ANALYSIS OF COMFORTABLE ASPECT IN DESIGNING A LUMBAR SUPPORT IN CLEAN ROOM AEROCOMPOSITE INDUSTRY

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ABSTRACT: In this paper, the reasearch focus on workers working in the cleanroom manufacturing composite layup. Cleanroom is a workplace facility that utilized as part of specialized industrial production or research that manufacture product that sensitive with normal environment. This room could control the and maintain the level of particulates such as dust, airbone organisms and vaporized particles. However, working posture done by the workers here are critical in ergonomics point of view due to major factors includes the mould design, time cycle and less of techonology facilities. Based on survey conducted and previous research, lumbar support is a reliable intervention tool in reducing and avoid back pain issues in composite layup workers. Though, the design and material of current lumbar support available in many choices and how it works in term of comfortability for users are untill doubtful. Here, the comfortablilty ascpect being analysed and validated using two method which are voice of customer (VOC) and thermal analysis (TA).

KEYWORDS: *Lumbar support; Neoprene material; Cleanroom; Voice of customers; Thermal analysis*

1.0 INTRODUCTION

Composites material applied in aeronautics, automotive, boats, sport parts and medical devices. It is in high demand for aerospace parts because of fabrication techniques of composites material, quality of parts, cost and size of production (Adrian & Gheorghe, 2010). In addition, the components of raw materials used are fabric carbon, metallic components and honeycomb core. The manufacturing process refers to engineering specification by aircraft manufactures (Kosmo, 2017). Furthermore, cleanroom was used in manufacture the composite material where the workers in perform working activities of push-and-pull activity and awkward posture. This activity needs the workers to push or pull the mould in a long distance into workplace manually throughout the working hours that as well contributes to awkward posture (Hashim, Kamat, Halim & Othman, 2014). Awkward posture defines as a practical working posture when joints are not in neutral position such lifting heavy products, reaching materials, bending forward their back when doing jobs, and pushing or pulling excessive loads because this requires a stable position and large degree of freedom (Seri et al., 2013).

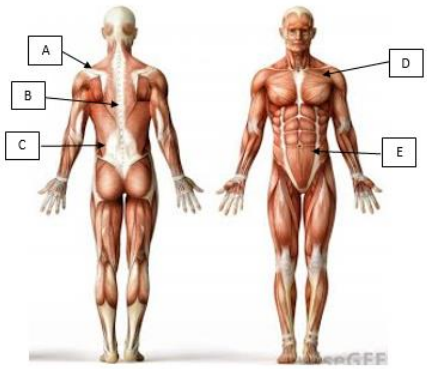
Psychophysical describes as one method that used to estimate acceptable load under variety of force, repetition, posture and period conditions. It is quantitatively investigate the relationship between physical stimuli and sensations and perceptions (Ciriello, 2008). Reported that another factor that can contribute to comfort is thermal influence due to interaction between human and the seating surface. A psychophysical approach in this study to evaluate the thermal influenced of tack chair with the seat pan temperature (objective variable) (Kumar, Fredericks & Butt, 2015). Moreover, the survey can also use to get feedback on product from customer satisfaction. Rating of perceived discomfort (RPD) was part of survey question with driving simulation being used in identified the discomfort level body (Gruevski et al., 2016). This paper study the comfortability aspect in relation to psychophysical and lumbar support intervention.

2.0 METHODOLOGY

The total respondents involve in this validation was 45 respondents from compostie layup workers. For comfortability aspect in design being validate by using VOC and thermal analysis using SOLIDWORKS Simulation software.

The VOC questionaire involves five parts which are personal information, knowledge in lumbar support, discomfort level of body scale, experience of wearing lumbar support, and redesign a new lumbar support. In personal information, the questions focus on respondents while in knowledge information focusing on reason of not wearing and wearing lumbar support lumbar support. One of the part of this survey consists part of body that feeling discomfort while wearing a lumbar support, it shows in Figure 1. The experience of respondents towards existing lumbar support will support in comparise with the new lumbar support design (Ulrich & Eppinger, 2010). The survey was distributed among 45 workers. The survey been analysed and interprated as graph and chart using Microsoft Excel software.

1. When wearing the current belt support, which part of the body that you feel discomfort? Tick scale of level of discomfort/pain. *Bila anda memakai "belt support" kini, bahagian tubuh manakah yang anda merasa tidak selesa? Tanda pada skala tahap ketidakselesaan.*



Part of body	Level of discomfort/ pain					
A	0	1	2	3	4	5
B	0	1	2	3	4	5
C	0	1	2	3	4	5
D	0	1	2	3	4	5
E	0	1	2	3	4	5

Figure 1. Discomfort Level of Subject Wearing Lumbar Support

Other than that, in validating the comfortablity of the material and design of lumbar support, this study used SolidWorks Thermal Analysis. The lumbar support was designed using SolidWorks software and was analysed using SolidWorks Simulation software. This analysis was conducted in way to validate the design and material application towards the user comfort. The thermal loads that being used are temperature of human body (37 °C) and convection of heat from surrounding that react to user body. The analysis was made using two condition of air temperature which are 21°C (clean room) and 32°C (production room temperature) (Roghanchi, Sunkpal & Kocsis, 2015). The constant variables of this analysis were body temperature, design of lumbar support and material of lumbar support (neoprene). The thermal finite element model represting the comfort of user while wearing this lumbar support device.

3.0 RESULT AND DISCUSSION

The survey was design in way to get the information about lumbar support design. the results show 80% respondents feeling uncomfortable during layup due to body posture that faced every day and believe that lumbar support can reduce their back pain issues during works. Customer requirement is important in designing and improving a product. This criteria and feedback will help the designer in

future. For the criteria that needed in new design were comfort (95%), easy to wear (80%), support body (60%) and sizing (around 36% to 32%) shown in Figure 2.

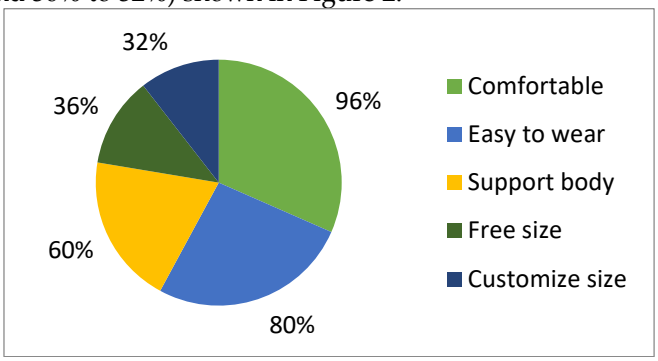


Figure 2. Respondents' Requirements for Proposed Design

Figure 3 shows the result of subjects without lumbar support (WLS), current lumbar support (CLS) and new lumbar support (NLS). This result shows that improvement of new lumbar support device in term of comfort while use it. Part A and B show an improvement from respondents, which are 40% and 60% of drop of discomfort. Based on subject, majority of them feel comfortable while using this new lumbar support device. These question describe comfortability and functionality of new lumbar support based on material, vest design, lumbar spine support, and lumbar plate. The subjects feel comfort with this neoprene material because high quality of material that belongs to family of synthetic rubbers which are ideal for orthopaedic. Moreover, this material have high tensile strength, breathable membranes and wide temperature range.

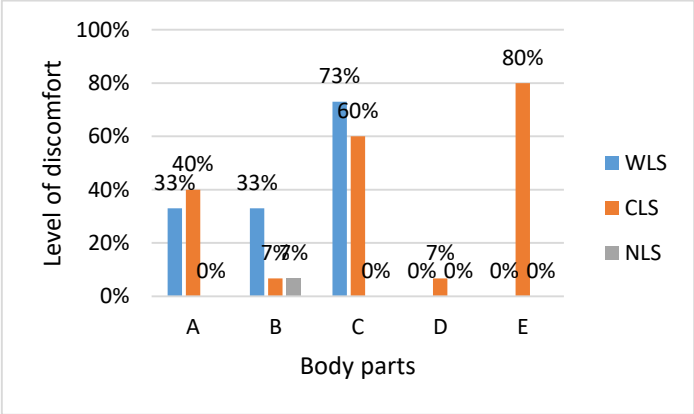


Figure 3. Comparison of Discomfort Level of Part Body

Figure 4 shows the proposed design of lumbar support for this study which successfully designed by SolidWorks software and prototype. The prototype was used in experiment of discomfort level of body part while 3D design was used in thermal analysis. Table 1 shows the proposed determination values of parameters used for thermal analysis.

Figure 4. Proposed Design of Lumbar Support Vest and Prototype

Table 1. Parameters Used for Thermal Analysis

Process variables	Range
Material	Neoprene
Temperature human body	37°C
Cleanroom temperature	21°C
Production room temperature	32°C

In this ongoing research, the thermal analysis was analysed based on the two tempature which are in cleanroom and production room. The mechanism of heat exchange between an external face of a solid body and the surrounding fluid such as air. The amount of heat moved by convection is proportional to the temperature difference between the solid body face and the surrounding fluid, and to the area that face exchanging (dissipating or gaining) heat.

4.0 CONCLUSION

As a conclusion, the study demonstrated that the comfortablability ascpect could analysed and validated using voice of customer (VOC) with the criteria that needed in new design were; comfort (95%), easy to wear (80%), support body (60%) and sizing (around 36% to 32%). In designing the lumbar support vest, it shows Solidworks 3D software able to modelled the part. However, the (TA) is still in research and analysis in order to complete the final result of this study.

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