of Cape Town Medical School by Bridger (1991) and that of Sakakibara et al (1995) which attributes higher prevalence of pain in activities which has higher pace of work and awkward work heights.

5.4.5 Seating

Seating typically consisted of straight-backed wooden/metal chairs. The provided chairs lacked any cushions for reducing compression and fatigue. The chairs lacked suitable backrests and were of improper height. The 73% that find their seating somewhat comfortable customized their chairs with cushions to adjust the height and increase pliancy. The seating cushions increased the height marginally. Although this eased the situation a little, this did not resolve their plight for adjustable and comfortable chairs of which its importance and requirements for enhanced productivity safety and health are set out in section 2.3.3. These findings concur with the findings of Videman et al (1990) who in their study highlighted the inherent lower back problems associated with seated tasks. Adding to this problem is the long periods that workers performed their seated tasks without a break. The recommendation of a maximum sitting limit without a break of fifty minutes by McGill Brown (1992) will certainly ease the present problem.

Management must also take heed of the fact simply providing the suitable chair without training and instructions on its benefits may result in may result little or no added value to the productivity. Grieco (1986) in his study argued that organizational factors such as information and training, work duration and pauses, job rotation must be taken into consideration. Simply by providing an ergonomically suited chair does not solve all postural problems and increase

Further investigation and evaluation of the visual efficiency of the workforce by an optometrist is needed as this also directly affects one's perception on illumination. Another issue is the colour of lighting. On inspection it noted that older fluorescent tubes emit a yellowish light. This directly affects the efficiency of illumination and should be replaced immediately. It is also suggested that regular inspection and maintenance be carried out.

5.4.8 Noise

The majority of the workforce found the noise levels within acceptable limits. One explanation provided was that they have become accustomed to the noise and in no way has impaired their motor or sensory functions. It was found that the twenty three percent who found the noise levels high were due to direct noises emitted from the equipment they operate such as hand held grinders.

Other sources of noise were from other machinery that is in need of lubrication. The following methods to control noise are suggested:

- Maintain and lubricate machines and equipment to eliminate rattles and squeaks.
- Replace loose and worn parts of machines.
- Rotate workers to maintain noise exposure dosage in an acceptable range.
- Use protective devices such as earmuffs, ear-canal caps and ear plugs.

5.4.9 Thermal Environment

Temperature regulation in the human body is normally maintained in a very close range around 37 ^{0}C. The study revealed that fifty three percent of the respondents found the temperature comfortable. This can attributed to the fact that many of them are skilled workers. Their level of energy expenditure is lower as they exhibit more economical movements and make fewer mistakes. The thirty one percent that found the temperature manageable could be attributed the process heat acclimatization. This is the process where the

body adapts to the thermal load of the environment. It is also found that dark – skinned individuals represent a natural adaptation for heat. The majority of this workforce falls in this category.

Other factors that can contribute to heat tolerance are physical fitness, medical history and state of nutrition (http://www.usernomics.com).

The majority of the workforce fall in the 35-44 age groups and it is a known fact that older people have a higher heat tolerance than younger people. The sixteen percent that found the thermal temperature uncomfortable could be due to their body build. Obese and stocky individuals have higher metabolic rates that produce heat which taxes the cardiovascular system. Fat and body surface area are two major factors determining the amount of heat stress that can be tolerated.

5.5 Company's Records

5.5.1 Absenteeism

There is no doubt that the records reveal that there is an unusually high level of absenteeism. This strongly correlates with the findings in which eighty four percent experienced aches and pains. The researcher during the observation phase noted many ergonomic mismatches which contributed to high levels of discomfort which can result in absenteeism. This is consistent with the findings of Olivier (1997) and Behrens et al (1994).

However, aches and pains may result from other than the workload, for instance as a complication due to other illnesses, consequence of problem of a psychological/psychosocial nature or to strenuous leisure time activities. Symonds et al (1996) highlight the importance and influence of psychological/psychosocial variables on pain and absenteeism. Medical certificates have been used as an indicator for absenteeism. This is an indicator that the person has seen the doctor because of symptoms of aches and pains, and following a medical examination, has agreed that the condition is serious enough to make the patient unable to work. This is not necessarily

the best indicator of a pathophysiological condition since many other factors also influence the decision to see a doctor.
Further study is recommended into the investigation of absenteeism as socio cultural factors could also be responsible or contribute to absenteeism.

5.6 Implementation Method

It has become quite evident that there are areas of weaknesses in the application of ergonomics. The study has revealed that the problem is not so much about the actual ergonomic principles and its application but more of a problem of finding it difficult to take action. This is primarily due to financial, infrastructure and operational problems.
Despite these constraints, it is still possible for the improvement of workplace conditions from an ergonomic point of view. This can be realized only if the process of implementing improvements is participative and makes full use of voluntary action.

The researcher emphasises that in order to obtain the optimal benefit and to enhance the positive effects that ergonomics can have, involvement from every single member, of the organisation, is needed. If appropriate guidance and support is given by management, many improvements can be made by means of self-help action using existing resources. Therefore it is important that the approach adopted by management must simple and understood by the entire workforce.
What follows is a proposed set of guidelines that will equip management with the necessary functional skills and tools to implement an ergonomics programme.
These guidelines are based on a theoretical model for ergonomics intervention in the workplace as proposed by Shanavaz, (1990). The proposition of this model is as follows:

- Worker Participation
- Viewing intervention as a dynamic process and adopting a continuous and ongoing programme.

- Actively involving all parties concerned in the whole life-cycle of the intervention process
- Using the existing experiences amongst the workforce and the available know-how.
- Low cost improvements

5.6.1 The Strategic Plan

The breadth and knowledge required to improve human-machine working relationships make it difficult to confine the improvements to a single person or department. The strategic plan for ergonomics is best developed by the management as they have a view of the overall operations.

The following questions can assist in developing a strategic plan:

- What do we want the ergonomics programme to do? This usually becomes the mission, vision, and scope of the ergonomics programme.
- How do we monitor results? What data do we measure to demonstrate progress worthy ergonomics? (these are the measures of success)
- What are the barriers and how do we overcome them?
- What policy issues are likely to be affected?
- Who is or should be involved and what are their roles? This should include both the management and the workforce .
- How important is ergonomics relative to other safety and health issues for our company?
- What is our general plan?

This information must be documented and shared with the workforce.

5.6.2 Action Plan

For the action plan to be successful a long term commitment is necessary. Action plans are developed stipulating the issues that need to be addressed including methods and outcomes. This may be changed several times before

they are agreed upon by all concerned parties. An example of an action plan is included (see appendix H).
Methods for implementing this plan may vary from company to company depending on the culture worker/ management relationship (Rohmert.1985).

5.6.3 Strategies for a Successful Ergonomics Programme

Ergonomics will not succeed without the understanding of employers and management. Management in the ergonomics team is the key player. Their main interests must be to meet desired production levels while maintaining or improving health.

Critical success Factors

- Ergonomics should be presented and explained so that it can be readily understood and use it to obtain a comfortable working environment and working conditions.
- Workers proposals for improving the environment must be taken into account by management before making any changes.
- Management must in turn take the workers proposals for improving the environment and dovetail it with those for improving and maintaining productivity and present a strategy that satisfies both.

5.6.4 Problem Solving Techniques

There are several ways in which ergonomics can be resolved. Management should carefully consider each problem and decide which approach is best suited for a particular situation. The use of problem solving teams is generally highly effective.

Guideline to problem solving process:

1. Identify the jobs/tasks at risk and select the ones to improve.
2. Analyze the problem to the extent required.

3. Develop alternate solutions.
4. Select the most appropriate solution.
5. Implement the preferred solution or if not possible, an alternate.
6. Follow up to ensure that the problem is resolved.

5.6.5 Evaluation

Common factors to evaluate after implementing ergonomics programme:

1. The time required solve problems relative to the quality of the solutions
2. The effectiveness of the solutions
3. The overall costs (time,materials,equipment,etc)
4. The overall benefits (injury / illness, lost time, productivity, quality, etc)
5. The enthusiasm for ergonomics that was generated.

5.6.6 Change Management

Our ability to apply ergonomics is limited by two human factors:

- Peoples' ability to change.
- Peoples' willingness to change.

However, affecting the willingness to change comes through understanding change. If we can get people to understand change, we can probably affect their willingness to accept change (Paton, 2000).

There is a need to encourage participation and involvement in the management of change by those who are to be affected. The aim should be to stimulate interest and commitment and to minimize fears, thus reducing opposition. Effective management anticipates change, diagnoses the nature of change, and then manages the change process.

Successful individuals or groups will have the confidence to change aspects of their work which are creating problems. (Pugh, 1978).The basic rules for managing or implementing change (adapted from Pugh, 1978):

1. Establish that there is a need
2. Discuss it informally with those likely to be affected
3. Encourage expression of all viewpoints.

Successful ergonomics programmes are guided by knowledge of organizational culture change models. There is a body of knowledge generally titled "change management" which deals with change in organizations. One especially helpful part of this technology is that it outlines the steps which must be followed before commitment to successful organizational change occurs.

As the ergonomics programme matures, it goes through six distinct stages, each with separate concerns and issues (Faville 1996).

The six stages in relation to implementing an ergonomics programme using layman's language are:

1. Awareness that a change is necessary (e.g., injuries are excessive)
2. Acceptance of ergonomics as a tool that can help.
3. Trial using ergonomics to see if it works.
4. Regular use of ergonomics because it does work.
5. Procedures written to include ergonomics.
6. And finally, a culture that is totally supportive of the use of ergonomics.

5.6.7 Management Objectives for Implementing Change

- To increase the level of trust and support among the workforce.
- To increase the incidence of confrontation of work problems, in contrast to 'sweeping problems under the rug.'
- To create an environment in which authority of assigned role is augmented by authority based on knowledge and skill.
- To increase openness of communications laterally, vertically and diagonally.

- To increase the level of personal enthusiasm and satisfaction in the workforce.
- To find synergistic solutions to problems with greater frequency.
- To increase the level of self and group responsibility in planning and implementation.

5.6.8 Economic Analysis for Ergonomic Programmes

Good ergonomics often has a positive economic effect. However, unless an assessment method is in place to document both costs and savings or income associated with ergonomic related activities, only the costs may become readily apparent. Ergonomics then appears as just one more expense. The benefits of ergonomics such as increased productivity and reduced expenses must be objectively documented, just as costs are, in order to change this view of ergonomics (http://www.ergoweb.com).

5.6.9 Tools for Change

People from different professions or different parts of a factory have different mind sets. This causes them to look for different things when trying to understand a problem. People perform fragmented tasks from which they may not be able to see relationships to the whole. Collectively these people would see more than an individual, thereby increasing the group's ability to understand and solve the problem. In any problem solving or system analysis exercise one may find an effective role for diagrammatically based analysis. In order for management to obtain a working environment they wish to have, it is imperative to overcome the complexity of problem solving. It is in management's interest to develop both a practical understanding of the available techniques and a level of expertise in applying them.

5.6.9.1 Pareto Analysis

This analysis is intended to separate the 'significant few' from the 'trivial many'. This is also known as the 80/20 rule. An important feature of this tool is

that it illustrates very clearly to the user what the major cause of the problem is likely to be. This quantitative analysis prioritizes causes from greatest to least impact in a single graph. This positive feedback can be motivating to those solving a problem. Most importantly, the Pareto diagram helps people identify the factors that have the greatest influence on the problem being solved (Ambrosini, 1998).

5.6.9.2 Cause-and-effect Diagram

This tool, sometimes called a 'fishbone chart', is useful when the problem is undefined and unstructured. It is good group facilitation techniques for helping people identify potential causes of the problem and possible interrelationships (Ambrosini, 1998). Unlike the Pareto diagram, which is quantitative, this qualitative analysis allows people to restructure their own thinking and agree on potential solutions.
Some guidelines for using the cause-and-effect analysis is included (see appendix I).

5.6.9.3 Link Analysis

This analysis is intended to chart the movement of people, information, work processes, or movements on a control board. Link analyses are powerful tools for participation because they are intuitive, quantitative and illustrative (Ambrosini, 1998).
They allow people to visualize inefficiencies, redundancies and wasted energy that contribute problems. This is an easy exercise that helps people to think about ergonomics and its implications.

5.6.9.4 Round-robin Questionnaire

Here the participants are given an open-ended statement such as 'The problem with my work station is....' Each statement is presented on a separate piece of paper. The sheet of paper is passed around and each participant must add an idea that is different from the preceding one. This is

done until there are no more new ideas or when every participant has had at least one chance to fill out the questionnaire.

Unlike traditional questionnaires, this procedure cuts out redundant answers and stimulates ideas one on the other. People have an opportunity to express ideas without having to go through a long discussion period (Noro, 1991).

5.6.9.5 Layout Modelling and Mock-Ups

It may be helpful for workers to evaluate new work stations or new work environments.
This can be achieved by having workers actually construct cardboard models of potential work areas. This use of models and mock-ups is useful in helping people to visualize potential changes in their workplace (Wilson, 1988).

5.6.9.6 Slides/Videos

It is helpful for workers to see their working environment and work processes in slides and videos. It provides immediate feedback and is cost effective, because the actual work situation needs not to be recreated over and over again (ILO, 1985, ILO, 1986 and Wilson, 1988).

The labour costs of case involvement can be reduced greatly. The learning process is greatly facilitated by using slides showing the workplace scenes before and after improvement. Slides of positive examples from similar enterprises and there use in training sessions are essential. These positive examples show clearly what can be done and how improvements can be carried out. Since the examples are taken from the workplaces in similar conditions, they can be used as the actual basis for improvement.

5.6.9.7 Written Programme

A written programme is essential for a success. However, the typical reaction of a small business to this suggestion is "more paper work." There are many

advantages to putting down in writing the basics, such as the objectives and who is involved.

Writing the programme basics helps to:

- Get the programme started more efficiently
- Organize thoughts and the best plan of action
- Clearly communicate the process
- Make it easier to introduce the process to a newcomer
- Establish the goals and achievements by which the programme can be assessed for success and improvement.

The written programme need not be a lengthy document but rather a clear statement conveying the objectives, goals and processes to establish and continue ergonomics within the company (Wilson, 1988).

For a written document to be effective important points to include are:

- An overall schematic of the components and process
- Programme objectives
- A list of those involved (or of job positions) and their responsibilities
- The programme process (e.g., who gets training, to what extent, and by whom)
- A section for the project action list, analysis, and record of changes and their effectiveness (these could be the minutes from project meetings).

5.6.9.8 Check Lists

A check-list is a practical and an important tool. It should consist of simple, low-cost measures which cover all areas of required improvements. The check-list enables the worker to choose those factors which they think are applicable to their particular workplace. It should be action orientated in order to guide the participants to select the measures to be taken.
An example of a checklist is included (see appendix J).

5.6.9.9 Research

With research, one is trying to identify all the ergonomics problems and opportunities - what is wrong and what can be improved. These also help determine the magnitude of the ergonomic programme and the resources needed. Research does not need to be burdensome or time consuming to be effective. Some things to look for when conducting research are included (see appendix K)

5.6.10 Barriers to Implementation of Ergonomics

In general, the main interest of management is to improve productivity. It is not easy to show how ergonomics can contribute to improving productivity. There are many employers and managers who believe that the introduction of ergonomics decreases, rather than increases, productivity and does not bring about any profits to the companies. No matter how welcoming management or the workforce is to change, it will still experience some degree of resistance to change. Why do people resist change? The prime reason is because they fear the unknown and are comforted by the familiar.

In terms of ergonomic changes the following can pose as barriers to implementation.

- Company staff does not understand the application of ergonomics.
- Management does not understand the gains to be made through the application of ergonomics.
- Ergonomic research is often carried out at research institutes or large corporate environments where variables such as space, finance and measuring instruments do not pose as limiting factors.
- Excessively high or added costs of enlisting the services of ergonomic specialists.

5.6.11 Ergonomic Tools

Ergonomic methods to be used must be simple. Text books cannot be brought near the machines. The ergonomic methods have to be simple enough to be remembered.

Pocket guides or manuals containing specific information related to a specific work process, are most suited to meet this criteria. Display charts containing the general common rated principles, should be placed at strategic points (Woodson, 1981).

5.6.12 Education and Training

First, some general education in ergonomics is needed by someone in the company so as to plan an ergonomics programme. In-depth training is recommended for a specified team, and general awareness training is recommended for managers, supervisors, and line workers. The extent of investment in training may depend upon the financial resources and the turnover rate.

A smaller team may be trained to save costs, but everyone should receive some awareness training. If a company suspects there are many problems requiring improvement, it maybe helpful to train gradually (Ackerman, 1991).

The objectives of training should be to:

- Generally understand the ergonomics programme.
- Appreciate their role and responsibilities in the programme.
- Recognize the early indicators of physical problems.
- Understand the company medical management system.
- Understand basic risk factors for injuries and illnesses.
- Know basic ergonomics principles.
- Understand their participation in job analyses.

Key factors for a training programme to be a success are:

- The subject matter must be clearly understood and must relate to practical work situations.
- Training must be directed toward developing the workforce's ability to recognize inconsistencies between task requirements and the performance capabilities of the individuals performing the task.
- It must encourage workers to attempt to solve ergonomic problems once they are recognised either by themselves or by seeking assistance from co workers, supervisors or management.
- It must emphasize the potential benefits that would be gained from the application of ergonomics in the work areas.

5.6.13 Self-Help Training

Self- help training can enable managers and workers to identify priority problems and find solutions by providing practical advice and concrete guidance about implementation.

For effective training, it is essential to build on and to focus on achievements. The technical content should concentrate on themes which have practical importance and are related to working conditions and productivity, e.g. materials handling, work-station arrangements, physical environment and work organization (Ackerman, 1991).
To facilitate the learning-by-doing with a view to self-help, good training tools should be developed and used.

5.6.14 Barriers to Training

The four common most obstacles to overcome

- Lack of time
- Lack of money
- Too few skills
- Lack of management support.

5.6.15 Ergonomic Programmes

The success of ergonomics in a company remains dependant on how well the programme is structured and carried out.

A" one size fits all" approach does not work when implementing an ergonomics programme (ILO, 1986).
The following factors influence an ergonomics programme and should be taken into consideration (Huse, 1980):

- Size
- Culture
- Resources

A programme does not need to reach full implementation to be successful. If a programme is minimally implemented it more likely to be a reactive approach. A proactive ergonomics programme requires commitment and involvement from every member of the organization. The ergonomic process is dynamic and regular evaluation and revision is necessary to maintain effectiveness.

5.7 Conclusion

Although it may seem straightforward it must be understood that this is not a detailed analysis of each problem and a great deal of complexity and significant number of decisions must be made to implement any changes.
The evidence suggests that an intense effort with a bias towards ergonomics has to be undertaken. It is better to consider the effect of ergonomic adaptations as such rather than the effect of more general changes in working conditions. It must be noted with caution that the work styles and processes are dynamic and will always demand a fairly high physical input. The researcher with this in view, recommends a phased introduction as acceptance can be more difficult since the advantages of the interventions will not be immediately apparent to both management and the workers.

CHAPTER 6 – CONCLUSION OF STUDY

This chapter concludes the research through the presentation of main findings, recommendations, problems encountered and limitations followed by the conclusion.

6.1 Main Findings

In the process of this study vast amount of literature was consulted. The amassed literature is indicative of the lack of easily accessible, user- friendly relevant guidelines for small manufacturing engineers.

Management are aware of ergonomics as a discipline but couldn't see the link to health, safety, productivity and how these impact on their business. Management presently are only concerned with focusing on getting the job on hand done with little or no concern how it is done and at what effects it has on workforce. Managements' main obstacle is how to implement and manage an ergonomics programme without additional labour costs.

Management presently view ergonomics as an altruistic theory in goodness of human nature. They need to be convinced about the commercial reality in which they operate and the move to improved worker relations will provide them the competitive edge.

The discussions through the various chapters have progressively highlighted the importance and impact of ergonomics as a tool for enhanced competitiveness and associated risks of a poor ergonomic environment. Ergonomics can be used as problem solving tool, however the study has shown that a proactive approach in ergonomics is the best suited for long term success. Ergonomics programmes must be on a continuous basis to reach its optimal desired effect.

The most effective method to implement change and problem solving requires active participation between the workforce and management.

The characteristics of small industries are conducive to a participatory approach. Due to managerial and financial constraints, it is only possible for management to consider low cost improvements. Without the input and active cooperation from the workforce this will not be possible to achieve. In – house workforce training programmes will serve as positive contributions of ideas and an early detector of potential ergonomic problems.

Manufacturing processes of the companies under study are still labour intensive and requires significant amount of repetitive, skilled manipulation through the various stages of manufacture. The research has shown that the overall data indicates the discomfort level experienced is significant to implement an ergonomics programme.

6.2 Recommendations

The researcher is of the opinion that there must be ongoing research by the creation of a research and productivity unit for small manufacturing engineers. This will enable technological developments necessary for the ergonomic viability of the manufacturing process thereby making it productive and efficient as it possibly can be. There is a dire need to carry out experimental interventions to demonstrate to management the clear linkages between ergonomics and its positive impact on safety, health and productivity. This will help to allay the initial existing fears presently existing among management. The researcher suggests that management must foster good relations with other similar companies, so, as when the need arises, they can consult, seek advice and exchange ideas from each other. This can be achieved through the formation of an official body or informal network.

Management must set mid point goals when implementing the ergonomics programme. This provides more concrete and manageable steps and benchmarks for change. It also safeguards the enthusiasm which can

sometime wane due to the pressures to meet customer needs and thus return to methods they are used to. Management should become systematic reflective thinkers and planners rather than simply responding to demands or pressures of the jobs. To make any ergonomic programme work, the researcher suggests that a resource-based approach be adopted by management.

For an ergonomics programme to sustain itself over a long period, it must be perceived as a value added element in the organization and must be integrated in the nature of the organization. Change needs to be achieved through a multitude of small incremental changes and over time; this can lead to a major transformation of the organization.

People social needs can have more influence on their work performance than financial incentives. Humans are not one dimensional being. People performance are not only a function of there pay packet and must not be viewed as economic beings. Workforce should not be treated as objects or obstacles to change, but involve them in the process of change. Management must realize that ingenuity, creativity and the ability to make good decisions are also present in the workforce. Workers are also capable of exercising self direction. If the workforce is given a greater responsibility they will become more committed to the objectives and will be more willing to contribute.

6.3 Limitations of Study

This study is clearly not exhaustive in covering all areas of application of ergonomics. The research is neither 'complete' in the scope of using all types of measurements method, or addressing all the components of the user machine system (controls and displays, anthropometry, workplaces, physical environment, and psychological environment). It was impossible to conduct a detailed study of all the components of the user machine system, due to time constraints and the fact that some components were outside the researcher's control. Since ergonomics can be applied to virtually any user machine

system, it is inevitable that some of the applications will be missed out in a selection of just three studies.

Most ergonomic problems, for example cumulative trauma disorders, are dose-response related. It was not possible measure these stress doses in this study. The study was limited to identification and prevention of ergonomic problems, and the considerable benefits that may accrue from reducing or eliminating these problems. There is no certainty the potential risks identified are bound to occur at any of the companies. The physiological and biomechanical techniques which are available require time consuming data analysis. It would be difficult to apply these techniques as the work is unstructured, to a large degree, and the tasks are varied.

Different people in the workforce have varying perceptions of workload. It must be noted that this perception may affect people's performance. The study is not complete in the sense it has not measured the mental workload rating of the respondents or thoroughly investigated psychological or psychosocial factors.

In studies of this kind the researcher must be mindful of contamination of data by the Hawthorne effect. Traditionally the Hawthorne effect is evidenced in increase in pace or style of work leading to increased production. No historical data was available to explore the possibility of such effect that may have occurred during the observation phase of the research.

The study cannot be generalized to the entire population of small manufacturing engineers. Nevertheless, the three companies under study gives the reader a good idea of the range of applications of ergonomics and the effectiveness of ergonomics based solutions in small manufacturing engineers.

6.4 Conclusion

This research has shown arguments that support a sound ergonomics based management system cannot be ignored. Small manufacturing engineers that wish to have a competitive edge must embrace the principles of ergonomics set forth in this study. Any production system that focuses on quality, performance, cost reduction, safety and health must be based on ergonomic principles to be successful. Ergonomics should be viewed as processes rather than single outcomes. Just as work continues to evolve, workers must be continually involved in helping the work environment change.

Not all control measures will be practical in every situation, or in fact even available, but a holistic view has to be considered when addressing problems of productivity, health and safety. It may not be possible to find a complete solution to the problems altogether, but if all aspects that have an influence on the problem are assessed and controlled as much as possible, then certainly a reduction in problem areas will be the final outcome.

Although this study provides an excellent start point for the creation and implementation of an ideal ergonomics programme, it must be noted that this study does not provide an all encompassing system that will solve all ergonomic issues in the workplace. Despite the fact that all major issues have been considered, more research is needed on a continuous basis. The researcher emphasizes that consideration also needs to be given to influencing factors beyond the workplace such as living conditions, health status and nutritional intake of workers, in order to holistically assess and solve problems in the workplace. This needs further research.

It is also important to understand and realize that a compromise has to be reached between the ideal ergonomics solution, and what is possible under financial, technical, and managerial constraints.

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http://iac.dtic.mil/hsiac

APPENDIX A

Questionnaires

Gender: _____

Age: _____

Classification:

Skilled	Semi - skilled	Unskilled

1) Workspace design and Layout

1.1) Are your primary tools always easily accessible?

1.2) Is the work surface height adjustable?

1.3) Do you have one metre or more free space around your work area?

1.4) Are all switches, controls and materials that you require to operate easily accessible?

1.5) Is your movement restricted in any manner whilst performing your work?

1.6) Do the machinery layout and production processes follow a sequence?

(For rating by researcher)

Good	Adequate	Poor

2) Work posture

2.1) Do you have to frequently forward/backward bend the trunk, head and neck?

2.2) Do you have to maintain the same posture for periods of more than one hour?

2.3) Do you have twisted body positions during performance of work?

2.4) Do you assume different postures while working?

2.5) Do you have to raise your arms for more than one minute repeatedly?

2.6) Are your hands at a convenient working height for the task you perform?

(For rating by researcher)

Comfortable	Somewhat comfortable	uncomfortable

3) Seating

3.1) Are you're feet firmly supported on the floor or with the aid of a footrest?

3.2) Can the backrest be utilized while performing the task?

3.3) Is your seat padded?

3.4) Are the seat height and backrest adjustable?

(For rating by researcher)

Comfortable	Somewhat comfortable	uncomfortable

4) Physical workload

4.1) Do you perform any lifting tasks repeatedly?

4.2) Are the items to be lifted positioned between the knuckle and shoulder height?

4.3) Do you lift items heavier than 4 kg?

4.4) Do you use any mechanical aids to move your goods around the workplace e.g. carts cranes etc?

(For rating by researcher)

Physically demanding	Somewhat demanding	Not demanding

5) Physical Environment

- Noise
  1. Can you communicate effectively with a fellow worker who is approximately one metre away?
  2. Do you use any machinery that emits noises that require you to wear protective hearing devices?
  3. Are the equipment regularly serviced and maintained?

(For rating by researcher)

High Level	Acceptable Level	Low Level

- Lighting
  1. Is the lighting uniform throughout the workplace?
  2. Do you experience any form of glare?
  3. Do you require any local lighting to enhance your work performance?
  4. Are there any sharp shadows on the work surface?
  5. Have you experienced any eye strain?

(For rating by researcher)

Good	Acceptable	Poor

- Temperature
  1. Do you sweat a lot at work?
  2. Do you experience any discomfort from this?
  3. Do you experience reduced physical performance due to work temperature?

(For rating by researcher)

Comfortable	Manageable	Uncomfortable

- Air circulation
  1. Do you work in an enclosed corner or in a narrow space surrounded by equipment or partitions?

Yes	No

  2. Please rate the air flow in the work area?

Good	Acceptable	Poor

6) Pain

6.1) please describe the intensity of your pain?

Severe	Moderate	Mild	No Pain

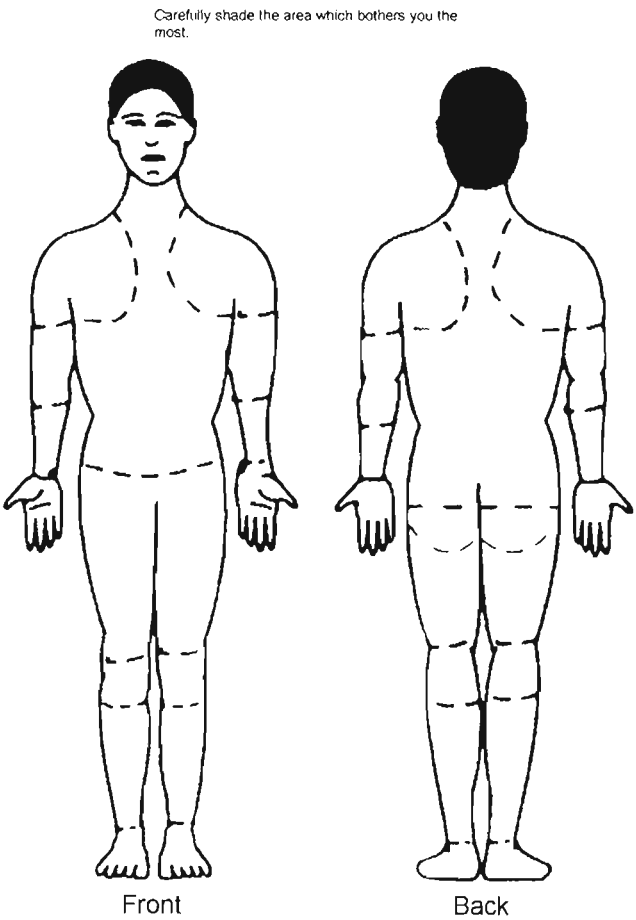
Key:

Severe – Unable to perform specified task, need medical help,

Moderate – Able to perform tasks with limitation- generally controlled by medication

Mild – Able to perform task with slight or no limitation

6.2) Please indicate on the diagram in which area do you experience pain. Use a separate diagram for each area?



6.3) please indicate the frequency you experience these aches and pains.

Never	Seldom	Often	Regularly

Key: Seldom - Less than once a month

Often - At least once a month

Regularly - At least Once a week

APPENDIX B

	Stature		Sitting Height		Knee height	
	F	M	F	M	F	M
NORTH AMERICA	1650	1790	880	930	500	550
LATIN AMERICA						
Indian	1480	1620	800	850	445	495
European and Negroid	1620	1750	860	930	480	540
EUROPE						
North	1690	1810	900	950	500	550
Central	1660	1770	880	940	500	550
East	1630	1750	870	910	510	550
Southeast	1620	1730	860	900	460	535
France	1630	1770	860	930	490	540
Iberia	1600	1710	850	890	480	520
AFRICA						
North	1610	1690	840	870	500	535
West	1530	1670	790	820	480	530
Southeast	1570	1680	820	860	495	540
NEAR EAST	1610	1710	850	890	490	520
INDIA						
North	1540	1670	820	870	490	530
South	1500	1620	800	820	470	510
ASIA						
North	1590	1690	850	900	475	515
Southeast	1530	1630	800	840	460	495
SOUTH CHINA	1520	1660	790	840	460	505
JAPAN	1590	1720	860	920	395	515
AUSTRALIA						
European extraction	1670	1770	880	930	525	570

Average Anthropometric Data (in mm) Estimated for 20 Regions of the Earth

(Juergens, Aune, and Pieper, 1990:198)

APPENDIX C

U.S. Civilian Body Dimension (in mm) of Industrial Relevance (Helander, 1995:233-4)

	Percentile					
	Male			Female		
Dimension	5th	50th	95th	5th	50th	95th
Stature	1640	1755	1870	1520	1625	1730
Eye height	1595	1710	1825	1420	1525	1630
Shoulder height	1330	1440	1550	1225	1325	1425
Elbow height	1020	1105	1190	945	1020	1095
Hip height	835	915	995	760	835	910
Sitting height	855	915	975	800	860	920
Sitting eye height	740	800	860	690	750	810
Sitting elbow height	195	245	295	185	235	285
Thigh thickness	135	160	185	125	155	185
Buttock-knee length	550	600	650	525	575	625
Buttock-popliteal	445	500	555	440	490	540
Buttock-popliteal	495	550	605	460	505	550
Popliteal height	395	445	495	360	405	450
Shoulder height	425	470	515	360	400	440
Hip breadth	310	360	410	310	375	440
Elbow span	875	955	1035	790	860	930
Vertical reach (stand)	1950	2080	2210	1805	1925	2045
Vertical reach	1155	1255	1355	1070	1160	1250

	Female			Male		
	5th	50th	95th	5th	50th	95th
Standing						
Tibial height	38.1	42	46	41	45.6	50.2
Knuckle height	64.3	70.2	75.9	69.8	75.4	80.4
Elbow height	93.6	101.9	408.8	100	109.9	119
Shoulder (acromion) height	121.1	131.1	141.9	132.3	142.8	152.4
Stature	149.5	160.5	171.3	161.8	173.6	184.4
Functional overhead reach	185	199.2	213.4	195.6	209.6	223.6
Sitting						
Functional forward reach	64	71	79	76.3	82.5	88.3
Buttock-knee depth	51.8	56.9	62.5	54	59.4	64.2
Buttock-popliteal depth	43	48.1	53.5	44.2	49.5	54.8
Popliteal height	35.5	39.8	44.3	39.2	44.2	48.8
Thigh clearance	10.6	13.7	17.5	11.4	14.4	17.7
Sitting elbow height	18.1	23.3	28.1	19	24.3	29.4
Sitting eye height	67.5	73.7	78.5	72.6	78.6	84.4
Sitting height	78.2	85	90.7	84.2	90.6	96.7
Hip breadth	31.2	36.4	43.7	30.8	35.4	40.6
Elbow to elbow breadth	31.5	38.4	49.1	35	41.7	50.6
Other dimensions						
Grip breadth, inside diameter	4	4.3	4.6	4.2	4.8	5.2

APPENDIX D

Anthropometric Aspects of Seat Design (Roebuck, 1975:301)

	Percentile					
	Men			Women		
	5th	50th	95th	5th	50th	95th
Knee height	490	545	595	455	500	540
Popliteal height (floor to underside of knee)	395	440	490	355	400	445
Buttock-knee height (to back of knee)	440	495	550	435	480	530
Elbow height (from seat)	195	245	295	185	235	280
Mid lumbar height (from seat)	195	240	285	195	230	265
Shoulder height (from seat)	540	595	645	505	555	610
Mid-cervical height (from seat)	660	725	785	605	660	720
Hip breadth (maximum)	310	360	405	310	370	435

APPENDIX E

Guidelines for Required Levels of Illumination (Helander, 1996: 271)

Type of work	Examples	Recommended Lighting (Lx)
General	Storeroom	80-170
Moderately precise	Packing; despatch works; simple assembly; winding thick on to spools;	200-250
	Work on carpenter's bench; turning; boring; milling; locksmith's work.	250-300
Fine work	Reading; writing; book-keeping; laboratory technician; assembly of fine equipment; winding fine wire; fine precision machining; fine working on tool making gig.	500-700

APPENDIX F

A Guide to Maximum Work Times without a Break (Pheasant, 1991: 327)

Permissible times for work	
Wet-bulb temperature (^{0}C)	Maximum permissible working time (min)
22	360
24	240
26	210
28	180
30	140
32	90
34	65
36	50
38	39
40	30
42	22

APPENDIX G

Guidelines for Handling Loads by an Individual (NIOSH, 1981:34)	
Below 16 kg	No special action required.
16-34kg	Identify population able to perform action.
34-55kg	Limited to selected and trained individuals; mechanical aids should be considered first.
Above 55kg	Mechanical systems should be considered first; selective recruitment and special training is essential if mechanical systems are not used.

APPENDIX H

Example of an Action Plan (adapted Render and Heizer, 2001, Robbins and Coulter, 1999).

Organization

The Ergonomics Organization will consist of representation from all areas of work.

Training

Provide education and training to increase ergonomics awareness.

New Projects

All new projects will utilize ergonomic principles and considerations in the design of products, manufacturing and assembly processes, and equipment.

Existing Projects

Based on medical data, safety considerations, or employee responses, existing processes identified as ergonomically stressful will be reviewed for ergonomic problems and improved.

People

Employees exhibiting the effects of ergonomic problems in their work will be encouraged to identify those problems to ergonomics task force and participate in their solution.

APPENDIX I

Guidelines for using the Cause-and-Effect Analysis

- Full participation will ensure that no causes are overlooked. All participants should feel free to voice their ideas.
- Encourage free information exchange: a non-critical free participation atmosphere will help this flow. Write down all ideas under the appropriate category.
- If causes become too cumbersome, group causes together and analyse these groups separately.
- Select the most likely cause after all ideas have been aired. Only at this point should ideas be evaluated.
- Focus on solutions. Avoid discussing how the problem started or who is to blame. Focus on solving the problem.

APPENDIX J

An Example of a Checklist for Identification of Upper Extremity Cumulative Trauma Disorder Risk Factors (Burke, 1992:114)

1. Physical Stress
   1.1 Can job be done without contact of fingers or wrist with sharp edges?
   1.2 Is the tool operating without vibration?
   1.3 Are the worker's hands exposed to temperature > 70°c
   1.4 Can the job be done without using gloves?
2. Force
   2.1 Does the job require less than ten pounds of force?
   2.2 Can the job be done without using finger pinch grip?
3. Posture
   3.1 Can the job be done without flexion or extension of the wrist?
   3.2 Can the tool be used without flexion or extension of the wrist?
   3.3 Can the job be done without deviating the wrist side to side (ulnar or radial deviation)?
   3.4 Can the tool be used without ulnar or radial deviation of the wrist?
   3.5 Can the worker be seated while performing the job?
   3.6 Can the job be done without 'clothes wringing' motion?
4. Workstation hardware
   4.1 Can the orientation of the work surface be adjusted?
   4.2 Can the height of the work surface be adjusted?
   4.3 Can the location of the tool be adjusted?
5. Repetitiveness
   5.1 Is the cycle time above 30 seconds?
6. Tool design
   6.1 Can the thumb and finger slightly overlap around a closed grip?
   6.2 Is the span of the tools handle between 5 and 8 cm?
   6.3 Is the handle of the tool made from other material other than metal?
   6.4 Is the weight of the tool below ten (10) lbs?
   6.5 Is the tool suspended?

APPENDIX K

Some Things to look for when Conducting Research (Adapted from Babbie and Mouton, 2001, Burke, 1992, Cooper and Schindler, 1998 and Helander, 1995)

- Ergonomics has safety and health implications. Therefore one of the first places to look is worker's compensation, medical records and restricted work cases. Eventually, as the ergonomics initiative moves from correction to prevention, additional techniques will be needed to identify ergonomics risk factors and early warning indicators of potential injuries.
- Examine traumatic injuries as well, since their cause is often rooted in an interface problem between the personnel and some piece of equipment. From these situations, the number and cost of injuries/ illnesses can be determined.
- Look for performance problems and cost issues as well as safety and health concerns. For example the recruitment, hiring, and training of replacement workers can often be costly. People who work at poorly designed work stations take more breaks, produce less, or turn out lower quality products. There are a number of ways in which ergonomics can improve job performance, management should be aware to these savings.

APPENDIX L

Recommendations for Effective Management of MMH tasks (NIOSH, 1981:31):

- Keep hands clear of pinch points to prevent crushing hands between hands;
- Don't take more than you can carry safely;
- Cross-tie when stacking;
- Don't stack too high;
- Don't carry a load so high that you can't see over it. Never block your vision;
- Pushing is safer than pulling;
- Always know your limitations;
- Protect your hands with proper glove;
- Get a good grip of the load.

APPENDIX M

Explanation of Anthropometric Terminology

Tibial height: This measure is important for manual materials handling. Items located between the tibial height and the knuckle height must usually be picked up from a stooped position.

Knuckle height: This height represents the lowest level at which an operator can handle an object without having to bend his knees or back. The range between the knuckle height and the shoulder height is ideal for manual materials handling and should be used in industry.

Elbow height: An important marker for determining work and table height.

Shoulder (acromion) height: Objects located above shoulder height are difficult to lift, since relatively weaker muscles are employed.

Stature: to determine the minimum overhead clearance required to avoid head collision.

Functional overhead reach: Determines the maximum height of overhead controls.

Functional forward reach: Items that are often used within the workstation should be located within the functional reach.

Buttock-knee depth: This defines the seat depth for chairs and clearance under the work table.

Buttock-popliteal depth: Determines the length of the seat pad.

Popliteal height: to determine the range of adjustability for adjustable chairs.

Thigh clearance: Sitting elbow height and thigh clearance help to define how thick the table top and the top drawer can be.

Sitting elbow height: Sitting elbow and popliteal heights define table height.

Sitting eye height: Visual displays should be located below the horizontal plane defined by the eye height.

Sitting height: Determines the vertical clearance for a seated work posture.

Hip breadth: Determines the breadth of chairs and whole body access for clearance.

Source :(Roebuck, 1975:308).