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Design and Development of Foot Stand Parameters for Machining Laboratory at Malaysian University

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Abstract – Most of the machines used in teaching and learning at Malaysian University such as CNC machine, Rapid Prototyping machine and so on are from the overseas companies. Therefore, the machine parameters such as machine height will be based on their origin population. Because of that, it was found that Malaysian University students have a problem to handle with the machine especially with their level of control panel. Student was found need to extend their foot in order to achieve the machine control panel especially for emergency button. Therefore this study is to design and develop the foot stand parameters for suit with Malaysian University students. A survey was conducted to collect anthropometric data of engineering students in UTHM. Seven body dimensions related to foot stand design such as *weight, height, eye height, arm reach forward, hand length, foot length and foot breadth* ***were measured using TTM" Martin's Human Body Measuring Kit on one hundred and twenty five engineering students which consist of 73 male and 52 female. The Solidwork software 2008 edition was used in designing the foot stand and ManneQuinPRO™ Software is used in simulate and validate the design using human modelling. Most of the body measurements of the male students are found higher than the female students; therefore, there is a need for refining the design of existing equipments based on ergonomic considerations before introducing it in laboratory for students use. Throughout the study, improvement on the working environment in mechanical laboratory that needs to be done has been identified. The recommendation is the requirement to design a foot stand that is located at floor level in order to avoid the students from raising their leg while using some of the machine equipment in the mechanical laboratory. The parameter and shape design of the foot stand is achieved after all ergonomic consideration and calculation taken in details with references to the newly developed eight body dimensions of anthropometric data. By having the foot stand parameters and design, it is helpful to the students in using the related machines with safety, healthy and comfort and also will increase their satisfaction.***

Keywords – Foot Stand, Anthropometric data, Body dimension, Malaysian University

I. INTRODUCTION

Improper design of workplace, tools and equipment, will contribute to the muscle fatigue, eyestrain, headaches, and other discomforts and also become factor in decreasing the effectiveness of workers performance. These factors act to decrease morale and motivation and eventually may cause injury and illness. In Malaysian Universities, most of the machines used in laboratory works, are imported from overseas such as German, USA and so on. Therefore, the machine parameters such as machine height will be based on their origin population. Because of that, it was found that Malaysian University students having difficulties in handling with the machine especially with the level of control panels. Therefore, this study is purposely to design and develop foot stand parameters that will suit with Malaysian University students.

II. METHODOLOGY

A. Observation

The observation has been conducted at three different mechanical laboratories (Advanced Machining Lab, Rapid Prototyping Lab and Computerized Machine Tool Lab) to verifying the ergonomic problem in deep include the environment and relation between human and machine. This is an effective method because real situation can be identified in mechanical student workplace and whether of student is comfortable or not with current equipment, tools and machinery design. The observation method used are by recording the engineering student activities in laboratory using camera and identified the problem happen that involved ergonomic aspect.

B. Subjects and anthropometrics data

The subjects involved in this study are among engineering students at Universiti Tun Hussein Onn Malaysia. One Hundred and twenty five engineering students are involved in anthropometrics data collection which consists of 73 male and 52 female using "TTM" Martin's Human Body Measuring Kit. Seven body dimensions related to foot stand design such as weight, height, eye height, arm reach forward, hand length, foot length and foot breadth were measured.

III. RESULTS AND DISCUSSION

A. Observation

From the observation, it was found that, the most critical and frequently used machine that represents the tallest machine is CNC Wirecut Machine (RA90) located at Computerized Machined Tool Laboratory and the smallest machine is RP Depowdering Unit at Rapid Prototyping Laboratory. Therefore, CNC Wirecut Machine (RA90) and RP Depowdering Unit parameters are considered in order to design the foot stand.

Besides that, student was found need to raising their leg and also need to tilt upward their head while using some of the machine equipment in the mechanical laboratory as shown in Fig. 1. It is because some of the female students shorter and they cannot seen and reach the control panel with normal posture. It will caused the student felt fatigue at their neck. Back pain, neck pain, and the class of conditions affecting the hand, wrist and arm which refer to as work-related upper limb disorders (WRULD) or repetitive strain injuries (RSI) are all conditions that characteristically result from over use of the muscles and other soft tissues in question [17].

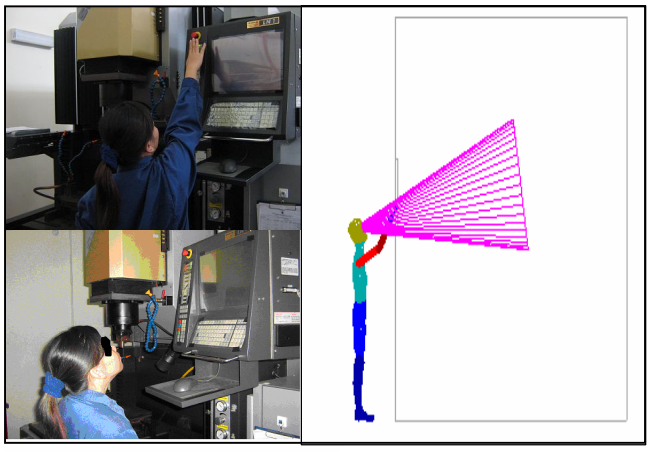


Fig. 1. The current condition at mechanical laboratory

B. Anthropometrics Data

Table 1 represent the anthropometrics data for main body parts obtained from the measurements of 125 engineering students in UTHM. It shows the 5th, mean, 95th percentile, and standard deviation (SD) values for different body dimensions. The data were taken in a static posture hence should not be used directly in the design which requires functional body dimensions. There are some guidelines to be followed in order to translate static body dimensions into dynamic and functional body dimensions which are more representative of human activities.[1]

It is obvious based on the results presented in Table 1, that the male students are taller than female students. The two body dimensions namely eye height and shoulder height of the subjects obviously shows the difference. Mean values of other two dimensions i.e. arm reach forward and sitting height of male students are found to be higher than female students emphasizing the necessity of modifying the existing equipment before introducing in the mechanical laboratory. The mean value of popliteal height of male students was also found to be higher than female students. Also the mean value of buttock-popliteal length of male students was also found quite higher than female students indicating a unique and distinct nature of anthropometry of the mechanical engineering students in UTHM. Furthermore, the mean value of hand length and foot length of the male mechanical engineering students were also found quite higher than female mechanical engineering students. Therefore, there is a need for refining the design of existing equipments based on ergonomic considerations before introducing it in mechanical laboratory for students use.

Table 1. Anthropometric Dimension of Students in UTHM
[M – Male (n = 73), F – Female (n = 52)]

No.	Body Dimension (cm)	Sex	5th %tile	Mean %tile	95th %tile	SD
1	Weight (kg)	M	55.05	69.80	90.51	12.36
		F	41.20	51.95	64.50	7.70
2	Height	M	149.25	168.70	180.29	9.55
		F	146.70	152.94	163.00	6.35
3	Eye Height	M	142.64	163.43	176.69	5.18
		F	131.48	137.86	149.65	5.16
4	Hip Breadth, Standing	M	28.30	32.20	36.03	3.05
		F	30.20	32.60	37.90	2.16
5	Arm Reach Forward	M	70.19	79.20	88.09	6.00
		F	66.15	70.22	76.00	3.92
6	Foot Length	M	23.00	25.81	28.12	1.75
		F	20.00	21.40	23.00	1.00
7	Foot Breadth	M	7.90	8.98	10.08	0.72
		F	7.90	8.77	9.75	0.66

C. Foot stands design parameters.

After getting the relevant anthropometrics data, the parameters for designing foot stand has been identified. The parameters involve are width, length, and height (adjustable). The critical parameter for this foot stand is the range of adjustable height. The maximum height of the foot stand should be able to accommodate the 5th percentile female eye height to the same level of the machine control panel height. So, it shows that this foot stand can be accommodating 90% of student population at Malaysian Universities.

Throughout the study, improvement on the working environment in mechanical laboratory that needs to be done has been identified. The recommendation is the requirement to design a foot stand that is located at floor level in order to avoid the students from raising their leg while using some of the machine equipment in the mechanical laboratory. Furthermore, the design of the foot stand must consider 5th percentile of female student and 95th percentile of male student using the newly develop anthropometric data of mechanical engineering students in UTHM. These recommendations are based on ergonomic point of view which is to ensure the comfortability and safety among mechanical engineering students in UTHM.

The parameter and shape design of the foot stand is achieved after all ergonomic consideration and calculation taken in details. In Table 2 shows the recommendations of an appropriate parameter for the foot stands. The recommended mechanism of the design is an adjustable foot stands that function by using pneumatic power (refer Fig. 2 and Fig. 3). The range of adjustable height will accommodate the variability of potential users.

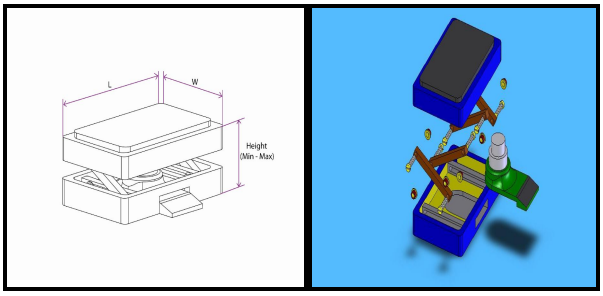


Fig. 2. The recommended design of the foot stand

Table 2. The recommendations of an appropriate parameter for the foot stand.

Recommendation Dimension	Recommendation Dimensional range (cm)	Guidance
Length (L)	60	95% tile male breadth standing + 22 cm clearance
Width (W)	45	95% tile male foot length + 17cm clearance
Adjustable height (Min – Max)	15 – 35	5% tile female eye height in standing position.

D. Simulation results.

The recommended foot stands is analyzed using software ManneQuinPRO to perform basic analysis including testing a mannequin's ability to reach the control panel of the machine, the mannequin various viewing angles and to determine whether or not people are compatible with the space by comparing current situation with recommended situation. In current situation, before the foot stand is applied, it shows that the eye sight of the 5th female manikin is not directly into the control panel. This represent the current situation where some of the female mechanical engineering students did having difficulties to see the displays on control panel and they have to raise their leg and head in order to do so. Furthermore, the students also have to twisting the body, facing excessive reaches situation and unnatural head positions because of visual requirement. These actions will cause health disadvantage.

Grandjean (1980) claims that poorly designed standing work postures may lead to back and neck aches, curvature of the spine, and slackening of the abdominal muscles. However, as for the 95th male manikin, the eye sight is directly into the control panel. With reference to newly develop anthropometric data in Table 1, the height of male students is slightly higher than the female students therefore they having no difficulties to see the displays on control panel.

By using the recommended foot stand, the 5th female manikin eyesight is more visibly and adequate. The optimal view analysis shows that the 5th female manikin can observe the displays in control panel clearly (Fig. 4 and Fig. 5). These prove that, the use of a foot stand is a must in order to define acceptable height of visual obstruction. The reach of the left and right arm of the 5th female manikin shows that

their reach ability is within the control panel when they stand on the recommended foot stand as shown in Fig. 6. Therefore, they don't have to extended reach by leaning, stretching, stooping or crouching because these postures can produce fatigue if they have to be assumed frequently or maintained for periods longer than a minute [2]

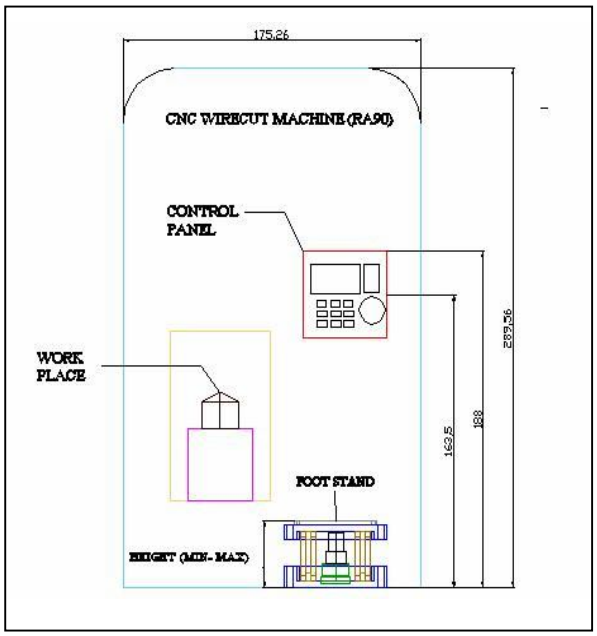
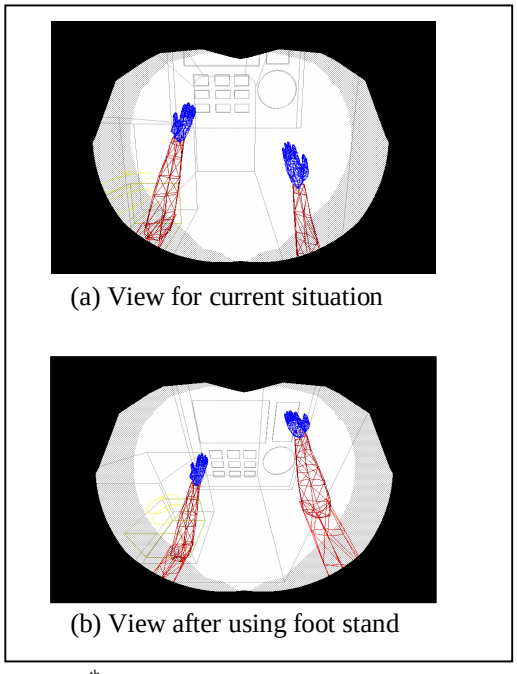


Fig. 3. The CAD drawing of the machine with recommended foot stand in front view.



(a) View for current situation

(b) View after using foot stand

Fig. 4. The 5th female manikin's eyesight in current situation and after using recommended foot stand

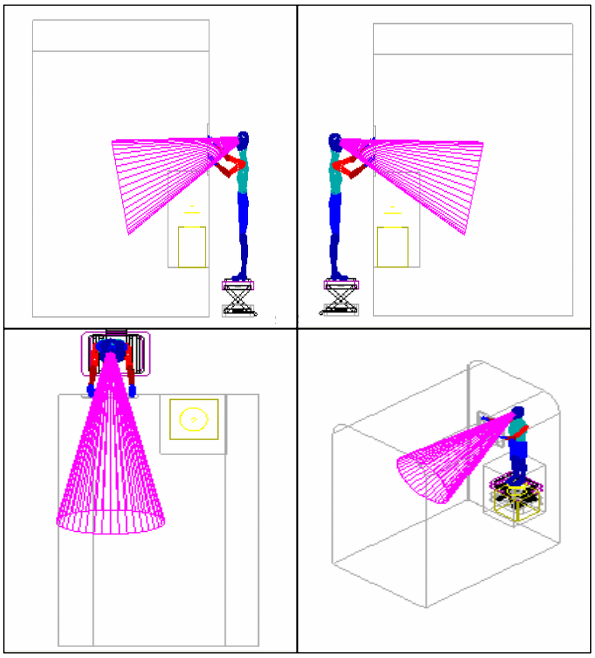


Fig. 5. Optimal View Cone in Recommended Situation

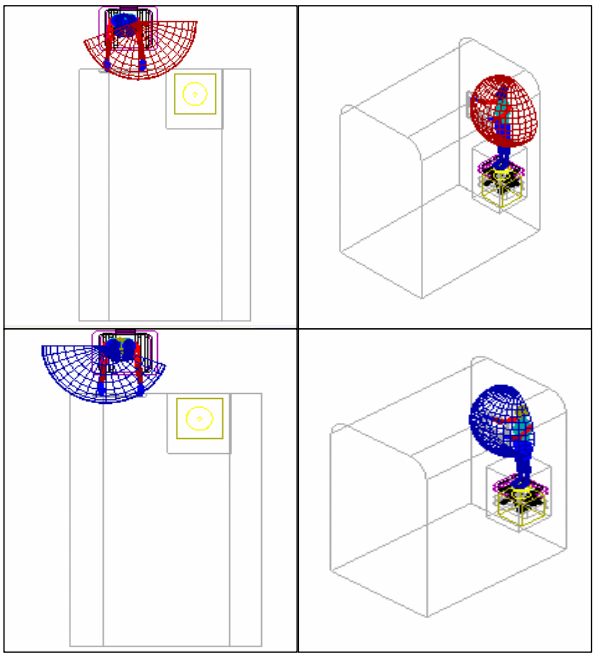


Fig. 6. Range of Left and Right Hand in Recommended Situation

IV. CONCLUSIONS

An anthropometric database is prerequisite for designers and engineers for designing ergonomic products and facilities. This data is important for users as well if they desire to use ergonomically designed products and facilities.

One hundred and twenty five measurements of mechanical engineering students in UTHM were summarized in this study which consists of 73 male and 52 female. This would be of great value in designing the work stations, tools and protective equipments.

The anthropometric data presented based on the result of this study constitute the first anthropometric database of engineering students in UTHM. This work provides the designers and engineers the basic of designing safe, healthy and comfort work environment and facilities for engineering students in UTHM. This data can be further analyzed and used to propose the improvement in designing workplaces and laboratory equipments by using ergonomics approach. Quality of life can be improved by applying anthropometric data, which can be regarded as an indicator of life quality for the engineering students in UTHM. This study has laid groundwork for improving the student's safety, health and life quality in performing their job as an engineering student in UTHM.

Further work and effort can be made to transfer the data into practical dimensions that designers and engineers may use conveniently for various products and facilities. Also there is a need to enlarge the sample size as data of one hundred and twenty five individuals is small to construct a relevant database which can be used for broader prospects.

ACKNOWLEDGMENT

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