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Improving Productivity and Reducing Accidents using Ergonomic Approach

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Abstract

The depressing economic situation of things in our country lead to the carrying out of this research as the bad economy can be responsible for low productivity in soft packaging industry. State of the art the industrial success mainly depends on the delivery, quality and uptime. The industry where this study has been done is engaged in the processing and manufacturing, flexible packaging solutions. This unit is engaged in printing required content on plain foils. In order to achieve this industry should implement new techniques which will increase the quality, productivity and decrease worker fatigue. Ergonomics is one such technique. The assessment is based on NIOSH calculation for lifting and the general survey among 8 workers for a month in industry. This study is on application of ergonomics in reducing musculoskeletal disorders, improving the quality of work system design and increasing productivity. Various factors which may cause injury at work station were checked out. The existing workstation design was studied and suggestion was given to improvise the method for productivity by reducing wristband shoulder injury and fatigue. In this study some causes which were responsible for low productivity such as inappropriate performance of machines and injuries to workers, keeping these facts in mind ergonomic approach were used to overcome these problems. The questionnaire for safety and health survey has been taken up from OSHA Nova Scott that for ergonomic survey has been taken up from NIOSH publication. In this study injury has been reduced to a great extent by conducting training and productivity has been improved by changing current outer diameter of rolls from 450 mm to 650 mm. It has been concluded by these implementations that the along with these main goals company also have reduced the amount of waste material from 5 - 7 % to 2 - 4% and storage space also reduced. Quality and machine performance was improved due to continuous run of machine in lesser breaks.
Keywords: Economic Situation, Productivity, Industry

I. INTRODUCTION

A. *Preamble*

Ergonomics is classified as the applied science of instrument design, as for the work place, aimed to maximize productivity by reducing worker fatigue, discomfort and injuries. Ergonomics improvements allow improving process quality and worker's productivity. Ergonomics (or human factors) is the science which concerned with the understanding of interface between humans and other elements of a system, and the concept that applies theory, principles, data and techniques to design in order to maximize human well-being and overall system performance. (International Ergonomics Association, 2000)

Industrial ergonomics is the implementation of human factors data in the system used by workers. The word human factors is referred to ergonomics. Most commonly used word in American books. Basically Ergonomics is a science concerned with the relationship between workers, machines and work environment. The aim is to maintain an optimum balance between all participants of this system.

B. *Benefits of Ergonomics*

Ensuring the health of production workers and diminishing the hazard of job-related injury is a complicated endeavor that is handled very differently by different organizations, depends on their resources, means and view of ergonomics. In a manufacturing unit, workers can be at risk for developing work-related musculoskeletal disorders (MSDs), may cause pain, inability to do work and high costs for the organization in respect of reimbursement, substitution of worker and productivity losses. Size matters, so as organizational framework, history and experience of descovering ergonomics issues, the tools that are available to analyze the workplaces, intervention of 'evaluating' functions (such as viewing tools, national standard requirements or unions), and the expectations of top management and manpower on the persons made responsible for Human Factors and ergonomics. The main value of the current thesis is that ergonomic risks must be minimized and extracted from the production system – recommended in a proactive approach, so that timely design change removes risks for MSDs in the system before any symptoms or unwanted aftereffects appear among workers. Nevertheless, targeting only on elimination of MSD risks constitutes a limited view of how distant the effect of enhanced ergonomics can reach. The recognized societal benefits of improved ergonomics have assorted in scope over the years. Human factors in production has been linked not only to health and sick-leave absence and psychosocial facets and to system performance facets too such as productivity and quality with some contributions addressing many of these facets together as a sideffect, economic improvements have progressively become a debate for improving manufacturing ergonomics in recent literature, in a study concluded that early elimination of ergonomic hazard in production helps to improve profit margins and savings.

C. The Diversity of Ergonomics

In terms of evaluating any type of ergonomics research contributions, it is neccessary to know that human factor as a discipline and practice is very vast, covers a wide diversity of subject matter, areas of implementation and influences. "Mainstream" ergonomics have a tendency to place its focus on interface between humans and technology, but changing frames of reference in latest scientific research and application have increased the scope of ergonomics considerably as it became a research field in its own right during the late 1940s. To know about the diversity of recent ergonomics research, researcher only need to discuss the proceedings of any recent ergonomics conference. For example, the 2010 annual meeting of the Human Factors and Ergonomics Society divided more than 500 contributions into the following 23.

- Aerospace Systems topics
- Aging
- Augmented Cognition
- Communications
- Cognitive Engineering & Decision Making
- Computer Systems
- Forensics Professional
- Education
- Industrial Ergonomics
- Health Care
- Environmental Design
- Human Performance Modeling
- Individual Differences in Performance
- Internet

D. Factors Responsible for Low Productivity

There are so many factors which may directly or indirectly affect the production rate of a manufacturing unit. Some of them are:

- Inefficient use of resources
- MSD (Musculoskeletal disorders)
- CTD (Cumulative trauma disorders)
- Workers disputes
- Poor information flow
- Low labour productivity
- Excessive rework
- Non productive unnecessary activities
- Waste of material
- Frequent machine breakdown/stoppage
- High variability of cycle time
- Excessive inventory

E. Purpose of the Study

The depressing economic situation of things in our country lead to the carrying out of this research as the bad economy can be responsible for low productivity in our industry. The purpose of this study is to find out those factors which are main causes for low productivity especially in the private sectors and to develope ergonomic tool used to check workstation design from an ergonomic perspective. This will help in finding out the factors that have contributed to cumulative trauma injuries/illnesses of the operators and low production rate that will hopefully lead to corrective actions performed by industry. This will assist our workers in the industries to improve their performance and thus help to improve the standard of living and general economy of India.

II. METHODOLOGY

The industry where this study has been done is engaged in the processing and manufacturing, flexible packaging solutions. This unit is engaged in printing required content on plain foils. To understand this flow chart better we can have a look on briefing of each step involved in the flow chart. The raw material to be used is transfers from store to Multi-Color Gravure Printing Machine using weight lifting machine partially and rest is done manually as the workers in this unit are not much familiar with the operations of weight lifting machine. This raw material is generally some rolls of plain foils whose normal diameters are of around 450 milimeter – 500 milimeter**.** The plain foils are initially fed into Multi-Color Gravure Printing which can print up to 8 colors at a time and having maximum width 1180 milimeter**.** Web video and automatic heat control system also important part of this unt. The main operation of this machine is to print required content on a plain foil. Plain roll is mounted from one end and printed roll can be collected from other end**.** In the Solvent Free Lamination, Lacquering and coating**,** main function of this machine is to add another layer on printed output foil of multi-color gravure printing machine. This layer is to be coated for packing purpose. The lamination done by this machine is important for adhesion at the boundaries of finished pouches or packets. This is also a fully automatic machine. In the **S**ilting unit it is fully Automatic high speed machine made with latest international technology. In this step the output roll of solvent free machine is fed into the input of a slitting machine to split it into small sizes as per the customer requirement**.** The output of slitting machine which **is** already in the form of different rolls of different sizes as per requirement. These rolls are directly taken to sampling for quality check whenever customer demands to finished good in the form of rolls. We can see clearly in the image above that there are three green rolls are there. These rolls are taken out of this machine by inserting a single large roll. In the Pouch Making segment a high speed machine is used in this step for making three sides, center sealing**,** standing pouch and zippers. The output rolls of slitting machine are simply fed into this machine and pouches of different sizes can be made by setting up this machine which is made by Speedway. Sampling step involves the quality check of finished goods by matching it with specimen provided by customer. Various dimensions are to be tested in this step. It's very crucial step for consignment conformance that's why to ensure accuracy all the dimensions are checked using appropriate instruments. Some major instruments used by this company are weighing machine, tensile machine, seal strength machine, oven test, dart impact, viscosity tester, treatment chemicals, etc. After testing the quality of final product successfully, the finished good is ready to dispatch and that either moves to store or sometimes directly loaded into the transport vehicles. Fig. 15 illustrates the flow chart of entire work process.

A. *Calculations Using Revised NIOSH Lifting Equation:*

This section describes the methods used for collecting data to be used in the Revised NIOSH Lifting Equation. Once the data was collected, it needed to be inserted into the formula using calculations and charts provided by the lifting equation. This section also includes a detailed description of the procedures for completing the equation using the data collected.

1) The subject was asked to perform the task of loading, unloading, and moving material.
   As the subject performed the task, the researcher recorded the action using the video camera for later data analysis.
2) A standard tape measure was then used to determine horizontal location (the horizontal distance between the hands and midpoint of the feet) and the vertical travel distance (the difference between the origin and destination of the lift). Each measurement was then recorded.
3) The goniometer was used to determine the angle of symmetry (the difference between the angle of origin and destination). That measurement was then recorded.
4) Frequency rate and duration were determined through observations and inquiries. The value associated with the frequency rate was determined using the Applications Manual for the Revised NIOSH Lifting equation. The data values were then recorded.
5) The coupling was observed. The value associated with this coupling variable was determined using the Applications Manual for the Revised NIOSH Lifting equation. This value was documented.
6) The recommended weight limit (RWL) was calculated using the measurements recorded by entering the variables into the equation and solving for the solution.

The RWL is defined as the following equation:

$$RWL = LC\ (23) \times HM \times VM \times DM \times AM \times FM \times CM$$

H = Horizontal location of the object relative to the body. (HM)
V = Vertical location of the object relative to the floor. (VM)
D= Distance the object is moved vertically. (DM)
A= Asymmetry angle or twisting requirement. (AM)
F= Frequency and duration of lifting activity. (FM)
C= Coupling or quality of the workers grip on the object. (CM)

B. *Lifting Index:*

Once the RWL has been calculated, it is then time to calculate the Lifting Index or LI. The Lifting Index (LI) provides a relative estimate of the physical stress associated with the manual lifting job which is expressed as a numerical value.

$$LI = (\text{Load weight}) / (\text{Recommended Weight Limit})$$

Where Load Weight (L) = weight of the object lifted (lbs or kg).
For each lifting task the evaluator will need to determine the task variables as outlined.
Here is the worksheet to assist with data collection: (APPENDIX I)

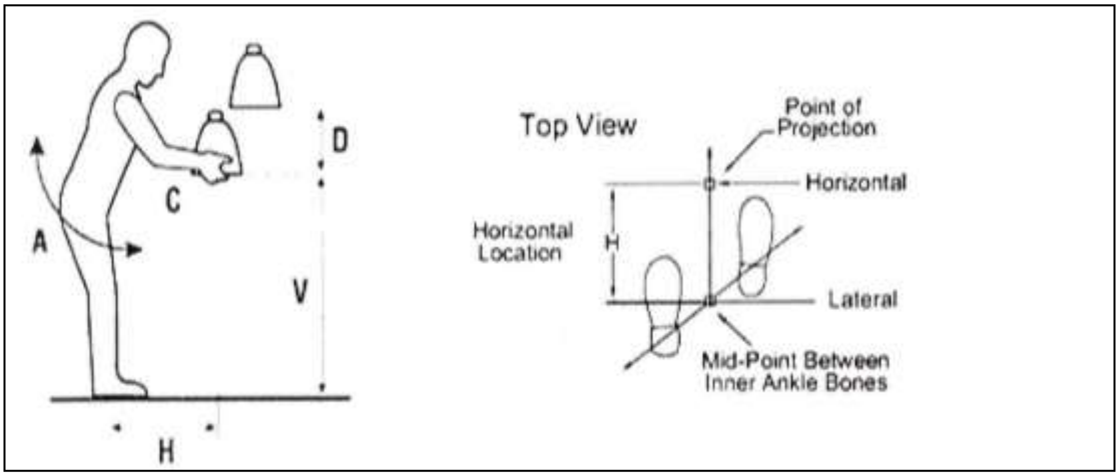

Fig. 1: shows the precise process of lifting an object used in NIOSH calculation.

Here;

1) Horizontal Location of Hands (H)

H= horizontal location of hands at the start and at the end of lifting task. It is the horizontal distance from the midpoint between the ankles to the hands while holding the object. Parameters for horizontal location of hand.

Distance (in centimeters)	*Horizontal Multiplier*
25	*1.00*
30	*0.83*
40	*0.63*
50	*0.50*
60	*0.42*

Measure and record the horizontal location of the hands at both the start and end of the lifting task and the range of distance is marked from factor table which will give the exact multipliers (HM) to put in the NIOSH equation. The horizontal location is measured as the distance (cm) between the employees ankle to a point projected on the floor directly below the mid-point of the hand grasping the object as shown in fig 1 denoted by H.

2) Vertical Location of Hands (V)

The vertical distance of hands from the ground at the start of the lift. Parameters for vertical location of hand for NIOSH calculation table.

Vertical Height in centimeter	*Vertical Multiplier*
0	*0.78*
30	*0.87*
50	*0.93*
70	*0.99*
100	*0.93*
150	*0.78*
175	*0.70*

Measure and record the vertical location of the hands above the floor at the start and end of the lifting task and the range of distance is marked from factor table which will give the exact multipliers (VM) to put in NIOSH equation. The vertical location is measured from floor to the vertical mid-point between the two hands as shown in Fig 1 denoted by V. The middle knuckle can be used to define the mid-point.

3) Vertical Travel Distance (D)

It is the vertical distance which a load travels. Its parameters are shown in table.

Lifting Distance (in cm)	*Distance Multiplier*
25	*1.00*
40	*0.93*
55	*0.90*
100	*0.87*
145	*0.85*

The vertical travel distance of a lift is determined by subtracting the initial vertical location (V) from final vertical position. Whereas for a lowering task subtract final position from initial position. The range of distance is marked from factor scale which will give the exact multipliers (DM) to put in NIOSH equation as shown in figure 1.

4) Asymmetric Angle (A)

The twisting angle of body while lifting measured in degrees. Parameters for asymmetric angle for NIOSH calculation

Angle (in degrees)	*Asymmetric Multiplier*
90	*0.71*
60	*0.81*
45	*0.86*
30	*0.90*
0	*1.0*

Measure the degree to which the body is required to twist or turn during lifting task. The asymmetric angle is amount of trunk and shoulder rotation required by the lifting task.

Note: sometimes the twisting is not caused by physical aspects of the job design, but rather by the employee due to poor body mechanics. In that case no body twisting (0 degrees) is required by the job. If twisting is required, determine the number of degrees the back and body trunk must twist to accomplish the lift and the range of distance is marked from factor table which will give the exact multipliers (AM) to put in the NIOSH equation.

5) Coupling (C)

CM (coupling multiplier) = the quality of grasp classified as good, fair, poor and depends on the body position. Parameters for coupling for NIOSH calculation,

Table

Coupling	*Coupling Multiplier*
1.00	*Good*
1.00	*Fair*
0.90	*Poor*

6) Frequency (F)

FM (Frequency Multiplier) = the frequency of the lifts and the duration of lifting (in minutes or seconds) over a work shift. Parameters for frequency for NIOSH calculation.

Time between lifts	*One hour or less*	*Over one hour*
1.5 hour	*1.00*	*0.85*

7) Load (L)

Determine the weight f the object lifted. If necessary, use a scale to determine the exact weight. If the weight of the load varies from lift to lift, you should record the average and maximum weight lifted. Denoted by LC in NIOSH equation.

By choosing the appropriate value of multipliers from the concerning tables, the multipliers are put up into the worksheet as per described pattern and after then the RWL and LI is calculated.

Seven tables which gives standard values of these seven multipliers for all possible values has been enclosed in appendix III

C. Instruments Used:

The assessment tools selected include the NIOSH Lifting Equation. To accurately complete the assessments, an electronic scale, manual goniometer, digital camera, and digital video recorder were used.

Digital camcorders and cameras can be useful for assessment purposes, as the task can be played back and stopped. This helps to ensure accuracy when determining measurements with the goniometer, or later observations regarding frequency and duration. Other tools used include a Stanley 25ft tape measure and a standard desktop computer.

1) Goniometer

A goniometer is an instrument that either allows an object to be rotated to a precise angular position or measures an angle. The goniometer is mainly used for the measurement of angles required by the different tasks. This was accomplished by using the video footage to determine the most extreme postures. By stopping the video, the goniometer could then be used to measure the angle as observed on the video screen. The goniometer used was a Baseline Stainless manual goniometer.

Fig. 2: illustrates a goniometer

D. Machines Studied:

1) Multi-color Gravure printing Machine

Multi-color Gravure printing machine is mainly prints any specimen of all possible colours by compiling maximum up to 8 colors at one time. commonely the machine can work on a foil of width 1180 mili meter**.** It is a Fully automatic, gravure printing machine made by Expert Industries Ltd, equipped with automatic registration control system Quad Tech [USA], Web video[EL] and automatic Heat control system. The main operation of this machine is to print required content on a plain foil. Plain roll is mounted from one end and printed roll can be collected from other end. **Fig.** shows a multi color gravure printing machine used by the industry where this study has been done.

Fig. 3: Multi Color Gravure Printing Machine

Fig. 4: Solvent Free Machine

2) *Solvent Free Machine*

Solvent free machine is a fully Automatic high speed machine made by Expert Industries Ltd. having latest international technology. The main function of this machine is to add another layer on printed output foil of multi-color gravure printing machine. This layer is to be coated for packing purpose. The lamination done by this machine is important for adhesion at the boundaries of finished pouches or packets. **Fig** shows a solvent free machine used by the industry where the study has been done.

3) *Slitting Machine*

Roll slitting is a shearing operation of cutting a wide roll into thinner rolls. Mainly two types of slitting are available: log slitting and rewind slitting. Log slitting machine treats roll of material as a 'log' and multiple slices are taken from it without an unrolling/re-reeling process. Whereras rewind slitting machine unwound and run the web through the machine, passing via knives and lasers, before rewounding on multiple shafts to form thinner rolls. The machine used in this study is rewind slitting machine made by Nuzen {Kody} with latest international technology. In this step the output roll of solvent free machine is fed into the input of a slitting machine to split it into small sizes as per the customer requirement. fig. shows the machine used.

Fig. 5: Slitting Machine

Fig. 6: Pouch Making Machine

4) *Pouch Making Machine*

Pouch making machine offers flexibility to make pouches from unsupported film rolls. In this study the industry is using High speed machine for making three sides, center sealing and standing pouch & Zipper is used in this step. The output of slitting machine is simply fed into this machine and pouches of different sizes can be made by setting up this machine which is made by Speedway. Fig. showing pouch making machine.

5) *Weighing Machine*

Weighing machine is a delicate instrument which is used accurately to weigh samples. Automatic analytical machines are the most practical device for modern industries. The machine used by company has weighing accuracy in range of 0.01 to 20 kg. In the present study KEROY machine was used which shows in Fig.

Fig. 7: Weighing Machine

6) *Tensile Machine*

It is a fundamental test in which a sample is exposed to a controlled tension until failure. The results from the test are generally used to pick a material for an application, for quality control, and to predict the reaction of a material under the impact of various forces. The directly measured properties via a tensile test are maximum elongation, ultimate tensile strength and decrement in area. From these measurements the following properties can also be determined: Strain-hardening characteristics, Poisson's ratio, yield strength, and Young's modulus. Fig shows a tensile machine.

Fig. 8: Tensile Machine

7) *Seal Strength Tester*

The Seal Strength Tester is used to compute the durability of adhesion or seal sensitivity of auto- adhesive pressure sensitive materials to open a seam of a package by pulling. Seal Strength is defined as the mean force at unit width of seal needed to disjoint increasingly a flexible material from a firm material or another malleable material, under the circumstances of the test. This machine is capable of separating a laminate through an angle of 180 Degree with an accuracy of +/- 2% and with a jaw separation rate of 300 mm per minute. The machine used by the company is manufactured by Presto Stantest. Fig illustrates this machine.

Fig. 9: Seal Strength Tester

Fig. 10: Oven

8) Oven

Oven is an enclosed heated compartment, usually lined with refractory materials, used for drying substances, firing ceramics, heat treating. The heat resistance quality of finished goods is tested by this oven. In the present study oven was used of Tempo Laboratory Precision. Fig shows the oven used by the industry.

9) Impact Tester

An impact tester is used to determine the impact resistance of materials. A fulcrum is raised up to a particular height (consistant potential energy) and then released. The pivoting arm swings down hitting the specimen, breaking the sample. The energy gained by the specimen is calculated from the height the arm swings after hitting the sample. A notched specimen is commonly used to find out impact energy and notch sensitivity. The machine used by the company is manufactured by Presto stantest. Fig shows an impact testing machine.

Fig. 11: Impact tester

10) Data Analysis:

The charts used in analyzing and report presenting the data are:

– Column Chart
– Bar Chart
– Line Chart

a) Column Chart:

A column chart is a series of columns whose heights represent magnitudes (e.g. totals, means or proportions). This can be used for qualitative and quantitative variables. A column chart should be used for few points and the columns should all have identical widths. There are number of adjustments in a columns chart. A grouped column chart has several variables grouped in bars side by side. There should be no more than three bars in a group. For example, the manager of a company wants to compare total revenue, total sales and net income over a period of time. The following is an example of a grouped column chart, where the side by side column represents consecutive years and each group of columns represents the number of passengers visiting a given region by city of passenger's origin.

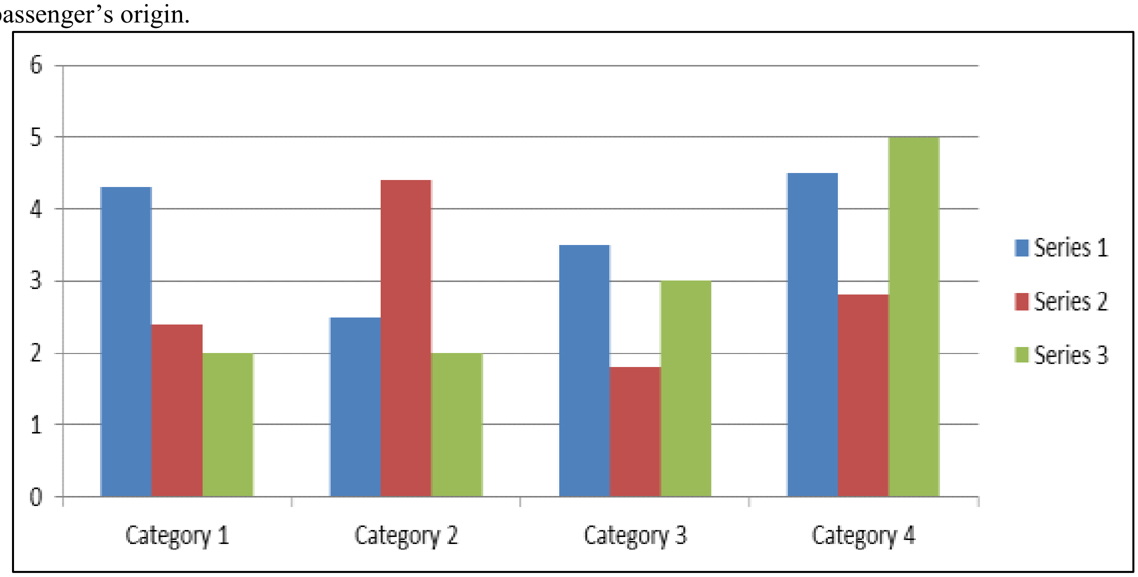

Fig. 12: General form of a column chart

b) Bar Chart:

A bar chart is a sideways column chart. While preparing a bar chart, bars should be arranged in order of length (from the longest to the shortest, or vice versa). If exact values are shown, the chart should be annotated (i.e., the exact value should be placed at the end of each bar). If these sub headings are lengthy, a bar chart may be easier to read and appear less scattered than a column chart. There are many variations on the basic bar chart, corresponding to the different types of column chart (e.g., stacked, grouped, etc.)

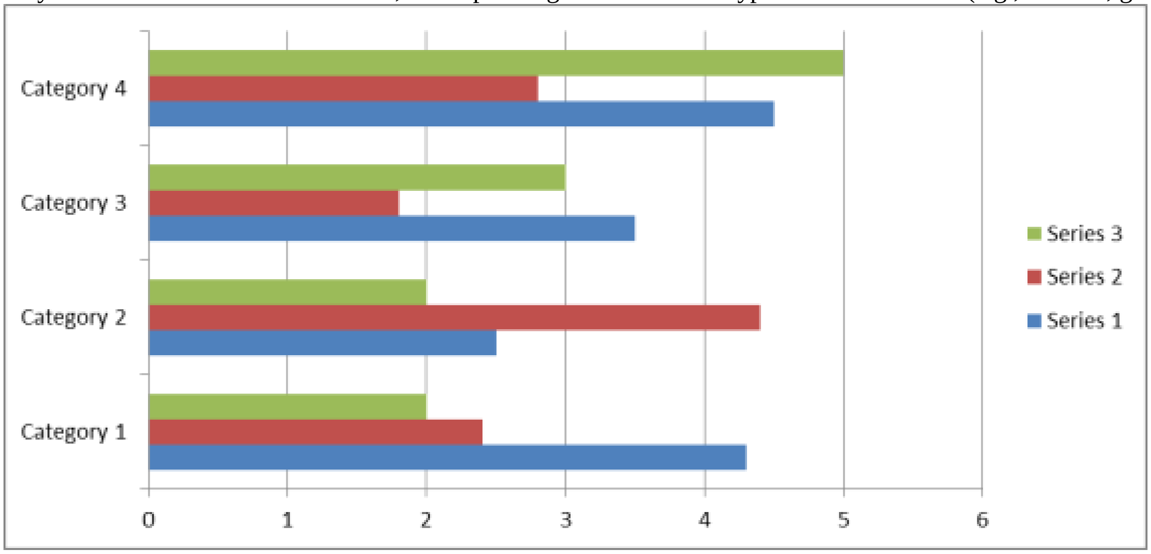

Fig. 13: General form o a bar chart

c) Line Charts:

A line chart shows variation in the magnitude of a variable over a period of time (e.g., totals, means or proportions over time). Time is placed on the horizontal axis. The range of values of the variable of interest is placed on the vertical axis. A point (i.e., a measure of magnitude) is plotted for this variable for each unit of time, and the points are connected in sequence. The lines can either be straight lines from point to point, or smooth curves.

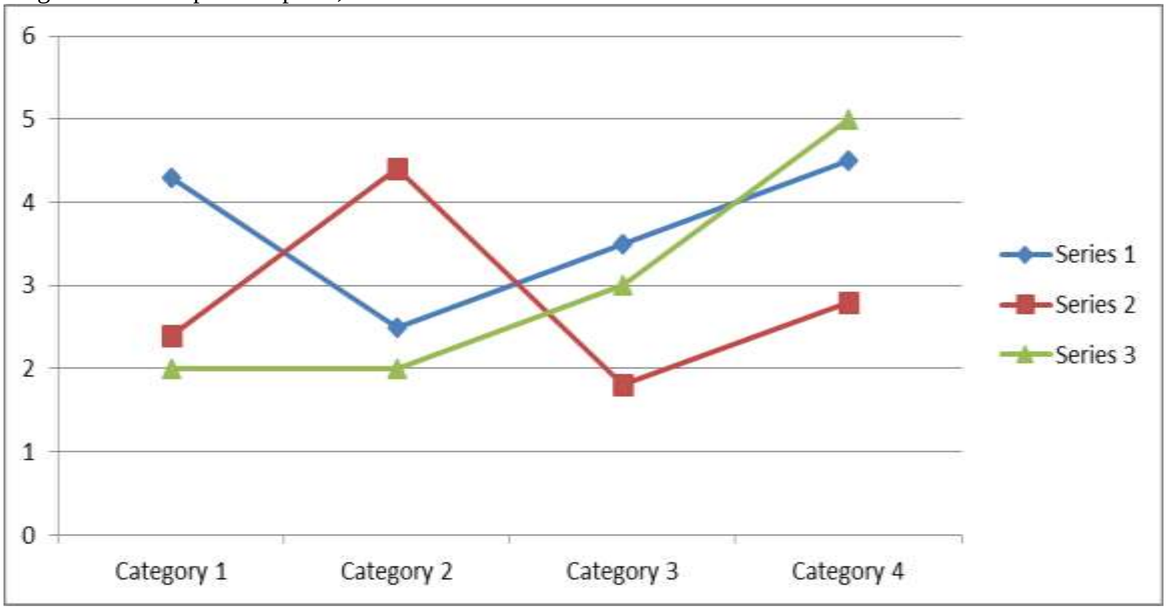

Fig. 14: General form of line chart.

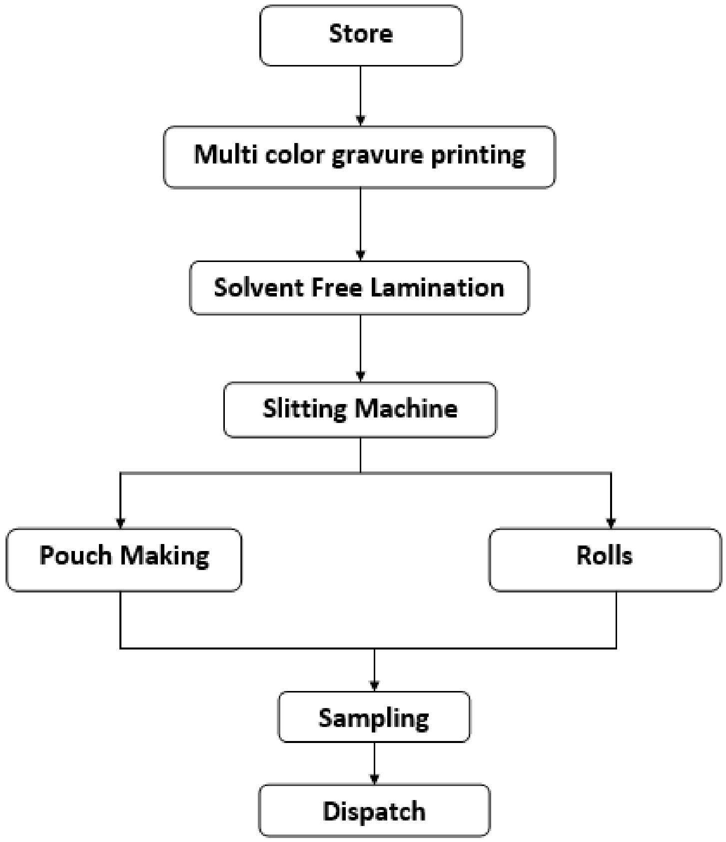

Fig. 15: Flow Chart

III. RESULT & ANALYSIS

In this study two factors of ergonomics has been taken into consideration, those were work related injuries and optimum performance of machinery.

It has been founded by reviewing various journal paper and different ergonomic techniques such as NIOSH and other one's that a major part of this reimbursement could be cured for years by investing just 25% of this reimbursement of 6 months. This investment refers to organize training for workers to aware them about ergonomics which describes perfect body postures to do a manual work and how to use basic machinery in an industry. It has been observed that the workers in the industry were not very much familiar with weight lifting machine and so they were used to do all heavy work manually rather than using the machine, which were resulting in musculoskeletal, cumulative trauma disorder and damages to fingers. The reimbursement given to workers for these three injuries was 70,000 INR within just 6 months. Table 1 shows proper comparison between previous and reduced cost of compensation. As proposed, this suggestion has been implemented in the concern industry and training was conducted for a week to overcome discussed injuries and the results were outstanding when analyzed after a month. It has been concluded from above data that a monthly reduction in all compensations given by company is 11,260 INR has occurred after implementing this proposal. It may be results into approx 1, 35,000 INR could be saved annually.

Table 2 shows a proper comparison of requirement versus production in the two cases, those are with previous outer diameter which was 450 millimeter and revised outer diameter that is 650 millimeter. It has been concluded on the basis of facts and data that due to this small modification in existing system the production quantity has been raised. First we observed the existing work system which was working with outer diameter (OD) of 450 mm for 5 days. Then after this proposal of using outer diameter of 650 mm were given and experimented for next 5 days and results in much improved production rate. Fig 16 explains a proper comparison between production rate using 450 mm and 650 mm outer diameter. Whereas Fig 17 shows the improvements found in reducing the occurrence of injuries due to proposed method. It has also been observed that quantity of waste material which was 5 - 7%earlier is reduced to 2 - 4% by using 650 mm OD. Fig 18 shows earlier improper material handling process whereas Fig 19 shows proposed proper method of handling rolls to avoid injuries.

Table - 1
Experimental Result

Name of Injuries	*Number of Injuries*		*Compensation Distributed*		*Reduction of Compensation*
	Average (Jan. - June)	*Experimental Month*	*Average (Jan. – June)*	*Experimental Month*	
MSD	*8*	*1*	*4000 INR*	*500 INR*	*3500 INR*

CTD	*6*	*2*	*6000 INR*	*2000 INR*	*4000 INR*
Headache	*15*	*4*	*1500 INR*	*400 INR*	*1100 INR*
Respiration Problem	*2*	*2*	*3000 INR*	*3000 INR*	*-*
Eye Problem	*2*	*1*	*2000 INR*	*1000 INR*	*1000 INR*
Finger Problem	*0.83*	*0*	*1660 INR*	*-*	*1660 INR*
Total			*18,160 INR*	*6,900 INR*	*11,260 INR*

Table - 2
Comparison between Previous and Proposed Outer Diameter

Month	*Using 450 mm outer diameter*		*Using 650 mm Outer Diameter*	
	Quantity Produced (tonne)	*Time elapsed per tonne*	*Quantity produced (tonne)*	*Time elapsed per tonne*
Day 1	*5*	*4.8 h*	*6*	*4 h*
Day 2	*4.5*	*5.33 h*	*6.5*	*3.7 h*
Day 3	*4.6*	*5.22 h*	*7*	*3.43 h*
Day 4	*5*	*4.8 h*	*6.8*	*3.52 h*
Day 5	*5.5*	*4.36 h*	*7.2*	*3.33 h*

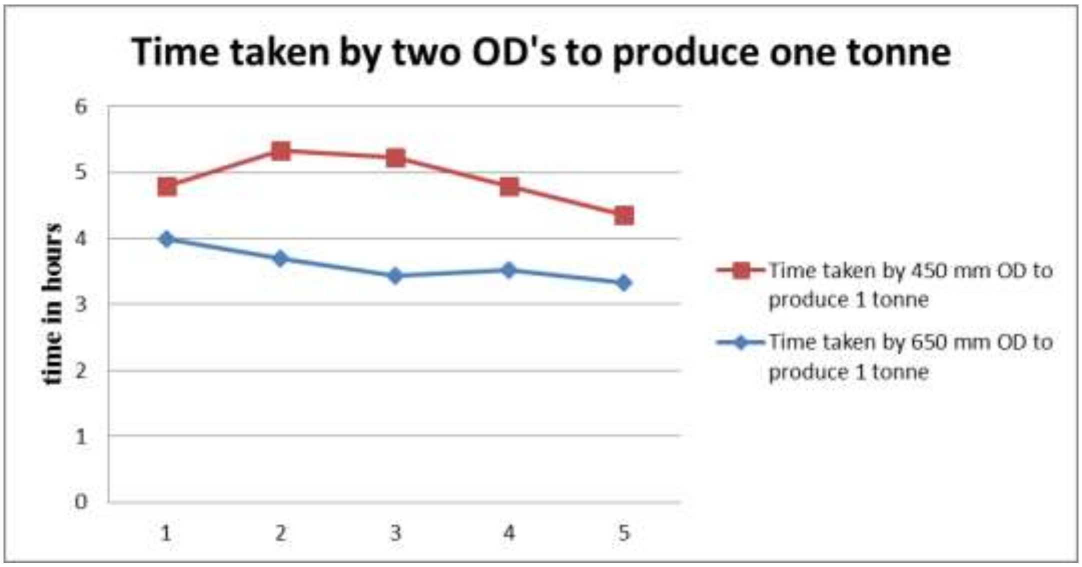

Fig. 16: Improvement in productivity using 650 mm OD

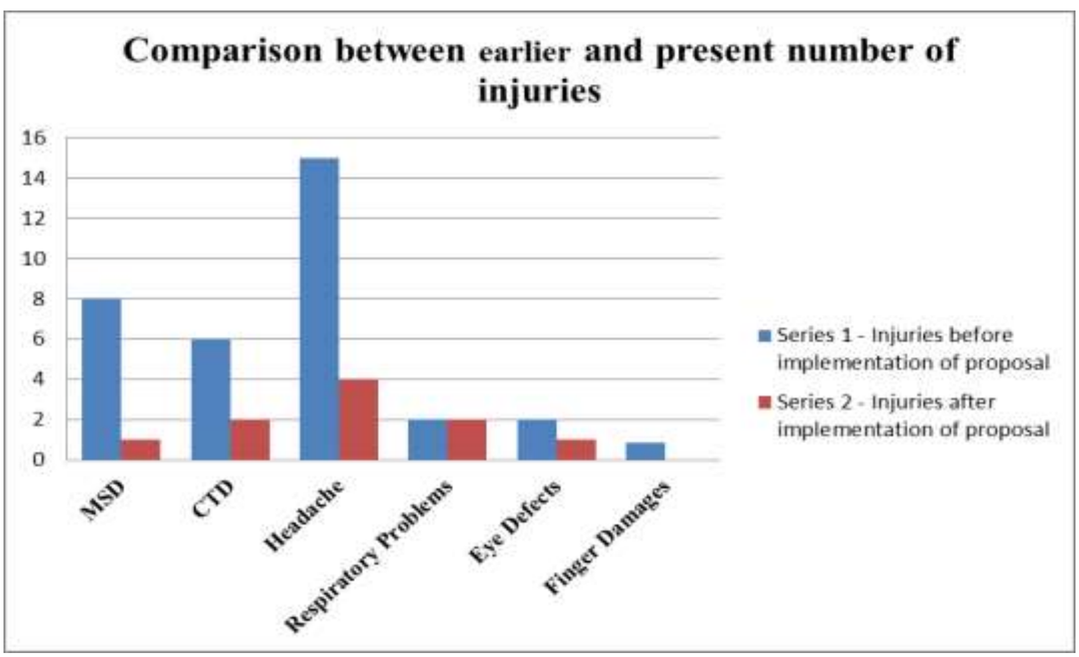

Fig. 17: Comparison between earlier and current number of injuries

Fig. 18: Earlier material handling process

Fig. 19: Proposed method of handling rolls

Fig. 20: Difference between earlier and proposed roll size

A. *Results Summary:*

- The material handling process was not according to ergonomic techniques. Most of the time material were handled manually which were resulting in huge amount of injuries to workers.
- A huge amount of money was wasting as compensation due to injuries. It was reduced to a great extent by organizing a basic ergonomic training to aware workers about proper body postures and tool handling methods to work safely.
- A new dimension of raw rolls were introduced which resulted in higher productivity. Outer diameter of 650 mm was proposed at the place of 450 mm. It can be easily seen in figure 20.
- Almost every observed worker was falling within danger zone on the basis of NIOSH calculations thus company the improved their lifting functionality for raw rolls. The impacted zone of discomforts are hand, shoulder and back thus the roll are now lifting by proper number of workers satisfying NIOSH standards or by machines like fork lift.

IV. CONCLUSION

The amount of literature, especially ergonomic Literature, related to work place design has grown rapidly in recent years. This research identified how NIOSH and other simple methods can be used to improve work and work process and at the same time reduced workers fatigue. This study identified by making simple changes to the existing process, it can reduce the time taken for each component to improve the flow and speed up the process. Several conclusions can be made about the material handling processes used by industry. In each case it was found that the current material handling processes present a high risk of musculoskeletal injury resulting from awkward postures- according to the NIOSH calculation and trainers, the awkward postures that account for a large portion risk for ergonomic injury are MSD, CTD, headache, finger damages, lack of familiarity with handling tools and auxiliary machines and etc.

The proposal was examined and conclusions are as follows:

- Manufacturing time reduced due to improved outer diameter.
- Occurrence of injuries and workers fatigue reduced to a great extent.
- Quantity of waste material reduced.
- Productivity improved and machine maintenance also reduced.
- Quality and machine performance was improved due to continuous run of machine in lesser breaks.
- Storage space reduced, as number of rolls reduced.
- Material handling time reduced.
- Injuries caused due to loading and unloading of rolls were reduced.
- Close observation of the work place performance and appropriate modifications are critical for guaranteeing the workers' welfare and system performance.
- SCOPE Search methods by which injuries can be reduced to some more extent, specially breathing problem and eye problem as these are very severe problems if continues for long time.
- Train some more workers which can operate multi-color gravure printing machine and solvent free machine as these are major machine so by having some more operators shuffling of workers can be done more frequently due to which serious injuries can be reduced.
- The influence of organizational/relational aspects should be better incorporated in the development of new (instrumental) ergonomics methods, procedures and tools.
- Look for methods by which multi-color gravure printing machine using 700 mm OD without any threat to machine.
- Look for some other aspects by which productivity can increase to some more value.
- Work on possibilities of reducing or reusing wastage by any means.
- Work on other methods by which work atmosphere can be stress free and interesting.

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