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Productivity Enhancement by Integrating Occupational Ergonomics Through TPM

Chintada Anusha[1] V. Umasankar[1] and D. Ganesan[2]

[1]*School of mechanical and building science, Vellore Institute of Technology, Chennai-600 127, India. Email: chintada.anusha@gmail.com, umasankar.v@vit.ac.in*

[2]*TPM and Technology Development, Turbo Energy Limited Vellore-632505, India. Email: ganesan.d@turboenergy.co.in*

ABSTRACT

Total productive maintenance has been established in many industries to improve their operational efficiency but still operator comfort and safety remains as the driving force for achieving total employee involvement. This is possible only when operational ergonomics is integrated with total productive maintenance. This paper explores the advantages gained by integrating the SHE pillar with focus on operational ergonomics. With existing TPM structure operator comfort, communication and safety features with improvements have enabled substantial improvement in productivity and customer satisfaction. As part of expanding the benefits of TPM companies have implemented in reducing the manual effort of physical loading and unloading of jobs to machines, converting the manual feeding into automatic feeding of semi-finished and finished components for further processing with gantry cranes and jib cranes. The operator is also provided with anti-fatigue mats which help in improving the blood circulation and reducing the fatigue. Clamping and unclamping of the jobs are carried out with pneumatic cylinders resulting in reducing operator effort in addition to ensure proper clamping promoting machined part accuracy. The outcome of the exercise has established the necessity and advantage of focusing operational ergonomics in every aspect of total productive maintenance. As with industry 4.0 TPM is getting transformed into Total plant reliability the current findings will address the aspect of human productivity. Thus by implementing the above factors such as automated machines the operator fatigue is increased and safety and morale of the operator is improved.

Keywords: Total Productive Maintenance, Occupational Ergonomics, Operator Productivity, 5S, Operator Fatigue, Safety Health and Environment.

1. INTRODUCTION

Every industry is finding the challenge of employee motivation, awareness and competition from multinational companies and some are challenged by their principal companies themselves. Employee attrition and managing with maximum temporary manpower has really impacted the motivation, awareness and commitment of operating people. Though Total Quality Management has been attempted by many companies it has not yielded the benefits due to the environment in Indian industries. Motivation and awareness of operating personnel are achieved by due recognition, empowerment and pride in the work allotted. Everyone should have a feeling that he is an important member of the organization and has a defined role and responsibility so that he can be proud that he is contributing and which is valued and recognized by top management. Productivity can be achieved only by happy and healthy work environment which also provides an empowerment and ownership. Manpower makes all the difference from competing companies than the infrastructure, equipment and compensation. Total productive maintenance is successful in providing the above requirements and enabling employee motivation through Safety, Health and Environment panel.

SHE panel has the following objectives: create a safe workplace and a surrounding area that is not damaged by our process or procedures, create awareness among employees through various competitions like safety slogans, quiz, drama, posters etc can be organized at regular intervals, along with Zero accident, Zero Health damage and Zero fire.

The idea of SHE pillar is developed in the organization based on the assumption of parallel improvement of two areas operators' and technical staff's technical culture and safety culture[1] Figure1. Model of the "she" pillar[1]

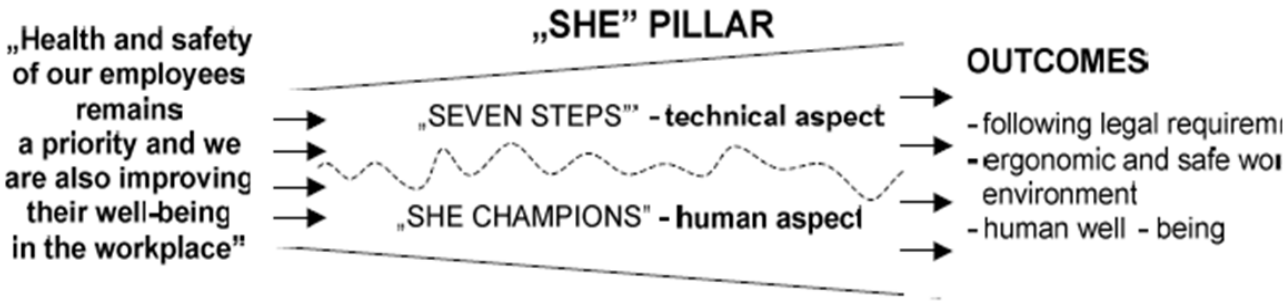

Figure 1: Model of the "she" pillar[1]

Successful implementation of TPM has been found to improve the competencies of their employees at all levels. This has resulted enabling employees to take responsibility, improve the organization's core competency and maintain the reputation among the industries[2] . This is achieved by improving the work environment through 5 S and other activities of 8 pillars. It has been studied that implementation of TPM results in reducing operator fatigue, ease of working and enhancing health by inherent work place design, clarity in responsibility and accountability along with ownership .

Ergonomics is defined as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance or ergonomists

contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of the people. At the workplace, ergonomics is applied to the design of work equipment and tasks and to work organisation. It is often referred to as occupational ergonomics as it is an important part of occupational health and safety. As such, it aims to promote health, efficiency and well being in employees by designing for safe, satisfying and productive work. Ergonomics can play an important role in occupational health and safety management where the primary aim is to reduce risks of injury or disease while enhancing the quality of working life. Good ergonomics in the workplace can improve productivity and morale of workers and decrease injuries, sick leave, staff turnover and absenteeism. In occupational ergonomics it is necessary to examine not only the physical design aspects of work or the 'hardware', but also areas such as work organisation and task design, job content and control over workload, support and training. The social and managerial environment is important. Usually these aspects require ergonomics to be integrated into the broader work systems. In general the loading and unloading of the component is done by the operators which leads to the more accidents in the machine shop and also operators are suffering from illness through which the productivity of an organisation will be reduced due to the less involvement and lack of motivation in the operators in the organisation. The above factors can be improved by implementing the TPM in the industries. In which the SHE pillar plays a very important role to reduce the fatigue and to reduce accidents to the zero.

Total productive maintenance plays a very important role in improving the productivity and overall equipment efficiency. The industries which are following the TPM took more efforts to reduce the fatigue and workload on the operators and also providing the safe working conditions in the industries by creating awareness about the accidents and also by placing the white tag near the machines to rectify the abnormalities in the machine which are the main cause for the accident in the machines. Thus by implementing the above factors the occurrence of the accidents have become zero and also the workers have been motivated to work which leads to the improvement of the productivity in the industry. The company can reach the highest level of TPM manufacturing process, if the company concentrate on improving the skill of the operators and they should even go an extra mile by giving operators external training to enhance their skills. Besides management support system, the company can exercise worker flexibility as an element of trust that is shown by management to its employees[3] . This current paper is based on the case study of a leading auto ancillary industry which successfully implemented TPM and analyses the benefit achieved by employees by reduction in work related health hazards, fatigue, and improved their understanding resulting in higher employee productivity. Basically though TPM is focussed on productivity, to achieve its principles are based on enabling operating personnel to understand the importance and necessity of observing the abnormalities and establish what can be done by himself and what can be achieved with the help of maintenance department, it focuses on avoiding 16 big losses in productivity and mitigate them with human excellence.

1.1. Occupational Ergonomics

The company has successful actions in employing and implementation of 5S, Ergonomics and executing TPM and also their relations are meaningful[4] . Ergonomic guide lines describes ergonomics as "Ergonomics is the scientific discipline concerned with the fundamental understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to

design in order to optimise human well-being and overall system performance[5]. Derived from the Greek ergon (work) and nomos (laws) to denote the science of work, ergonomics is a systems-oriented discipline that extends across all aspects of human activity, and therefore promotes a holistic approach to enhancing the well-being of people at work. To achieve this it considers the physical, cognitive, social, organisational and environmental aspects of work and the impact, both positive and negative, that these may have on the worker and also it gives information about different domains in ergonomics such as physical ergonomics, cognitive ergonomics, organisational ergonomics, micro and macro ergonomics. The employee participation in applying ergonomics principles and identifying work place problems are also explained in the ergonomic guide lines It also states that application of ergonomics provide benefits such as minimising the wasted effort, reduced damage to the equipment ,less waste of the product and improve productivity.

2. CASE STUDY-TURBO ENERGY LIMITED

Turbo energy limited is an automobile company which is established in the year 1982 at 67, chamiers road, Chennai, Tamilnadu, India with 1008 employees. It is a manufacturer of turbocharger & parts. The vision of the company is to achieve customer satisfaction by providing products and services of high quality at globally competitive prices. The main process of the company is machining in order to achieve the machining process without any break downs, defects in the component and to achieve the customer satisfaction through total productive maintenance implemented in the company. The TPM is started in the year 2009 through which the maintenance activities is shared by the operators in equipment autonomous maintenance. The TPM is implemented in the company to resolve and to accelerate the loss prevention in all business processes by making TPM a way of work life in their organisation which can be achieved by promoting total participation of the people in the overall development of the organisation. The company has achieved TPM Excellence award and TPM consistency award. All the 8Pillars in the TPM are interlinked which helps in improvement of the productivity.

5S is the base platform for TPM and TQM is integrated into Occupational ergonomics as depicted in Table 1 in all functions which has become an organizational culture of creating and developing or modifying the workstation design with absolute ergonomic principle[1]. In many industrially developing countries the ergonomic problems have manifested themselves, and have become more obvious in this era of rapid industrialisation. The fast transformation from a rural-agrarian to an urban-industrialized life has come at a cost and workers are paying in terms of a tremendous increase of industrial injuries and increased stress at work. Many of these problems remain hidden, because official statistics which can illuminate the true state of affairs are usually not available. For example workers in Asian countries do not like to complain about ergonomics problems, which hence go un noticed. Table 1. Example of 5S with ergonomics principles incorporated.

In the transition to industrial status, Industrially developing countries have bypassed several stages of development and are now totally immersed in the computerised global environment. What took the western world 200 years has been accomplished in just 20 years by IDCs. Associated with this development are new Human Factor ergonomics problems in education and training personnel. There is a tremendous need for training local employees to understand ergonomics, so that they can themselves monitor potential hazards. Human factor specialists, who understand training problems, could have a significant role to play. A world-wide survey of HFE professional societies was undertaken by the international ergonomics association[6].

Table 1
Example of 5S with ergonomics principles incorporated

	Theme	*Stage*	*Example of characteristics to be assessed*
5S and Ergonomics	Strategy	2. Awareness	All team members have undergone practical 5S training , emphasizing 'making work easier' through basic ergonomics such as MODAPTS (Modular Arrangement of Predetermined Time standards).Relevant links, interface and for integration with other work practices are clearly articulated & understood (eg. Autonomous Maintenance, Safety-Health-Environment (SHE) of characteristics to be assessed
		3. Foundation	The 5S master plan has been reviewed and refined to focus more extensively on equipment cleaning and equipment cleaning and equipment condition e.g. integration with Autonomous Maintenance There is evidence that basic ergonomics concepts (e. g, MODAPTS) have been applied to 5S improvement projects.
		4. Development	The 5S master plan has been reviewed and refined to focus on causes of dirt causes of wasteful motion or ergonomics ; causes of difficult cleaning conditions; causes of cleaning requirements Define methods and procedures exist to identify ways to ensure equipment, files and supplies are up to date and ready for use.
		5. Innovation	The 5S master plan has been reviewed and refined to eliminate on causes of dirt causes of wasteful motion or ergonomics ; causes of difficult cleaning conditions; causes of cleaning requirements There is evidence of an ongoing review of safety, health and environmental date for identification of potential ergonomics projects.

The environment-operator-machine system is included in which the environmental factors of operators such as work design and operational parameters of the workers are taken into consideration[7]. The work design is designed in such a way that the operator has to feel comfort and motivated to do the work. The work piece locator in the machine should be placed at the certain distance from the operator which makes operator to be more comfortable at his work place.

The visuals of oil tank, lubricant tank are placed at certain height on the machine through which the operator can take the note of the above factors without any strain on the human body through which the fatigue of the operator is reduced. In general the operator perceives the environment by visual and auditory through which few problems can be solved themselves and rest of the problems will be solved by maintenance people. In visual such as the level of the oil in the oil tank will be noticed easily by placing the oil tank at certain height in which it will be feasible to note the readings of the oil in the oil tank. And also in order to reduce the movement of the operator around the machine to note the visual reading such as temperature, pressure and level of oil in the oil tank etc. All the above visual displays are changed to front panel which helps operator to have a comfortable environment and the movement of the operator is reduced compared to the previous.

In the case of auditory to identify the sound and noise levels of the machine is enabled by placing the indication stickers such as ear symbols on the machine[8,9] and also the breakdown of the particular machine is identified easily by the operators through visual display light on the machine in which it represents with different colours. The ear muffs are provided to the operators to reduce the effect of noise levels in the

work place. In an organisation the operator is prone to stress such as physical stress and mental stress due to improper design work environment and the human fatigue is increased and there are many occurrence of accidents in the organisation. The physical stress such as movement of the operator around the machine for noting the operational parameters and loading and unloading of the component is done manually which is reduced by introducing the semi automatic machines and movement of the operator is reduced by placing the visual displays at the front panel. The mental stress is also involved during the machining process by the operator such as completion of the production within the lead time without any part rejection. The above factors are shown in the Figure 2. Stress to operator due to improper work design

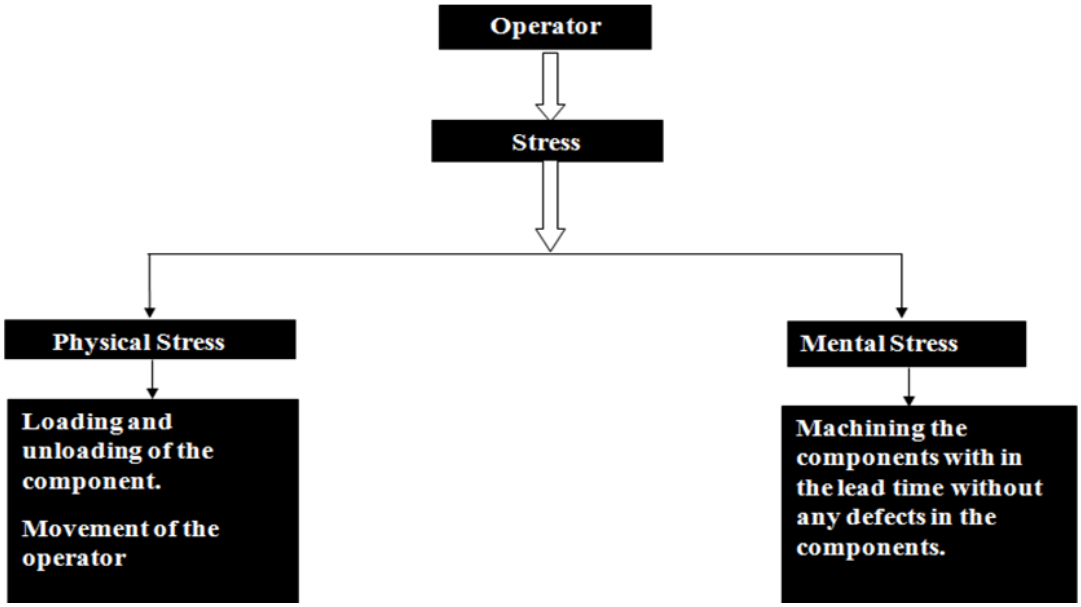

Figure 2: Stress to operator due to improper work design

In an organisation to reduce the human fatigue, stress and zero accidents 5s also plays important role to implement standard organisation environment through which the operators are trained and created awareness about 5s in detail such as sorting, simplifying, systematic cleaning ,standardizing and sustaining. In which the working environment of the operators are systemised and the human effort is reduced by following 5s.The 5s is also followed in office TPM where the files are sorted out according to the requirement and according to the batch number.

The do s and don't s while loading and unloading the components is shown visually through one point lessons displayed on the machine. The operators are trained daily in the morning about unsafe acts and unsafe conditions in the machine shop and how to avoid the accidents in the particular place. In order to reduce the human fatigue due to loading and unloading of the components are done by semi automation in which the involvement of the operator will be less compared. With the help of semi automation the work load on the operators are reduced in which it results in improvement in the productivity of the organisation and in turn it gives comfort and work satisfaction to the operators. The improvement of the productivity is done by changing the work design from manual loading to semi automatic loading which is discussed in the further paragraphs. In the different areas such as in compressor wheel machine shop the loading and unloading of the component is done manually by the operator in between the two machines where the operator need to walk more times between these machines which gives more stress to the operators

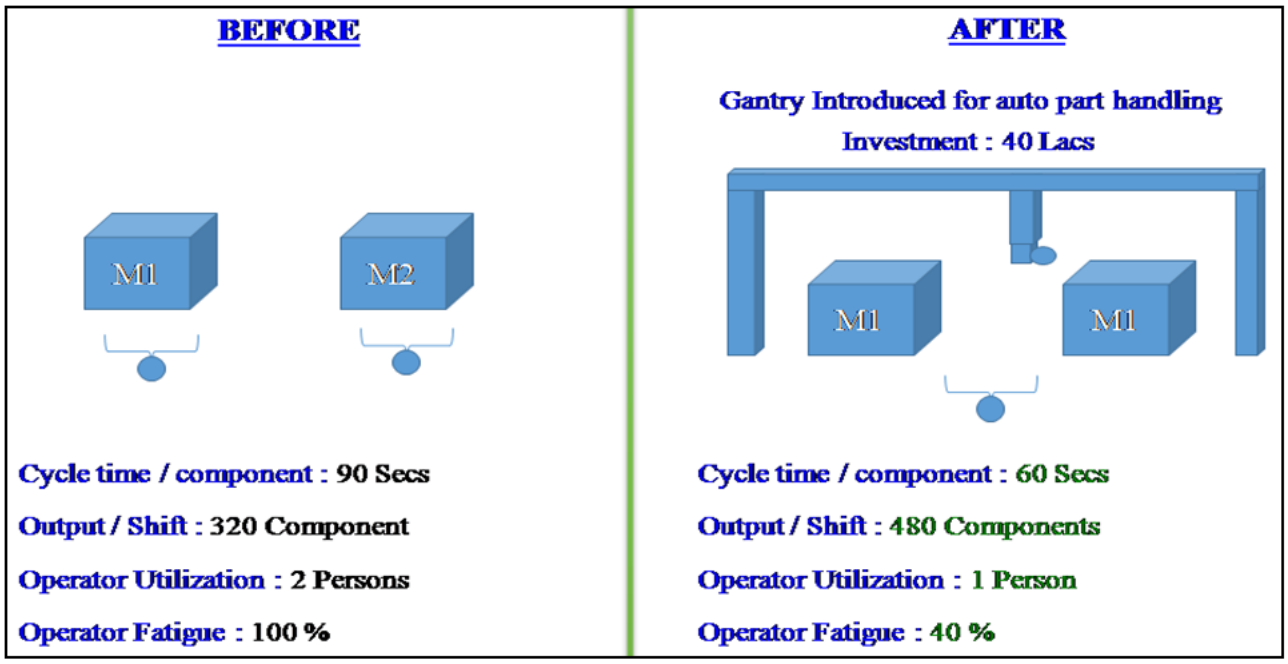

Figure 3: Improvement in productivity by Gantry type machine

Figure 4: Introducing fatigue mat to increase blood circulation fatigue

and also there will be the possibility of the human error by clamping the component improperly leading to misalignment or damage of the component which effects the production in the organisation. Thus in order to avoid the above factor the semi automated machine, gantry type machine is introduced in which the operator will load the component in the machine and the process will be done by automation and the finished component will be unloaded automatically where operator takes the part for inspection through which the movement of the operator is reduced and also leads to the increase in productivity. Through the implementation of pick and place robot with gantry type the cycle time/component, output/

shift, operator utilization, operator fatigue which leads to the increase in the productivity as shown in the Figure 3. Improvement in productivity by Gantry type machine. The foot pedal is introduced to clamp the component in the machine which reduces the more stress on the hands of the operators. The fatigue of the operator is reduced due to the continuous standing posture of the operator for eight hours which in turn it leads to the sore feet, poor circulation, swelling in the feet and lower limbs and leg fatigue and also causes the musculoskeletal disorders in the operators[10]. In order to avoid the above factors The fatigue mat is introduced to improve the blood circulation in the human body and also to reduce fatigue as shown in the Figure 4. Introducing fatigue mat to increase blood circulation fatigue.

In turbine housing machine shop the loading and unloading of the component is very much difficult aspect to the operator which causes more accidents such as slipping of the component on the legs and also handling the component with hands for more time will leads to pain in hand and muscles which cause illness to the operator. The production of the component takes more time and productivity of the organisation will be reduced. In order to avoid the above factor the distance between the machining process of the turbine housing is reduced from 3m to 1m and also the conveyor with pneumatic cylinder is used for transporting the component to the machines for different. Thus by implementing the automation in the organisation human effort is reduced which in turn reduces fatigue of the operator. Implementation of pneumatic operation for loading of the component in the turbine housing is shown in the Figure 5. Implementation of pneumatic actuator for loading the component in the turbine housing.

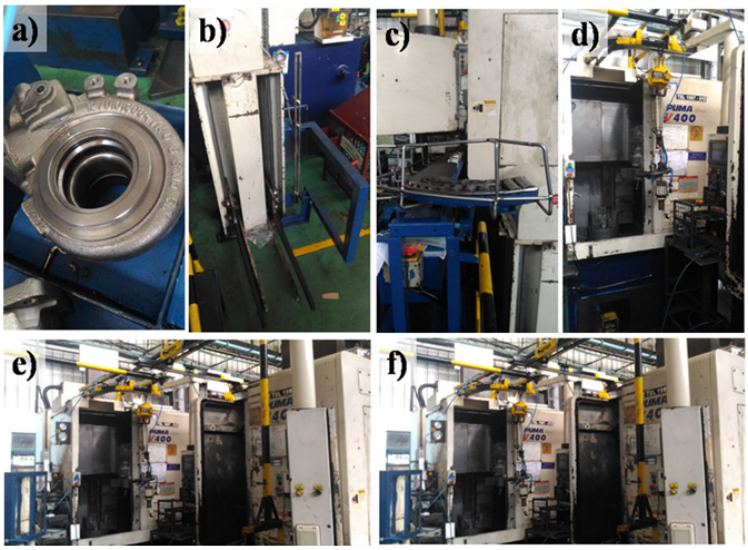

Figure 5: Implementation of pneumatic actuator for loading the component in the turbine housing

Initially the components are lifted by the operator and have taken from one work station to another work station which have caused body pain to the operator and leads to the serious illness. In order to reduce the fatigue the trolley is introduced to carry the component from one machine to the other machine in the in house itself to reduce the operator fatigue in which the trolley is used for moving the material from store to assembly in batch production. The time taken for material movement is 35minutes in which the process flow is done in clockwise. In order to reduce the material movement time the conveyor is used for single piece production where the time taken for movement of the material from store to assembly is taken 5minutes and the process flow is done in anti clock wise direction which is as shown in the Figure 6. Reduction of Material movement time from store to Assembly.

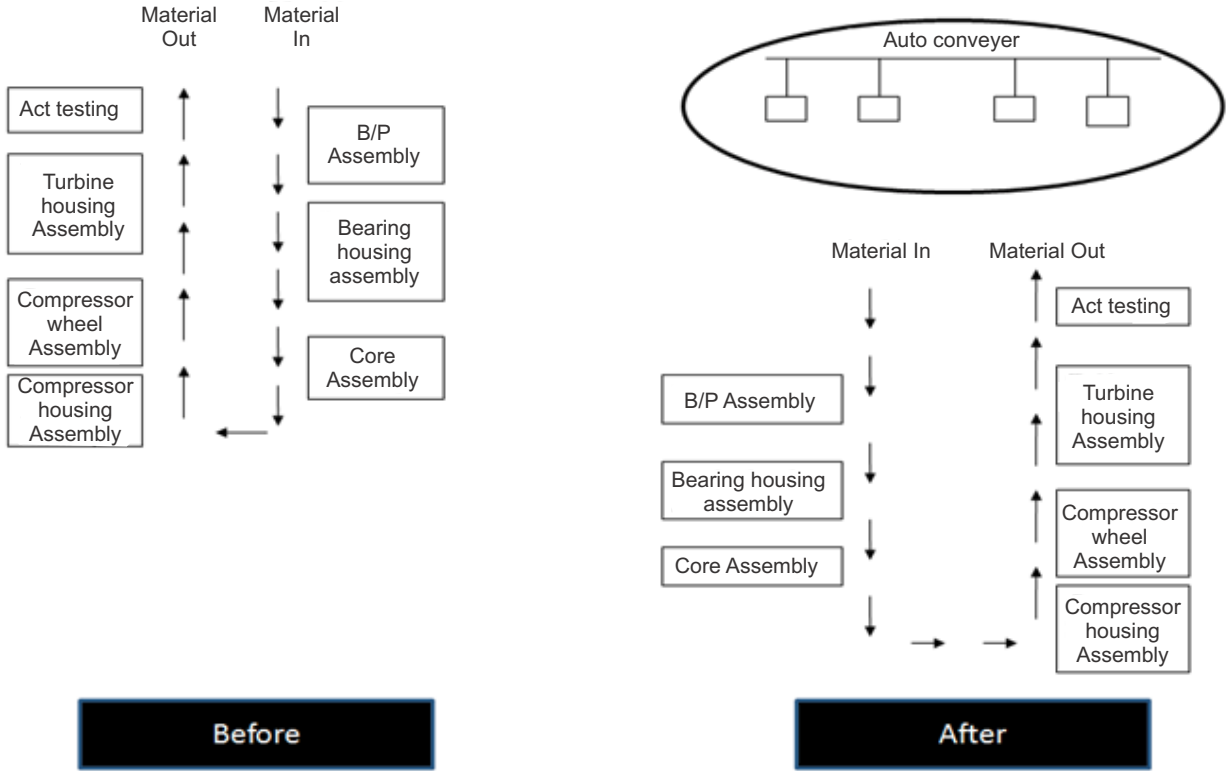

Figure 6: Reduction of Material movement time from store to Assembly

In the work station the work station is designed by the operator measurements which is called anthropometric measurements which involves many factors such as Tibial height, knuckle height, elbow height, Shoulder height, stature etc are considered through which the operators physical stress is reduced and human fatigue is reduced[11,12]. The operators are trained about the posture that they have to maintain near the work station and also the people in the organisation are also trained about the postures at their work place[13,14]. In order to reduce the noise levels ear protectors are used by the operators when they are working near by the machine. As part of SHE pillar accident prevention and identification and avoidance of near misses with a systematic study the organization has achieved its targets as portrayed[1] below in Figure 7. Accident prevention achieved through TPM pillars[1]. In effect of implementation of TPM and through operational ergonomics approach TEL could achieve appreciable benefits as depicted in the following Table 2. Comparison of factors before and after implementation of TPM in TEL[1].

Table 2
Comparison of factors before and after implementation of TPM in TEL

Factors	*Before implementation*	*After implementation*	*% Improvement*
Accidents	36	0	100%
Kaizen	1468	2476	68.66%
Cycle time	90seconds	60seconds	50%
Production	320	480	50%
Profit	10400	15000	44.23%

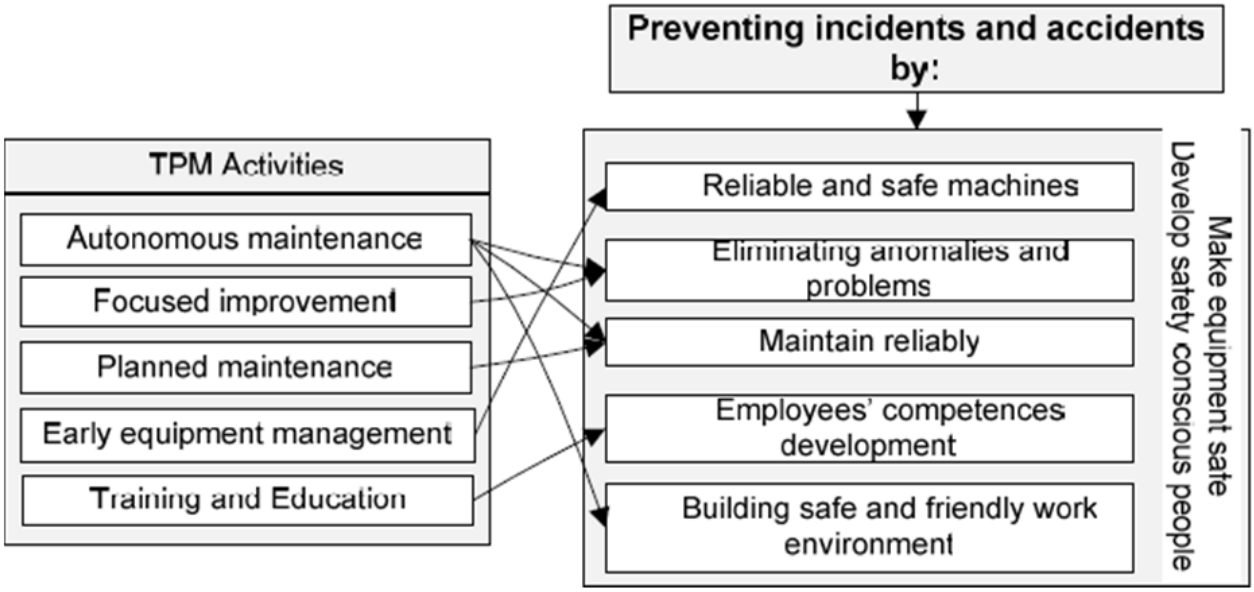

Figure 7: Accident prevention achieved through TPM pillars[1]

3. CONCLUSION

It has been found that TPM implementation in Turbo energy limited has resulted in improving occupational ergonomics and enhanced operator morale and motivation resulting in improved productivity, awareness and involvement in the company. Thus by implementing the automated machine for loading and unloading of the component the cycle time/component is reduced from 90 seconds to 60 seconds, output/shift is increased from 320 to 480 components and operator fatigue is reduced from 100% to 40%.

4. ACKNOWLEDGEMENT

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