

ERGONOMIC IMPROVEMENTS IN THE HANDLING OF FIBRE INSULATOR SHEETS CUTTING

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Graphical abstract



Abstract

This paper gives emphasis to an ergonomics study conducted in a fibre insulation bay of a medium-sized air handler manufacturing plant. Work-related musculoskeletal disorders and other health problems in the fibre insulator sheets cutting operations were closely looked into. Unstructured interviews were initially conducted to uncover the underlying problems, while Direct Observation (DO) and Participative Assessment (PA) methods were utilized to identify ergonomics risk factors. Ergonomics interventions by means of real life experiments were implemented. These included 1) providing semi leather gloves to replace cotton hand gloves, 2) providing plastic chairs with back rest for occasional sitting, and 3) installing a fiberglass rolling mechanism for fiberglass cutting on table top. Post survey incorporating both DO and PA methods was subsequently conducted to gauge its effectiveness in minimizing work-related musculoskeletal disorders and other health problems. This action-oriented study finally produced fruitful results which included insignificant low back pain and legs ache, minimized hand irritation sensations, relieved tiredness of operators, reduced nose irritation, eye itchiness, sore throat and dizziness.

Keywords: Ergonomics intervention, direct observation, participative assessment, work-related musculoskeletal disorder (WMSD)

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1.0 INTRODUCTION

Ergonomics is the science of fitting tasks to working personnel. In the manufacturing environments, various ergonomics studies have been conducted to bring improvements in human-machine interactions. These include (1) Steel Manufacturing Sector [1], (2) Automotive Sector [2-6], (3) Electronics Field [7-9], (4) Air Conditioning Field [10-18]. In this research, the authors extended their effort of finding ergonomic improvements in a medium-sized air handler manufacturing plant in terms of reducing work-related musculoskeletal disorders (WMSDs) and other occupational health and safety (OHS) problems. Before ergonomics interventions, the operators suffered from WMSDs and poor OHS in the handling of cutting glass fibre material causing their poor productivity. The operators' limitations and capabilities in handling the cutting process were

investigated. Ergonomics concepts and methods were utilized to improve the operations via the introduction of new facilities to ease their cutting tasks with the main objective of improving work comfort leading to job satisfaction [19-21].

2.0 METHOD

2.1 Survey Techniques

A factory survey began with the sub-assembly workstation. A general idea of the workplace activities and ergonomics problems in handling fibreglass cutting were obtained via an unstructured interview [22] in the presence of employees of different seniority (manager, engineer and supervisor). Participative Assessments (PAs) [23] on major work-related problems were carried out by

conducting structured questionnaire interviews with six male operators involved in fibreglass cutting activities. The questionnaire was designed, tested on two operators and revised before finalising it for all the six operators using Sinclair's PA [23] method. The complaints about WMSDs such as low back pain, legs ache and other OHS problems such as dizziness, nose irritation etc. were gathered during the interviews. Direct Observations (DOs) [24] were made using video recordings to confirm the findings of the PAs and to further investigate the work problems. One

hour recording was made on each team of two operators in their glass fibre cutting activities. This sums up to a total of 3 hours of video recording covering six operators. The recordings were analysed by playing them in slow motion to investigate each operator's problems in detail (e.g. bending of back to reach the fibreglass material on floor, etc). The recordings were also played in fast motion to search for occurrence of a particular problem (e.g. squatting posture to place a measurement panel on top of glass fibre sheet before cutting).

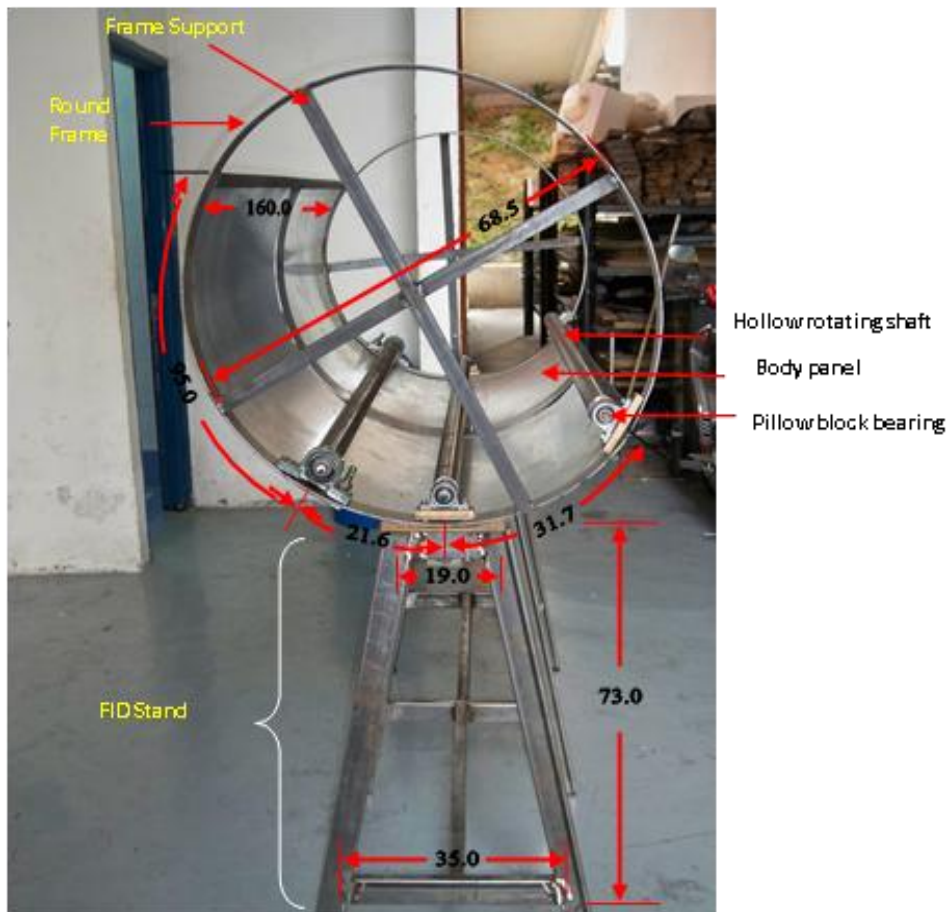


Figure 1 Fibre insulator dispenser (FID) – final structure for real life operations at Fibre Insulation Bay

2.2 Ergonomics Interventions Study

After obtaining a clear picture of the major problems, a meeting was held to report the findings to the management. Three ergonomics interventions were proposed to include 1) providing locally made semi leather hand gloves to all the 6 operators in the workstation to replace existing cotton gloves (i.e. Intervention I), 2) providing two locally obtained simple plastic chairs with back rest for occasional sitting (i.e. Intervention II), and 3) installing a new fibreglass dispensing apparatus, named Fibre Insulator Dispenser (FID) (Figure 1) (i.e. Intervention III) to match with a work table to prepare for fibreglass

cutting task on table top (Figure 2). After obtaining the management's approval to go ahead with the proposals, ergonomics interventions was implemented to solve the problems one at a time. This was to ensure a clear relationship between the cause and effect, i.e. between each intervention and its effects on the problems. Non-parametric test was used to determine the effectiveness of the interventions.

Two months after each ergonomic intervention, PAs and DOs were conducted again on the six operators to determine its effectiveness in reducing WMSDs and other OHS problems.



Figure 2 Fibre insulator dispenser (FID) – pulling the leading edge of glass fibre sheet to unroll the fibreglass roll

3.0 RESULTS AND DISCUSSION

3.1 WMSDs and OHS Problems

From the survey and analysis, it was found that there were eight problems reported namely low back pain, legs ache, tiredness, hands irritation, sore throat, nose irritation, eyes itchiness and dizziness. They are listed in Table 1 below. The table also summarises the observations of the reported problems and the methods used to investigate those problems involving six operators in the workstation.

Table 2 below presents the paired samples t-test on the Likert Scale Ratings (LSR) of WMSD and other OHS problems before and after ergonomics interventions.

3.2 Ergonomics Interventions Results

In Table 2, the Improvements in Interventions I and III are encouraging. The adoption of semi leather hand gloves (Intervention I) in place of the cotton knitted structures gave a significant impact (see Table 2). More benefits were reaped via the introduction of the FID (Intervention III) resulting in major reduction in WRMDs and other OHS problems since most of the ergonomic risk factors were removed. All the six operators involved in the study experienced stress relief.

Table 1 Ergonomics methods used to investigate reported problems of six operators in the workstation.

No.	Problems (WMSD & OHS)	Methods	Observations
1	Low back pain	PA of operators on lower back problems DO of operators' postures while performing fibreglass cutting PA of operators on leg problems	High operators' rating on lower back pain (LSR 4.2 ± 0.8) All operators bent their back 4.08 ± 0.59 hours/day* to cut glass fibre sheet due to material placed on floor. High operators' rating on leg ache (LSR 3.8 ± 0.8)
2	Legs ache	DO of operators on their squatting postures	All operators squatted on floor 2.53 ± 0.35 hours/day* to place metal plates (with handlers) on glass fibre sheet to take measurements for cutting.
3	Tiredness	PA of operators on their degree of fatigue DO of operators on their general FIB activities	Slightly higher than neutral operators' rating on fatiguing (LSR 3.3 ± 0.5) All operators showed sign of slowness in their glass fibre cutting operations after 45 minutes to 1 hour of continuous squatting and bending of back in the cutting task. They took rest by sitting on floor occasionally with their back leaning against a pillar, or sit on carton boxes as makeshift chairs.
4	Hands irritation	PA of operators on irritation problems DO of operators on their hand wear	High operators' rating on hand irritation (LSR 4.8 ± 0.4) All operators were using cotton gloves, similar to the type widely used by all maintenance technicians in the plant for machine service and repair. They did not use them during meal hour and tea breaks. They removed them while not handling glass fibre for a short rest.
5	Sore throat	PA of operators on throat condition DO of operators' mouth protection PA of operators on their nose	Higher than neutral operators' rating on sore throat (LSR 3.5 ± 0.5) Operators used face masks. They did not use them during meal time and tea breaks. They removed them while not handling glass fibre for a short rest due to discomfort. Higher than neutral operators' rating on nose irritation

6	Nose irritation	sensation DO of operators' nose protection	(LSR 3.7 ± 0.5) Operators used face masks. They did not use them during meal hour and tea breaks. They removed them while not handling glass fibre for a short rest due to discomfort.
7	Eyes itchiness	PA of operators on their eye problems DO of operators on the use of eye goggles	High operators' rating on eye itchiness (LSR 4.5 ± 0.5) The operators used eye goggles only when they performed glass fibre cutting task. Eye goggles were removed during meal hour and tea breaks.
8	Dizziness	PA of operators if they experienced dizziness DO of operators' postures while taking measurements and cutting glass fibre on floor	Higher than neutral operators' rating on dizziness (LSR 3.5 ± 0.84) All operators bent their back 4.08 ± 0.59 hours/day* and squatted on floor 2.53 ± 0.35 hours/day* to take measurements and cut glass fibre on floor.

FIB = Fibre Insulation Bay; PA = Participative Assessment; DO = Direct Observation

$x \pm y$ = mean \pm standard deviation; LSR = Likert Scale Rating

* The figure was extrapolated from the one-hour DO (of the 6 operators) to an 8-hour work shift (excluding meal time and tea breaks)

Table 2 Paired samples t-test on Likert Scale Rating (LSR) of work-related problems before and after ergonomics interventions.

No	Problem	LSR Before Intervention (Mean \pm SD)	Intervention	LSR After Intervention (Mean \pm SD)	t-value	p-value	Result
1	Lower back pain	4.2 ± 0.8	III	1.3 ± 0.5	7.059	< 0.05	significant difference
2	Legs ache	3.8 ± 0.8	III	2.2 ± 0.8	5.000	< 0.05	significant difference
3	Tiredness	3.3 ± 0.5	II III	3.2 ± 0.4 2.2 ± 0.4	1.000 7.000	> 0.05 < 0.05	insignificant significant difference
4	Hands irritation	4.8 ± 0.4	I	2.5 ± 0.5	7.000	< 0.05	significant difference
5	Sore throat	3.5 ± 0.5	III	1.3 ± 0.5	5.398	< 0.05	significant difference
6	Nose irritation	3.7 ± 0.5	III	1.3 ± 0.5	7.000	< 0.05	significant difference
7	Eyes itchiness	4.5 ± 0.5	III	1.5 ± 0.5	8.216	< 0.05	significant difference
8	Dizziness	3.5 ± 0.8	III	2.3 ± 0.8	3.796	< 0.05	significant difference

LSR = Likert scale Rating; SD = Standard deviation

4.0 CONCLUSIONS

Ergonomics interventions in the fibre insulator sheets cutting process helped in significant reduction in WMSDs and other OHS problems which included the resulting insignificant low back pain and legs ache, minimised hand irritation sensations, relieved tiredness of operators, reduced nose irritation, eye itchiness, sore throat and dizziness. Such improvement studies are the solution to the problems of poor working conditions which have deprived the workers of a conducive working environment.

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