National Conference in Mechanical Engineering Research and Postgraduate Studies (2nd NCMER 2010)
3-4 December 2010, Faculty of Mechanical Engineering, UMP Pekan, Kuantan, Pahang, Malaysia; pp. 195-201
ISBN: 978-967-0120-04-1; Editors: M.M. Rahman, M.Y. Taib, A.R. Ismail, A.R. Yusoff, and M.A.M. Romlay

ERGONOMICS ASSESSMENT OF WORKSTATION DESIGN IN AUTOMOTIVE INDUSTRY

[1]A.R. Ismail, [2]N. Jusoh, [2]A.Z. Ismail, [2]M.H. Abu Bakar[2], W.H. W. Deraman[2] and [3]A.P. Puvanasvaran

[1]Faculty of Mechanical Engineering, Universiti Malaysia Pahang
22600 Pekan, Pahang,
Phone: +609-4242268, Fax: +609-4242202
Email: arasdan@gmail.com, rasdan@ump.edu.my
[2]Department of Mechanical and Material Engineering
Faculty of Engineering and Build Enviroment, Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, Malaysia
[3]Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka (UTeM), Ayer Keroh, 75450 Melaka, Malaysia
E-mail: punesh@utem.edu.my

ABSTRACT

The purpose of this study is to demonstrate the ability to interpret the various aspects of ergonomics contributions and influences in the manufacturing industry. The application of knowledge and understanding of the ergonomics theories and techniques in the manufacturing industry also will be demonstrated in this study. Besides that, this report will be able us to appreciate the ergonomic role in manufacturing industry and everyday context by showing the ergonomics contribution towards employees' health and safety in the workplace and tangible or intangible profitability of the company. Adequate posture, work height, normal and maximum working areas are determined for the intended user population. The procedure for determining the workstation dimensions and layout has been explained. The importance of building a mock-up of the designed workstation and its evaluation with representative subjects is emphasized. A case problem (Final Inspection workstation) is discussed to illustrate the workstation design procedure.

***Keywords*:** Workstation design, Healthy and Safety, Manufacturing Industry

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INTRODUCTION

An ergonomics approach to the design of an industrial workstation attempts to achieve an appropriate balance between the worker capabilities and work requirements to optimize: worker productivity and the total system, as well as provide worker physical and mental well-being, job satisfaction and safety. Over the years many theories, principles, methods and data relevant to the workstation design have been generated through ergonomics research. Basic design rules or guidelines for a successful industrial workstation have been provided by Khalil (1972), Tichauer (1975), Eastman Kodak Company (1983), Corlett (1988), Konz (1967), and Corlett and Clark (1995). Corlett (1988) has proposed the most comprehensive guidelines that include both task design and workplace layout. These guidelines emphasize the requirement of healthy operator posture and they are directed towards improvement of the operator's physiological efficiency. Many painful afflictions, of musculoskeletal system, known as cumulative trauma disorders (CTD), are associated with the working posture. These are caused and aggravated sometimes by the repeated forceful exertions connected with awkward work postures of the upper extremities (Armstrong et al., 1986).

Often in industry the workstation is designed in an arbitrary manner, giving little consideration to the anthropometric measurements of the anticipated user. The situation is aggravated by the non-availability of usable design parameters or dimensions (Das and Grady, 1983; Das, 1987). The physical dimensions in the design of an industrial workstation are of major importance from the viewpoint of production efficiency, and operator physical and mental well-being. Small changes in workstation dimension can have a considerable impact on worker productivity, and occupational health and safety. Inadequate posture from an improperly designed workstation causes static muscle efforts, eventually resulting in acute localized muscle fatigue, and consequently in decreased performance and productivity, and in enhanced possibility of operator related health hazards (Corlett et al, 1982). The study was conducted on Oktober 2009 at Hicom Yamaha Manufacturing Malaysia (HYMM) Sdn. Bhd. located in Shah Alam, Selangor. HYMM is the only engine manufacturer for Yamaha motorcycle in Malaysia. One of the engine assembly processes, final engine inspection process workstation has been selected for a purpose of study. The study proceeding is related to environmental aspects. The purpose of study is to evaluate any environmental effects that may influence the worker performance at the workstation. The second category is study of existing characteristics workstation.

METHODOLOGY

Study was conducted at engine final inspection workstation which part of engine manufacturing processes as illustrate in Figure 1.

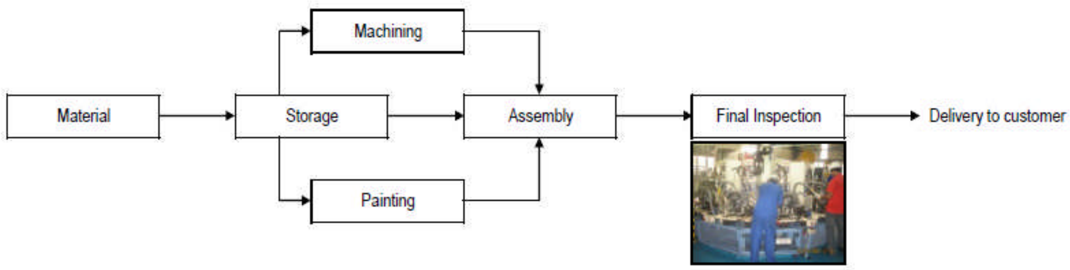

Figure 1: General engine manufacturing flow

The study was conducted by using questionnaire which required interview session to the personnel involved from top management up to the operators responsible to the workstation. In this category, study was focused to the discussion on issues related to ergonomic and evaluation of all the key points related to anthropometric data at existing workstation design from manufacturing ergonomic point of view.

Workstation design and subjects

Final inspection workstation consists of eight substations which every substation was designed equally. Every single substation operates by different operators. Figure 2 proposes the workstation design dimension. For designing an industrial workstation, it is necessary to obtain relevant information or data on task performance, equipment, working posture and environment. The work and motivation schedule can see in Table 1. This schedule can make workers relax for a while.

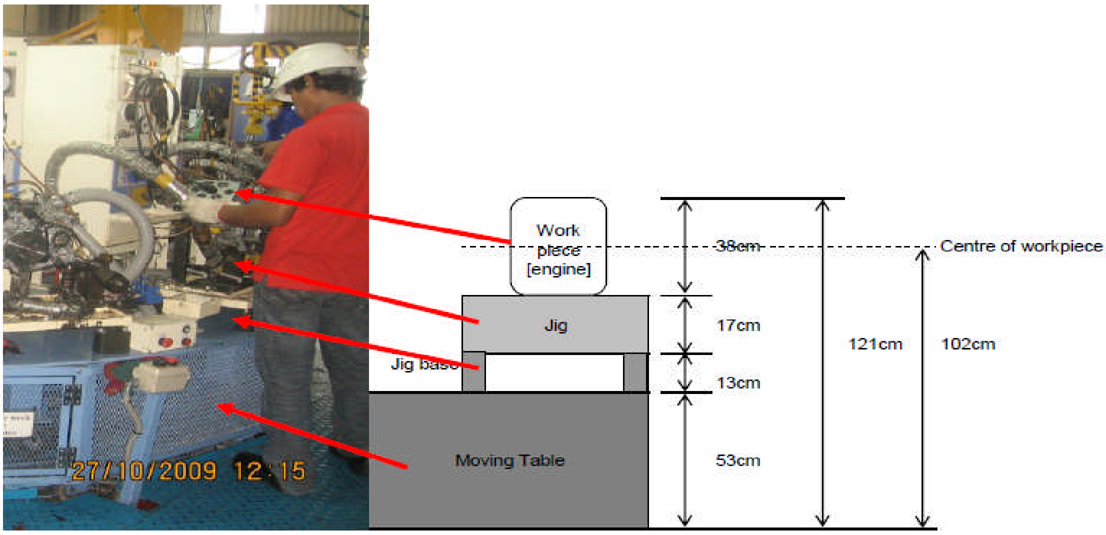

Figure 2: Workstation design dimension

Table 1: Work and motivation schedule

Time start	0800	0810	0820	1030	1045	1305	1345	1530	1540	1720	1730
Time finish	0810	0820	1030	1045	1305	1345	1530	1540	1720	1730	
Duration[min]	10	10	130	15	140	40	105	10	100	10	
Activity	Meeting	Set-up Operation	Operation	Morning Break	Operation	Lunch Break	Operation	Tea Break	Operation	5S	Operation Stop
Motivation	☺			☺		☺		☺		☺	
Total working hours	570 minutes [Pre operation 30 mins, operations 475 mins, rest time 65 mins]										

The layout or experiment set up of Final Inspection Workstation can illustrate by Figure 3. The explanation every substation of Figure 3 points out can be see clearly in Table 2.

The workstation has been set up to inspect the product called completed motorcycle engine. This engine consist of more than 200 components which main components are crank case, body cylinder, crank shaft and head cylinder as proposes as in Figure 4 below. All these parts assemble at engine assembly line which consists of 34 processes. After assembly process completed, engine will be sending to this workstation for final inspection before delivery to customer to fix to the motorcycle body.

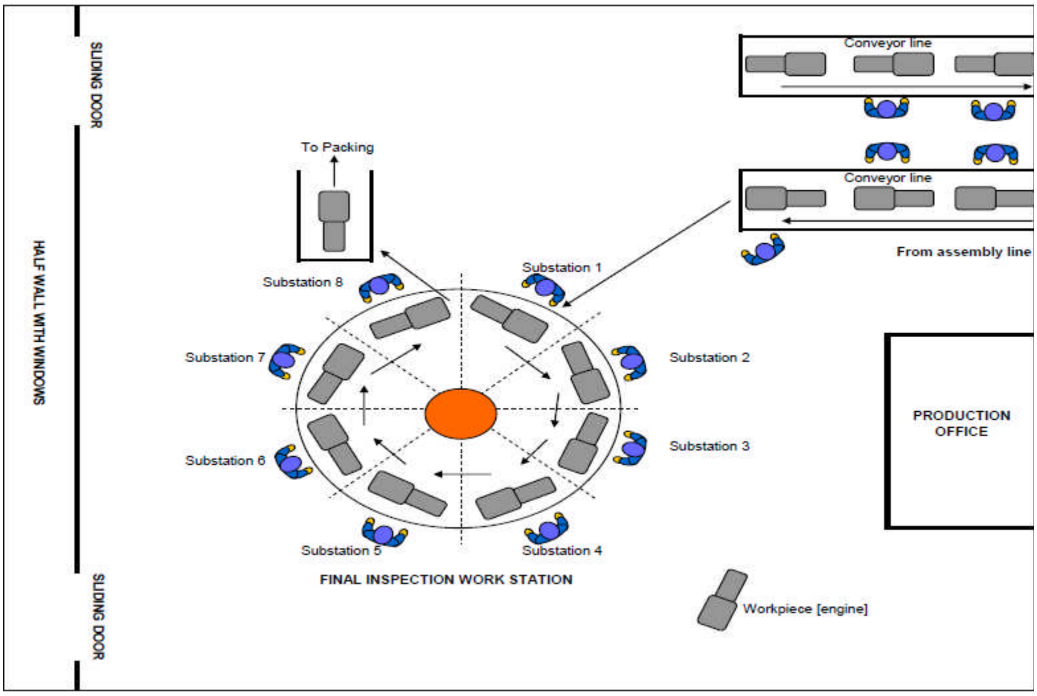

Figure 3: Experiments set up

Table 2: The explanation substation activity at the workstation

SUBSTATION	1	2	3	4
WORK SEQUENCE	Check 4T oil Tighten 4T oil plug Set engine at jig	Fix carburator Fix wire harness On petrol/starter	Fix exhaust Tighten bolt Fix spark plug cable Fix air hose	Fill up coolant Check process 1,2,3 Switch on engine
SUBSTATION	5	6	7	8
WORK SEQUENCE	Check gear Check noise level Check oil flow	Open bolt Remove coolant Re-tighten bolt	Dismatle exhaust Open bolt Dismantle wire Dismatle air hose	Check H.Cyl thread Put engine at pallet Sent engine to next process

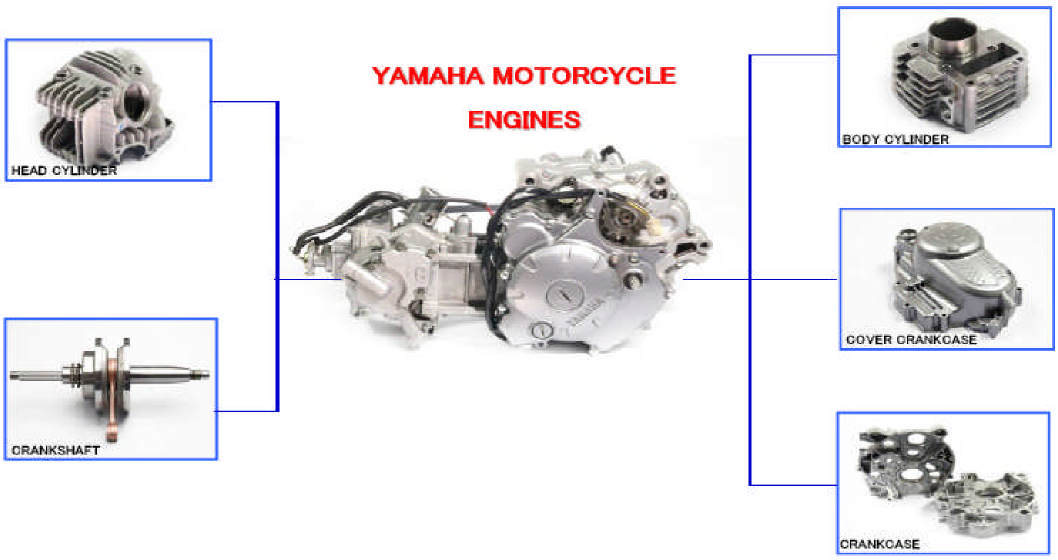

Figure 4: Main component of engine

RESULTS AND DISCUSSION

Workstation Design Assessment

Based on the Figure 5, work piece (engine) position is between 83 cm and 121 cm and all working activities for all substations around elbow high. Based on anthropometric data, average elbow height at 95 percentile is 110 cm within range of work piece position. The centre of work piece position is at 102 cm. the result shown that workstation design is suitable for the Malaysian worker. The lowest position of work piece at 83 cm within 95 percentile of fingertip height anthropometric data 69.5 cm. By comparing data from Table 3 below and anthropometric data used in 4.1, stature for all subjects are within 90 percentile of Malaysian people stature (147cm to 177cm). Therefore all the workstations are suitable to be operated by Malaysian people and able to minimize Cumulative Trauma Disorders (CTDs)

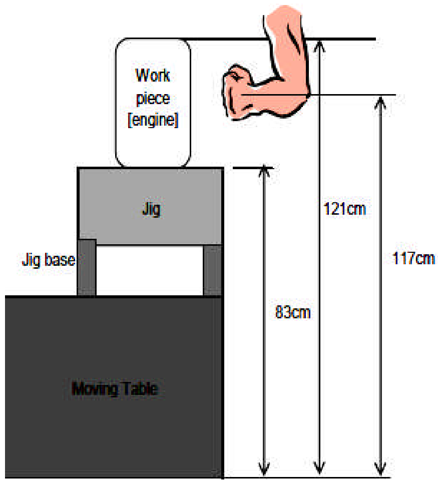

Figure 5: Work piece position

Table 3: Anthropometric data analysis

Items	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8
Subject	RIYANTO	ZAMRI	NGAFI	HANAFI	RANI	AZIZAN	AHMAD	KIDO
Age [year]	35	27	27	35	32	27	27	28
Gender	MALE	MALE	MALE	MALE	MALE	MALE	MALE	MALE
Height [cm]	167	173	165	170	160	162	160	160

Physiology Assessment As Well As Cognitive Of Workers

Main human body parts to perform a task at this workstation are hand. Example of the critical tasks are handling air gun to loose and tighten a bolt, fix a work piece at jig, fix a wire cable, spark plug cap and air hose. This is to ensure the engine will be functioning properly for inspection. The other human body parts which are important in this work station such as eyes for viewing the condition of equipment fixing and to make a conclusion of their own tasks based on standard given. Based on the daily work schedule, workers will not continuously expose to more than four hours performing task since enough rest time has been provided in the middle morning session, afternoon and during evening session. The other task which highly related to human body parts at this work station is engine noise level judgment using normal hearing process. The task which set at substation 5 conducted in a special room (sound proof). Noise level from the engine sound is at 95db. By the result, workers have been assigned to perform task alternately for maximum every four hours. Workers at the others substations are compulsory to wear ear plug.

Figure 6 shows a working space for every worker at their substation. Based on same anthropometric data used for 4.1, elbow to elbow breadth at 95 percentile 50.6 cm meanwhile space for every work area is 157 cm. This condition shows workers is working in the very comfortable condition. The photo shows action working area condition. The judgment meter located in front of the worker which the position of the judgment meter [height] is at eye view position. On the top side, workers are free from any obstacle which can make operator easily move without any hazard and risk. Housekeeping at the working area is in proper arrangement and helps to avoid injuries. From the visual environment, working area is well lit, clean and uncluttered and allowing good depth perception among the workers. From the thermal environment, temperature is within in the range of 30 to 34 Celsius. To reduce temperature to comfortable zone (26~30 Celsius) all the eight substations being provided with fans for worker comfort ability. Workers also provided with safety shoes with good coefficient of friction with floor to avoid from slippage or falling accidents. However, sight view for operator required improvement since view angle out of recommendation which is within angle 30^{o}.

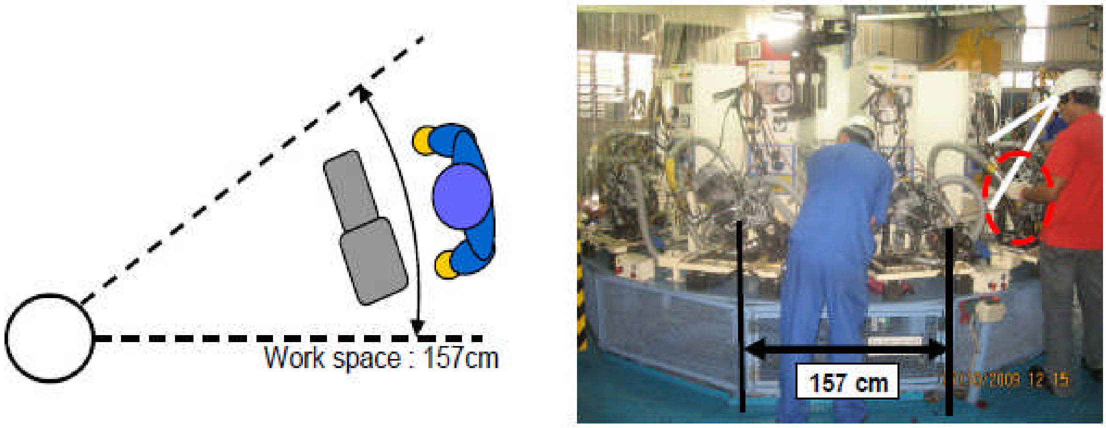

Figure 6: Working space for worker at substation

CONCLUSION

From management side, ergonomics is part of their consideration when dealing with man, machine, and methodology, material and working environment. Example of industrial ergonomics related activities currently being implemented are:

- Continuous training to all workers on environmental, safety and health.
- Health check to all workers at least once a year.
- Conduct periodical 5S and Safety audit to ensure all working area are in good condition at all situation and to identify any improvement required.
- Space of working areas for a subject decided based on recommendation by R&D Division at Head Quarters, Japan.
- Employee Suggestion Scheme where employees are encouraged to give a suggestion to management for any improvement from quality, cost, delivery, safety and morale point of view. The practical suggestion will be implemented by management and reward will be given.

REFERENCES

Armstrong, T. J., Radwin, R. G., Hansen, D. J. and Kennedy, K. W. 1986. Repetitive trauma disorders: Job evaluation and design' Human Factors 28: 325-336

Corlett, E. N. 1988. The investigation and evaluation of work and workplaces Ergonomics 31: 727-734

Corlett, E. N. and Clark, T. S. 1995. The Ergonomics of Workspaces and Machines: A Design Manual, 2nd edn, Taylor & Francis, London, England

Corlett, E. N., Bowssenna, M. and Pheasant, S. T. 1982. Is discomfort related to the postural loading of the joints? Ergonomics 25: 315-322

Das, B. 1987. An ergonomics approach to the design of a manufacturing work system' Int J Industrial Ergonomics 1: 231-240

Das, B. and Grady, R. M. 1983. Industrial workplace layout design: An application of engineering anthropometry. Ergonomics 26: 433-447

Eastman Kodak Company. 1983. Ergonomics Design for People at Work, Belmont, California, USA, Lifetime Learning

Khalil, T. M. 1972. Design tools and machines to fit the man Industrial Engineering, Institute of Industrial Engineers 4: 32-35

Konz, S. 1967. Design of workstations' J Industrial Engineering 18: 413-423

Tichauer, R. E. 1975. Occupational Biomechanics: The Anatomical Basis of Workplace Design, Institute of Rehabilitation Medicine, New York University, Medical Centre Rehabilitation Monograph No. 51, New York, NY