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Design and fabrication of antilock braking system test rig

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Keywords: ABS test rig; design for manufacture; fabrication

ABSTRACT – In this research, a new design of a quarter car antilock braking system (ABS) test rig is fabricated. The test rig is designed due to the problems arise during analysis of the behavior of an ABS in a vehicle. Commercial computer aided design (CAD) software is used to design and analysis the test rig formation in modeling 3-dimensional (3D). The material selected for the main parts of the test rig is mild steel. The material is selected through the commercial material selection software. Further analysis of the project is carried out with two methods of computation to obtain the load at each point on both wheels and roller shaft. The CAD software is used to generate structural analysis workbench to analyze the components of the rig and roller body. Cutting process for the rig and roller body materials are performed using metal cutter saw, hand drill and grinder. The joining methods applied throughout the fabrication are the metal inert gas (MIG) welding, and bolt and nuts. The assembly processes of the components are then carried out according to the design that has been finalized. The ABS test rig was successfully tested and performed as predicted.

1. INTRODUCTION

Braking system in a vehicle, especially a four wheel vehicle, is very important due to the safety of the passengers and the vehicles itself. It is quite critical in term of analysing the behavior of a car braking system [1]. A road test using an actual car is very difficult and requires much hard work, although it is possible to be done [2,3]. The invention of the antilock braking system (ABS) has changed the automotive industry a lot. Risks of accidents to occur have been reduced due to the invention of the ABS. By having a well-functioning braking system, risk of accident will be reduced to its minimum. The study on the braking behavior, and the invention of several test rig or test bench actually ease the process of researching and development of the ABS system [4]. In past years, various outdoor tests have been set up for validating the antilock braking system behavior. The outdoor road tests are still the best approach for functions validating of the ABS and tuning the control parameters [5].

In this paper, an ABS test rig is designed and fabricated. A simple stress analysis is performed to determine the safety of the test rig [6]. The selected design is fabricated using available materials and components. The design for manufacture approach is practised [7].

2. METHODOLOGY

All of the test rigs that had been set up in the previous studies were considered in designing the ABS test rig for this project. All the parts, components and layout of the components, were taken into consideration in producing the best design. Therefore, the main parts in setting up a test rig in this project were; wheel, motor, brake system, sensor roller and rig body. Wheel is the main component for this test rig. An actual scale wheel was used. The actual scale of the wheel provides better precision for the test rather than smaller scale of weight that acted as a car wheel. The electric motor used in this project supplied the rotational torque to the wheel. Figure 1 shows the CAD assembly of the test rig.

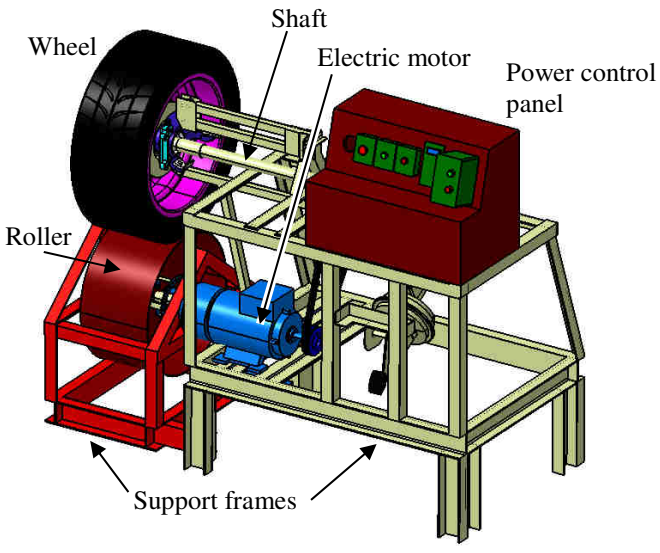

Figure 1 CAD assembly of the ABS test rig

3. RESULTS AND DISCUSSION

The chosen material, for the analysis on the part as shown in Figure 2, is low carbon steel. The yield strength of the low carbon steel ranges from 250 MPa to 395 MPa. The lowest value of the yield strength was considered to ensure that all the parts would be in the safest condition. The factor of safety calculated with maximum pressure force of 1000 N was 1.5. Figure 3 shows the final prototype of the ABS test rig.

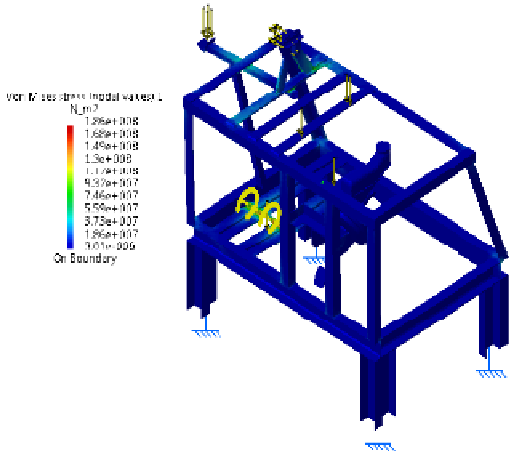

Figure 2 Stress analysis

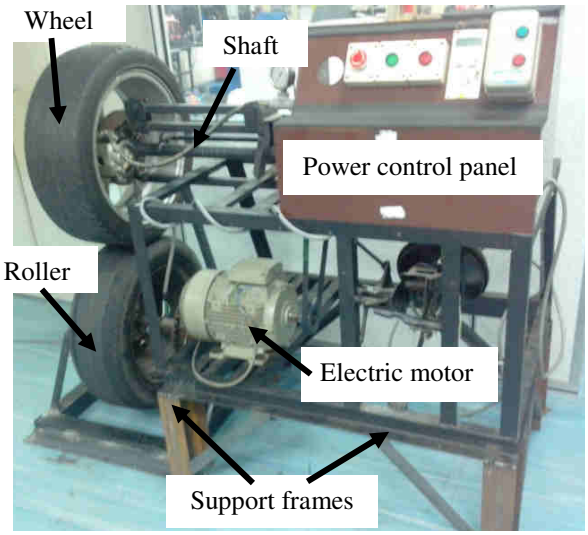

Figure 3 Final ABS test rig prototype

4. CONCLUSION

In conclusion, the antilock braking system test rig was successfully designed and fabricated after considering all the available components and the requirements in designing the ABS test rig. The material selection processes did not only consider the strength of the material, but also its availability in the market, with its standard sizes and dimensions. The functionality test were run successfully, and the data obtained were valid to prove that the ABS test rig was considerably approved to run test and experiments on the behavior of standard passenger antilock braking system vehicles.

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Multi-order PID control for a simple suspension system

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Keywords: PID; multi-order PID; active suspension

ABSTRACT – This paper presents the comparison among passive, proportional-integral-differential (PID) and multi-order PID (MOPID) controlled active suspensions. The quarter car model is validated with previous experimental results. The active suspension control via simulation is performed at three different frequency regions which are below natural frequency of body, in between natural frequency of body and wheel and above natural frequency of wheel. The parameters are tuned and Dormand-Prince solver is used in the simulation. The MOPID controller produces good performance in controlling vertical body displacement and acceleration thus improve ride performance and comfort.

1. INTRODUCTION

Due to ride quality and vehicle handling compensations in passive suspension system [1], many researches have introduced several semi active and active suspensions in order to improve ride quality without compromising vehicle handling and stability [2]. These semi active and active suspensions have been implemented in simulations, laboratory scale test rig and actual in-vehicle experiments whether in non-guided vehicles such as passenger car and guided vehicles such as railway and locomotive [3].

The dynamic characteristics (vibrations and moments) which affected the vehicle performances [4] can be observed through real driving experiment of vehicle instrumented with simple and user-friendly data acquisition (DAQ) system [5]. The vehicle performances affected are mainly ride quality, handling and stability. The controlling of vehicle heave and pitch motions are hardly investigated and some used 2 degrees of freedom (DOF), 4DOF, 5DOF and 7DOF vehicle models [4] are investigated in controlling active suspension of ground vehicle [6]. In their research various active suspension system models with either quarter or half car models have been used in the design of the controllers.

This paper investigates and compares the performance of active suspension between PID and MOPID control approaches. The performance criterion to be evaluated is the ability of the controller in reducing vertical sprung mass acceleration and suspension travel.

2. METHODOLOGY

Three steps of methodology are followed in this study. The steps are modeling and validation of 2DOF quarter car model through comparison with experimental result, PID and MOPID control approaches. The quarter car model with two degree of freedom (Figure 1) contains the displacement of the unsprung mass Z_u and the displacement of the sprung mass Z_s. The road input is express by Z_r and the differential equations of quarter car model for active suspension two degree of freedom are given by;

$$M_u\ddot{Z}_u + K_t(Z_u - Z_r) + K_s(Z_u - Z_s) + C_s(\dot{Z}_u - \dot{Z}_s) - F_p = 0 \quad (1)$$

$$M_s\ddot{Z}_s + K_s(Z_s - Z_u) + C_s(\dot{Z}_s - \dot{Z}_u) + F_p = 0 \quad (2)$$

Where M_u represents the wheel mass or unsprung mass, 30 kg, M_s is the body mass or sprung mass, 150 kg, C_s is the stiffness of the damper, 1000 Ns/m, K_s is the stiffness of the spring, 37500 N/m, and K_t is the stiffness of the tire, 100000 N/m. F_p is the actuator force. The validation of quarter car model is validating using the experiment data [6] which is using the same parameters. Validation is described as the differentiation between the simulation model performances with the experimental result.

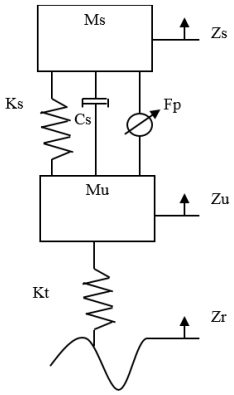

Figure 1 Active suspension quarter car model

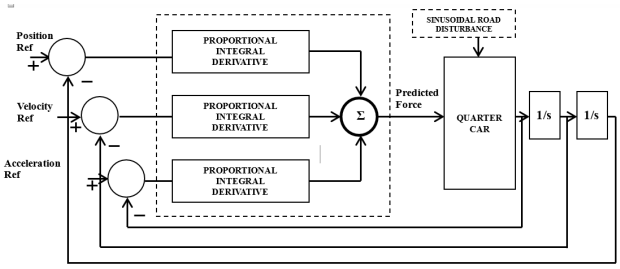

Figure 2 MOPID control structure

3. RESULT AND DISCUSSION

Body vertical displacement of the model is validated at 0.94 Hz (Figure 3). Figure 4 shows the body vertical displacement feedback from the input of the 0.5 Hz road disturbance at the amplitude of 0.04 m. It shown that body vertical displacement after the introduction of MOPID active suspension system are better compared to PID active suspension and passive suspension system. The output amplitude reduced to approximately 0.01 m for the MOPID. The 75% reduce of body displacement after the sinusoid input shows that the MOPID active suspension improves the performance of the vehicle suspension.

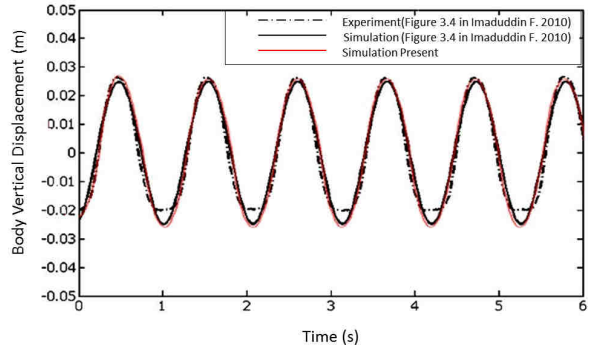

Figure 3 Validation result for vehicle body vertical displacement at 0.94 Hz

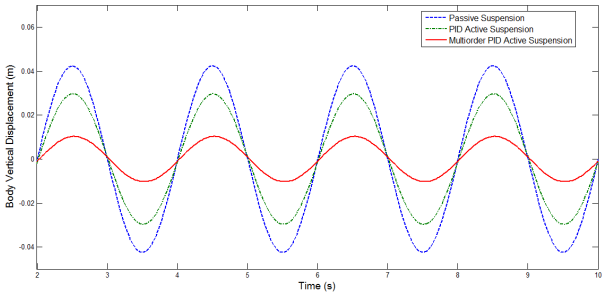

Figure 4 Body vertical displacement of 0.5 Hz sinusoid road profile

4. CONCLUSION

The simulations were carried out with the same parameters of [6]. The results show that the trends between simulation and the experiment and simulation data of [5] are identical and have the same pattern. Thus, the model is validated. The simulation of MOPID control for active suspension has been studied to investigate the performance improvement between MOPID controller, PID controller and passive system. The introduction of multiple PID loops, outer loop and inner loop are able to improve the ride performance and ride comfort. The amplitude displacement is reduced to 0.01 m, which is 75 % of the original disturbance amplitude. It can be concluded that the proposed MOPID controller has good performance in controlling the body vertical displacement. The MOPID controller system improves the ride performance and ride comfort of the vehicle.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the Advanced Vehicle Technology (AcTiVe) research group of Centre for Advanced Research on Energy (CARe), the financial support from Universiti Teknikal Malaysia Melaka, PTPTN and The ministry of Education, Malaysia under Short Term Research Grant, Grant no. PJP/2014/FKM(10A)/S01330 and Fundamental Research Grant Scheme (FRGS), grant no.: FRGS/2013/FKM/TK06/02/2/F00165.

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Effect of carbon nanofiber nanofluids as coolant on surface roughness and tool wear in turning of D2 steel

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Keywords: Turning; nanofluid; D2 steel

ABSTRACT – The present work studies the effect of carbon nanofiber (CNF) nanofluids as a coolant for turning of D2 steel. The CNF nanofluids were varied in terms of concentration and the turning performances such as surface roughness and tool wear were investigated. The result shows that 0.75% of CNF nanofluid gives the optimum result for both surface roughness and tool wear**.**

1. INTRODUCTION

Turning is one of the basic processes of metal removal. Turning is generated for external cylindrical surfaces. However the workpiece quality and tool life is affected by the heat generated in the cutting zone during turning process [1]. This problem is more pronounced when turning hardened material such as D2 steel. To overcome this problem, many researchers come out with several ideas such as changing the coolant type and technique.

For example, Navas et al. [2] found that cryogenic machining is the best solution since it reduced machining problems of heating, leading to tool life improvement and better surface integrity of turned components. Meanwhile other researchers [3] said that minimum quantity lubricant (MQL) can give better surface finish beside promoted green environment in the shop floor, minimized the industrial hazard and usage of large quantity of cutting fluid. Srikant et al. [4] stated that with inclusion of nanoparticles, it enhanced heat transfer hence give better tool life. However, to date, the studies of nanofluid in turning process are still limited.

Therefore, in this study, five different concentrations of carbon nanofiber (CNF) nanofluid were evaluated on turning of D2 steel. Surface roughness and tool wear were investigated experimentally.

2. METHODOLOGY

The experiments were performed using conventional lathe machine and PVD coated carbide was used as the cutting tool. D2 steel having 50 mm diameter was used as the workpiece.

The cutting fluid used was carbon nanofiber (CNF) nanofluid which is made from deionized water (base fluid) and CNF as its nano adding material. The nanofluids were prepared using two-step method. The CNF at concentration as stated in Table 1 was dispersed into the 500ml deionized water with the aid of poly vinyl pyrrolidone (PVP) as surfacant by using ultrasonic homogenizer for one hour at 50 amplitude. The concentration of nanofluid is selected from previous literature [5]. PVP within the same mass of CNF for each concentration is added into the solution to avoid sedimentation and agglomeration.

Tool wear was measured using Mitutoyo toolmaker's microscope meanwhile the surface roughness was measured using Mitutoyo portable roughness tester. The experiment was repeated three times for each concentration. The details of machining conditions are presented in Table 1. The selection of depth of cut and speed is based on the recommendation of tool guide book.

Table 1 Machining condition

Depth of cut (mm)	0.25
Cutting speed (m/min)	300
Concentration of CNF nanofluid (vol%)	0, 0.25, 0.5, 0.75, 1.0

3. RESULT AND DISCUSSION

3.1 Surface roughness

Figure 1 shows the surface roughness (Ra) value at different level of concentration of CNF nanofluid. From the graph, it can be seen that with inclusion of 0.75% of CNF, it gives the lowest Ra value which is at 2.37 µm. It also showed that the surface roughness is getting better with the increases of CNF concentration. This phenomenon might due to the present of CNF which having high thermal conductivity and advanced tribological properties [5]. According to Krishna et al. [6] the increasing of temperatures highly influences the surface quality of the machined workpiece. Therefore, the CNF particles in the nanofluid might reduce the temperature at cutting zone as due to its nano size, it can fill in the gap between the tool and the workpiece and thus transfer the heat produced.

However, when the concentration is reached at 1%, it produces rougher surface finish (3.51µm). When the CNF concentration increases, the number of nanoparticles in the fluid will increase as well. So it will disturb the cutting process where too much CNF particles might slip in the gap between the tool and the workpiece and take over the role of cutting tool to cut the material. Rahmati et al. [1] also stated the same

where in their investigation, it found that the nanoparticles were shear off by other incoming nanoparticle exfoliated film and thus resulting higher surface roughness.

3.2 Tool wear

Figure 2 shows the tool wear when turning of D2 steel under different CNF concentration.

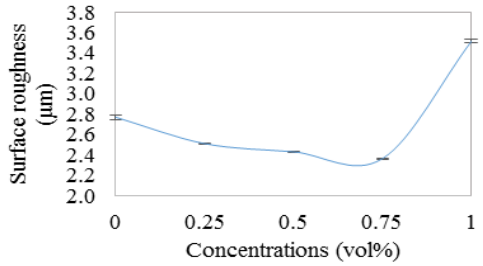

Figure 1 Effect of nanofluid concentrations on surface roughness

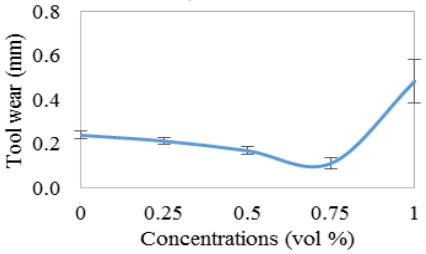

Figure 2 Effect of nanofluid concentrations on tool wear

Figure 2 shows the effect of nanofluid concentrations on tool wear. It can be observed that the wear gradually decreased up to 0.75% volume fraction of CNF. Rao et al. [7] said that the concentration of nanofluid does affect the tool wear. Because of its nano size and shape, the CNF particles might be mending to the tool and act as the protective film. Besides that, it was found that nanoparticles have excellent tribological behavior thus reducing friction and wear as it prevents direct contact between tool and workpiece because of the protective film produced [8].

However, when 1.0% volume fraction of CNF was used, the wear is drastically increases and even higher than the one obtained with 0% volume fraction of CNF. This might be due to the thicker film that produced when higher concentration was used and it required higher cutting force thus lead to increasing the wear. Padmini et al. [5]also found the same whereas with increase in concentration it may resulting poor stability of nanofluid where there might be agglomeration of nanoparticles. Therefore, this may increase the coefficient of friction which leads to obstruction during machining.

4. CONCLUSIONS

This study is focused on the investigation of turning process on AISI D2 steel using CNF nanofluid. The percentages of CNF concentrations were varied to investigate their effects on the turning performance, which is surface roughness and tool wear. From the results obtained through this entire investigation, it can be concluded that better surface quality and lower tool wear can be obtained using CNF nanofluid compared to conventional cutting fluid. The optimum CNF concentration for turning D2 steel is at 0.75% for both surface roughness and tool wear.

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Industrial robotics in the lean enterprise: A case study in semiconductor industry

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Keywords: Lean Enterprise; industrial robotics; human interaction

ABSTRACT – Industrial robots can replace human workers in almost all field due to their abilities to multitask, flexibility and configurability in any position they involved in. However, implementing industrial robotics is challenging due to their high cost, expert handling and complexity. The case study will determine the current mapping of the industrial robotics through studying these areas availability, ease of use, standardization and visualization. Performance measurement will be determined using the QCDAC method or (quality, cost, delivery, accountability and continual improvement). Cross tabulation is developed to show the intersection between the usage of industrial robotics and their performance. Human- robot interaction considered to guarantee the workers safety working alongside industrial robotics. So introducing the industrial robotics into lean enterprise will support it in terms of quality improvement, cost reduction and efficiency.

1. INTRODUCTION

The industrial robotics defined as "a re-programmable multi-functional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions. Industrial robotics have a various rang of application in different fields to perform tasks such as assembly, transportation and repetitive tasks prepared with minimal sensing and computing. The wide usage of industrial robotics with the competitive climate along with different benefits from reducing waste to increasing efficiency. However, the investments in industrial robotics is challenging because its costly and complex in terms of programming, controlling and architectures [1]. Cooperation between industrial robotics and human will enhance the flexibility and performance of the industrial environments. Industrial robotics performance can improve productivity, flexibility, quality, cut waste [2].

The process of waste elimination studies the whole system of the company, from the raw materials to the sales of the products and every segments in between is being inspected. Lean enterprise is "a group of individuals, functions, and legally separate but operationally synchronized companies" [3]. Lean enterprise focuses on all the employee of the enterprise from the bottom to the top and making them as an important strength of the company [4].

2. METHODOLOGY

The focus of this study is divided into three parts. The first part is to define the industrial robotics as a desirable tool in lean enterprise, the second part is to map the current usage of the industrial robotics and the third is to determine the performance of the industrial robotics. The first part of the study can be achieved by going through the literature review on three main areas which are industrial robotics, lean enterprise and human interaction.

For the second part of the study it can be achieved by focusing on 4 areas to determine the mapping of the industrial robotics as shown in Figure 1.

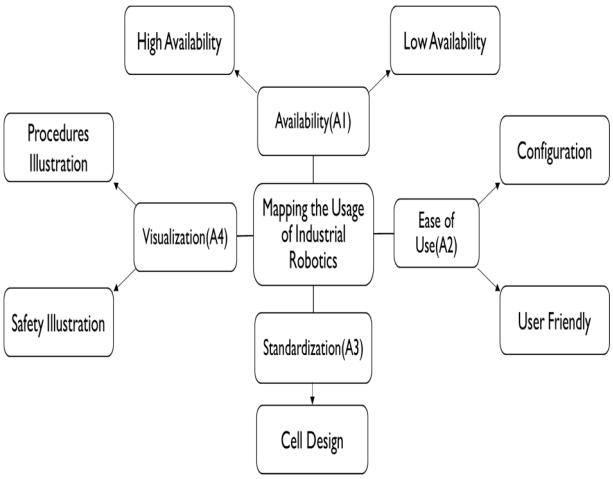

Figure 1 Mapping the usage of industrial robots

For availability, it is a common problem when a number of machines is connected. It will make the cell have several stops which will lead to other problems that could be avoided such as maintenance cost and so on. For ease of use, it's in term of configuration, setting up the industrial robot and user friendly interface. For standardization, it concentrates on similar design of robot working cells which will make the operator interaction easier due to design similarities. Lastly for visualization, it covers the operator's interaction with the industrial robotics and their safety as well providing illustration to show how to interact with the industrial robotic safely.

The third part of the study will be achieved by the QCDAC method shown in Figure 2.

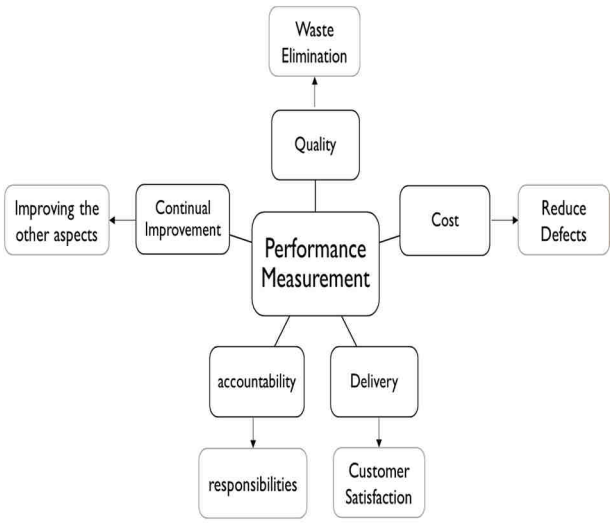

Figure 2 Performance measurements

This method will measure each activity that is related to all these areas. Quality of products will increase due to industrial robotics accurate and fast technology level which lead to cost reduction. Delivery on time will improve for products batches and that will lead to customer satisfaction alongside with accountability and continual improvement.

3. RESULT AND DISCUSSION

Cross tabulation shown in Table 1 have been developed to map between the usage of the industrial robotics shown in Figure 3 and the performance measurement of the industrial robotics shown in Figure 4.

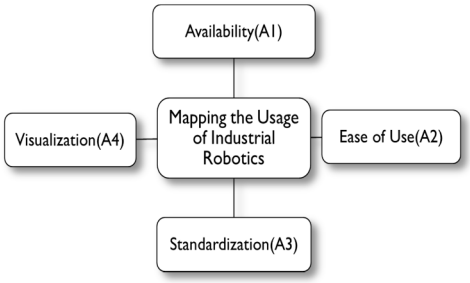

Figure 3 Usage of industrial robots

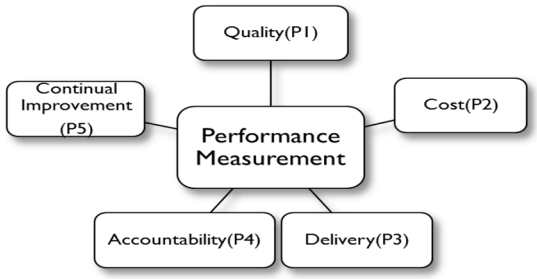

Figure 4 Performance measurement of industrial robots

Table 1 Cross tabulation

P / A	P1	P2	P3	P4	P5
A1	A1P1	A1P2	A1P3	A1P4	A1P5
A2	A2P1	A2P2	A2P3	A2P4	A2P5
A3	A3P1	A3P2	A3P3	A3P4	A3P5
A4	A4P1	A4P2	A4P3	A4P4	A4P5

The cross tabulation in Table 1 shows the interaction between (A1), which is the availability from the mapping process and (P1), which is the quality from the performance measurement and so on. It will show how industrial robotics could be used in lean enterprise to improve quality in term of the availability of the industrial robotics.

The expected result after finishing the project will be summarized in that the usage of the industrial robotics will support lean enterprise in many areas. The advanced technology offered by industrial robotics accomplish multitasks fast and with efficiency and that will be a good step to become a world-class manufacturer.

4. CONCLUSIONS

Industrial robotics advanced technology enabled them to replace the human workforce in manufacturing application and tasks that need speed, efficiency and precision in completing them. Due to their features, industrial robotics has a wide range of application in all fields. Even though they have a very complex architecture and expensive cost but their benefits super pass that because they are flexible and they adapt to changeover fast. They can be reconfigurable and reprogrammable which mean that the industrial robotics can be repositioned in the production line to suit the task that they are required to do. Introducing industrial robotics in lean enterprise which is concerned in eliminating waste and improve the quality of the products considered as desirable step to take the organization to the next level.

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Development of cyber-physical system for the reconfigurable conveyor system

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Keywords: Cyber-Physical, reconfigurable conveyor system, software-in-the-loop

ABSTRACT – Cyber-Physical is a new generation system with integrated computational and physical capabilities that can interact with human. This paper shows the understanding of Software-in-the-Loop (SIL) by the implementation of cyber system to the development of Cyber-Physical system to the Reconfigurable Conveyor System (RCS) using Tecnomatix Plant Simulation software.

1. INTRODUCTION

Technological advances have brought us to involve with the complexity of system construction shrouded by the sub-system around more primitive but equally complex. In future, this system will evolve into larger sub-systems, more complex and super-system. RCS is designed where it can adapt to the rapid changes in conveyor physical structure and software component where it can quickly adjust production capacity and functionality of part family in response to the sudden changes in market demand [1]. For the prototype development, high cost is required to make a full conveyor system based on its criteria and specification needed. In addition, the last minute of modification to the finished physical system involve waste in the factor of cost and time. So, involvement of cyber system gives huge impact where it can avoid repetitive process when designing the configuration of reconfigurable conveyor system and reducing cost

The term Cyber-Physical systems (CPS) refers to another era of systems with incorporated computational and physical abilities that can communicate with people through numerous new modalities. The capacity to collaborate with, and extend the abilities of, the physical world through calculation, correspondence, and control is a key empowering agent for future innovation advancements [2]. Hardware and software parts, middleware, and working systems should be created that go past existing advancements. The hardware and software must be very dependable, reconfigurable, and, where required, certifiable, from segments to completely incorporated systems. Such unpredictable systems must have a dependability that is inadequate in large portions of today's cyber infrastructures. Advances in Cyber-Physical systems research can be quickened by identifying needs, difficulties, and openings in a few mechanical segments and by empowering multidisciplinary community inquire about amongst the scholarly world and industry. The goal is to grow new systems science and designing techniques for building high-certainty systems in which cyber and physical outlines are good, synergistic, and coordinated at all scales. Momentum and past industry interests in Cyber-Physical systems innovation look into have been significant yet centred around shorter-term, snappier result restrictive advances.

Klebanov et. al. [3] state that cyber system is one of the tools for improving the manufacturing processes for research system based on a computer model that imitates the structure and processes of real system and also conducting computational experiments on models. Control system testing that can be done during the process development of system without wait the physical system complete called as virtual commissioning [4].

This paper presents the development process of cyber system based control system in performing SIL technique to support the RCS.

1.1 Methodology

Figure 1 shows the flow chart of process for cyber system development starting from physical system modelling, construction of control logic in cyber system, development of cyber system configuration, analyzing the integration capabilities and last but not least demonstration.

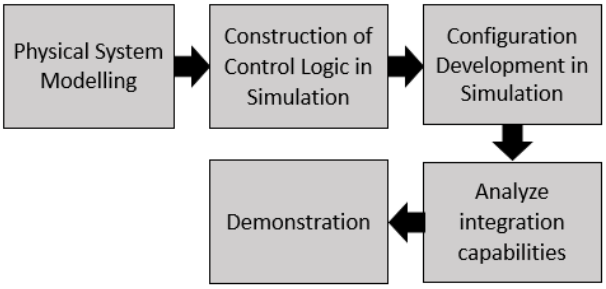

Figure 1 Methodology Flow Chart

1.2 Architecture

Figure 2 shows the architecture of the cyber system concept which to enable SIL in RCS. For the cyber system, Tecnomatix Plant Simulation software is the core of this cyber system where it is the medium for the systems model and controls model, which need to be

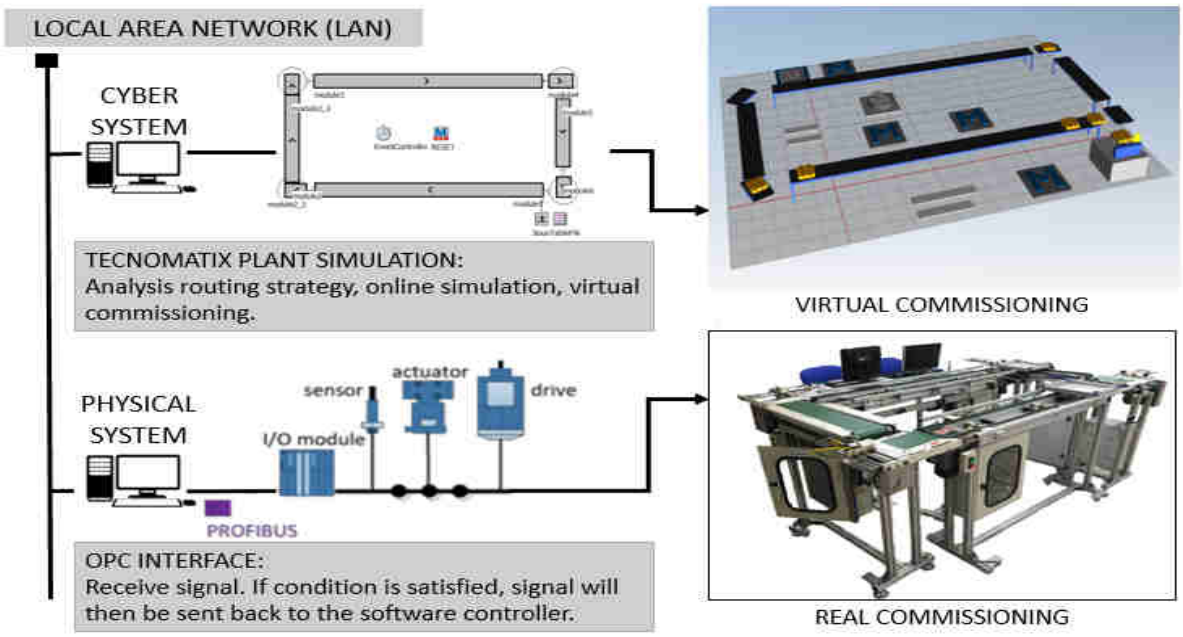

Figure 2 The Architecture of Concept for RCS involving SIL

constructed as close as possible regarding to the real system with homogeneous level of details. I/O has to be included in the model as Boolean variables and then mapped with the system I/O through OPC items. OPC server has to be used for creating the items.

2. RESULT AND DISCUSSION

The system model and control model of the assembly system have been created by using a Tecnomatix Plant Simulation software. Cyber system is then performed by using the internal communication of the software between system model and control model. The selected assembly system consists of a closed loop conveyor system and three other configuration which are straight line, U-shape, and L-shape. One of the example of physical system which is closed loop is built with six modules with linear single drive belt conveyors connected to each other in a closed loop topological structure. Cyber system were created according to the stated physical system including placement of actuators and sensors followed by programming for each modules.

Next, the control model is utilized to control the physical system through SIL strategy. Correspondence between them is done utilizing OPC protocol.The implementation of Cyber-Physical system involving SIL procedure required more opportunity to finish the entire operation because of some response times of the cyber system programming have not been considered in the system show.

3. CONCLUSIONS

In this paper, the overall possible layouts were done considering to the function and programming for each module. The cyber system was carry out by using Tecnomatix Plant Simulation software where it can minimize risk by suggest the best option and good decision before making the wrong concept. The architecture of concept approach to achieve this has been proposed. SIL strategy has permitted the Cyber-Physical software that generally utilized for system analyzing to specifically control the operation of assembling system. However, somewhat longer time is required contrasted with the cyber system due the response time amongst hardware and software. This extra time however is not perceptible. The results can be validated for the future research and study.

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Preliminary survey of redesigning an economical lumbar support device using Malaysian anthropometric data

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Keywords: Economical lumbar support system; anthropometric; musculoskeletal disorder (MSD)

ABSTRACT – Nowadays, the competition between industries give benefits to global economy. However, this will increase the working period and lower the productivity of workers in order to satisfy the market demand. The long working hours could potentially increase the cause of back pain and musculoskeletal disorder (MSD) to the workers. The redesign of the lumbar support system is among the method that could possibly solve this issue and improve the safety and comfort of the workers. Therefore, the aim of this research is to focus on redesigning the lumbar support for industrial workers using the Malaysian anthropometric data. Thirty workers were involved in the questionnaire survey and in the main experiment to validate this lumbar support device. These respondents were from industry and rehabilitation centre. The result of this work is expected to produce a comprehensive data in order to produce the design of lumbar support device following the Malaysian anthropometry data and this system expected to solve the back pain problem in industries.

1. INTRODUCTION

Back pain is the most common injury for workers especially in industries because of the working condition as identified by NHIS Occupational Safety and Health Information System (NIOSHTIC) [1]. Due to the nature of their occupation, about 46.7% suffered from low back pain (LBP). These postures of backward and forward during work, pulling object during work and work more than 10 hours/day are the factors of LBP [2]. Back pain is considered as one of the most prevalent musculoskeletal complaints and remains as the main concern in the occupational injury record in Europe. It is in the list of items of the occupational health and safety field, stated by the European Agency for the years between 2013 and 2020 [3].

Back pain can also be attributable to the effects of work stress because of the pressure in back body. Therefore, it can affect the productivity of workers [4]. Back pain often become the risk of physically demanding work in situation where the workers performing their work in awkward postures, repetitive work, lifting heavy loads, standing up for long periods of time and exposed to vibrations [2,3,5].

2. METHODOLOGY

There are four categories within the questionnaires consisting of category A (personal information), category B (knowledge on ergonomic), category C (level of pain at all body part) and category D (problems related to job activity). The questionnaires were distributed to each and every member of the PERKESO rehabilitation centre (PRC) and PHN industrial workers. Figure 1 below shows the flowchart of constructing and analyzing the questionnaire.

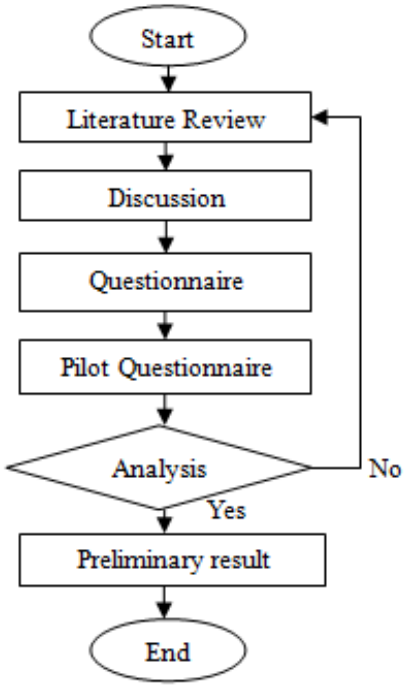

Figure 1 Flow chart of the methodology

3. RESULTS AND DISCUSSION

In this preliminary result, the survey managed to collect thirty responses. At this stage, the survey successfully interviewed four case studies. The work will be carried out to complete this study. As observed in this survey, respondents were suffering or doing work that can contribute to back pain problem. The respondents for this preliminary survey include one staff nurse and three rehab workers, which were involved in

lifting, pulling and prolong standing and sitting during working hours.

Analysis from the survey shows that the average age of these respondents are between 20-29 years. The respondents have been employed in similar position for a minimum experience of ten months and maximum experience of about five years.

Figure 2 shows the respondents' work activities versus number of respondents. Based on the survey, it was discovered that the respondents had health issues due to physical routine work activities such as lifting, pulling and prolong standing and sitting. Many previous studies agree that prolonged standing and manual lifting will develop into MSD [2,5].

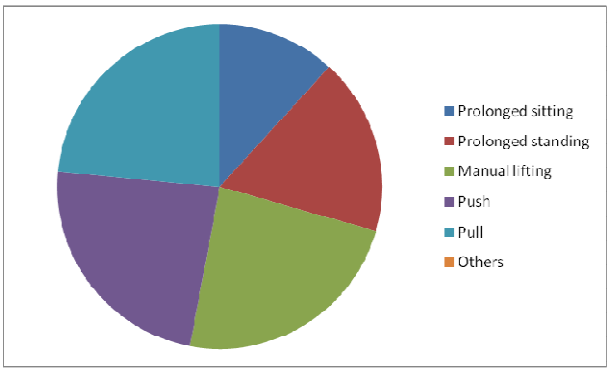

Figure 2 Graph of working activities versus number of respondents

Moreover, this strenuous works is proven to cause MSD of the body. Figure 3 shows the painful part of the body versus number of respondents. Many of them face pain at the same parts, which are lower back and feet.

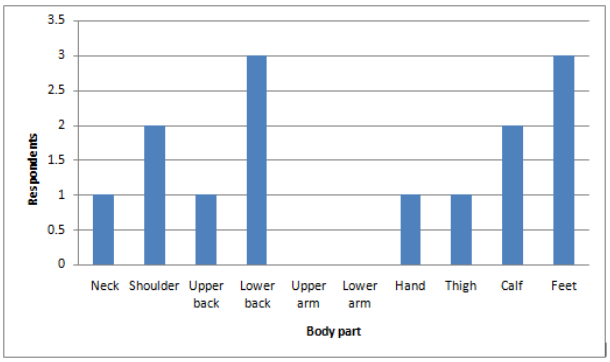

Figure 3 Graph of painful body part versus number of respondents

4. CONCLUSIONS

In conclusion, the MSD or back pain problems occurred when a person working activities include manual lifting, prolonged standing and backward/forward posture performed over a long duration. This survey also observed the problem faced by workers who are suffering with these issues. The information from this research could contribute to the device support design for lumbar, which can fulfill the economical values and user satisfaction. This is due to the reason that the support device can be customized based on each of the anthropometry data that have been collected within this research. In addition, the comfort from the support device can reduce the back pain and increases the productivity of the workers.

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Preliminary study on plantar pressure distribution associated with prolonged standing among workers in aerospace industry

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Keywords: Prolonged standing; plantar pressure

ABSTRACT – There are numbers of occupations that require workers to be in standing position for a long period. This will resulted into multiples health risks that include foot and lower leg deformities, back problems, lower extremity swelling, venous blood restrictions, discomfort and back pain. This also effect on the social insurance, absenteeism, productivity, and well-being of the worker. The health of the foot can be determined through examining the characteristics of plantar pressure. F-Scan is used in this study in order to measure the peak plantar pressure of the worker. The purpose of this study is to measure the magnitude of peak pressure and contact area exerted at the foot among workers in aerospace industry when they performed their tasks in a prolonged standing. It is expected that workers who are in standing position for a long hours will have a high peak plantar pressure.

1. INTRODUCTION

Many occupations such as automotive industry workers, cashier, bank tellers, casino dealers [1], health care personnel, retail staff and assembly line workers are required to work in prolonged standing [2]. It is found that 47% of workers spent 75% of their working hours in standing position [2]. Prolonged standing has been rated as the most common physical risk in European workplaces based on the result of The European Working Conditions Survey 2010 [3]. Standing is a normal posture for human and it brings no harm to health. However, working in standing position for a long duration of time and performed as a daily basis will develop into health problems. Working in prolonged standing will expose the workers to the risk of foot and lower leg deformities, back problems, lower extremity swelling, venous blood restrictions, discomfort [4]. Moreover, prolonged standing is often associated with musculoskeletal disorder especially low back pain [1,2,5]. These risks give negative consequences to the social insurance, absenteeism, productivity, and well-being of the worker [4].

Foot is the part of the body that interact the most with the environment during movement. For prolonged standing workers, it is exceptionally important to diagnose foot problems from the early stage in order to prevent injury. The health of the foot can be determined through examining the characteristics of plantar pressure [6]. Plantar pressure is the pressure that the human foot skin experience when carry out daily activities [7]. It is the pressure between the foot and the surface that support the foot during locomotion [6]. Pressure is an important variable in orthotic, prosthetic or footwear where a high pressure has a strong correlation to skin breakdown and cause pain [8]. One of the effective method of measuring the plantar pressure is by using in-shoe assessment device since it flexible and embedded in the shoe thus producing measurements that reflected the interface between the foot and the shoe [6]. F-Scan Mobile system (Tekscan Inc., South Boston, MA, USA) is an in-shoe measurement system that integrates insoles with 960 dissimilar pressure-sensing locations (sensels) and a spatial resolution of 4 sensels/cm^2 [9].

The purpose of this study is to measure the magnitude of peak pressure and contact area exerted at the foot among manufacturing workers in aerospace industry while they performed their tasks in prolonged standing.

2. METHODOLOGY

Data collection for the study will be done at an Aerospace company in Melaka. Ten subjects were selected to participate in the experiment. The subjects are from lay-up department where all of them performed their work in prolonged standing throughout their working hours. The experiment will be done towards the end of their shift which is the moment when they are at the most fatigue state. The subjects are all males and Malaysians. They will be explained about the purpose of the study and will be asked to give their consent before the experiment taken place.

For this experiment the subjects will be wearing their own safety shoes in order to resemble the actual scenario. The shoes are fitted with the sensors (F-scan Mobile System). One pair of sensors will be used in this experiment. The sensors will be trimmed according to the size of the shoes. Initially calibration will be done according to the Tekscan manual and the subjects will be asked to practice walking with the sensor on for about 10 minutes to ensure equilibration in the temperature of the insoles, and to allow the subjects to be familiar with the equipment. For the experiment, the subjects will be asked to walk for 3 steps with 3 trials. Previous studies showed that a mean of 3 steps improves reliability of plantar pressure measures to an acceptable level (ie, reliability coefficients > 0.70) [8].

3. RESULTS AND DISCUSSION

Since this experiment is not yet being done, the results and discussion part will only provide views on the expected results. It is expected that the peak pressure will be high especially if the subjects have ulcer at their foot. The contact area of the foot is expected to be low if the peak pressure is high. It can goes as high as 836 kPa as shown in Figure 1 based on a study previously done by Mueller. Once alteration of peak pressure by increasing contact area and provide necessary padding on the insole has been done, the peak pressure will be reduced. From that experiment, in the end the peak pressure has been reduced to 124 kPa.

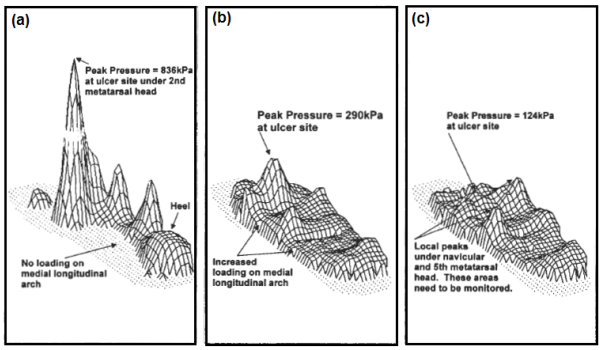

Figure 1 Peak plantar pressure of (a) barefoot, (b) in therapeutic shoes, and (c) in same therapeutic shoes with modifications based on readout of pressures in B [8].

4. CONCLUSION

In conclusion, as expected earlier workers that work in standing position for a long period of time have a high peak plantar pressure.

ACKNOWLEDGEMENT

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Proceedings of Innovative Research and Industrial Dialogue'16, pp. 155-156 (May 2017)

Virtual reality immersive system in aerospace manufacturing: A case study

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Keywords: Anthropometric database, DELMIA V5, body measurement

ABSTRACT – Virtual reality (VR) immersive system is a system that stimulates the user to acts as in reality but not in actual real life conditions. The VR is classified as similar to pilot simulation training that trains new pilot students before getting a license. In order to achieve the VR system for aerospace industrial workers, the anthropometric database for Malaysian aerospace industry has to be developed. The findings from this study shall obtain the best possible working postures and procedures for manual handling before the transfer process into the VR system. This will be used to train new workers in the aerospace industry and improves the quality of products manufactured. Thus, this will help in decreasing the wastage of materials and also improves the productivity of workers.

1. INTRODUCTION

The Malaysian economic growth and technological improvements will lead to greater demand and development of machinery and devices used in an industrial setting which also increases the high probability of human and machine interaction. Immersive virtual reality is a hypothetical future innovation that exists today as virtual reality art projects, generally. It comprises of immersion in a simulated environment where the user feels generally as immersed as often feel in consensus reality. Flight simulation which is known to virtual reality is an environment in which student pilots can safely learn the demanding mental skills to anticipate collisions and to select rule-conforming avoiding collisions [1]. Also, research shows that anticipation-based simulator training was effective for improving pilots' anticipatory processes and actions of pilots in recovering the aircraft from various critical states such as unusual altitudes, full stalls, and spins [2]. The application of VR is to develop a system for training before working in the aerospace industry and it covers in lay up process, mechanical assembly and spray painting process.

In recent studies, VR only covers on workplace for stud welding, hole drilling and manual assembly in the manufacturing industry and the application allows to present the virtual prototype of the workplace in its real operation environment, limiting the need for use of real mock-ups [3]. Another study was done to prove that VR system is their reliability and user acceptance manual welding workstation [4]. Both VR systems were performed in non-aerospace manufacturing industry. Figure 1 shows manual welding virtual scene. The VR can be developed by using software such as DELMIA V5 and SIEMENS PLM system. The population in Human Builder in DELMIA V5 software are using the Malaysian anthropometry data. However, there is a lack of anthropometric data involving the major ethnic group in Malaysia. Anthropometric database of Malaysian workers from 10 industrial sectors reference in Malaysian worker's workplace was developed; they were exposed to musculoskeletal disorders (MSDs). Since Malaysia is lacking in term of the anthropometric database, the anthropometric measurement is taken in the aerospace industry.

The objective of the project is to develop the virtual reality immersive system for training in aerospace manufacturing by using the simulation from DELMIA V5 software. This study aims to increase the quality of the products, improves the productivity of workers and reduce wastage of the materials. The study is conducted using anthropometric data of 100 Malaysian workers consisting of males and females in the aerospace industry.

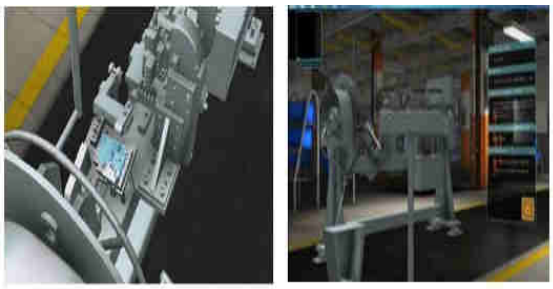

Figure 1 Manual Welding Virtual Scene (Ordaz et al., 2015)

2. METHODOLOGY

Data collection is divided into two parts which are qualitative and quantitative data collection (Figure 2). In qualitative data, one form of the survey questionnaire is distributed to workers in aerospace industry mainly in lay-up process workers. The questionnaire is divided into 4 parts. The first part consists of the demographic data of the respondent. Next, the survey will be divided into another 3 parts which are; discomfort experiences at the workstation, discomforts experienced during working activities and discomfort experienced on their bodies.

The equipment used in this study are measured tools comprised of Human Body Measuring Kit and Anthropometry for body dimension measurements. A total of 103 anthropometry dimensions based on DELMIA V5 software is identified in this study. The data collection is for both standing and sitting postures. Figure 3 shows a

posture while doing layup process as produced by DELMIA V5. The database comprised of the important values such as the mean and the standard deviation, the 5th and 95th percentile. The study successfully produces a detailed and comprehensive anthropometry database for a Malaysian population which can be used in the future by all designers and engineers in designing process. The database produce will be used by DELMIA V5 software to find the best possible working procedures that will be installed in a Virtual Reality system. DELMIA V5 is used in this research because it contains simulation that can predict any health problem issue that will occur due to the work procedures. Hence, it may avoid future health problems that are caused by the wrong working posture.

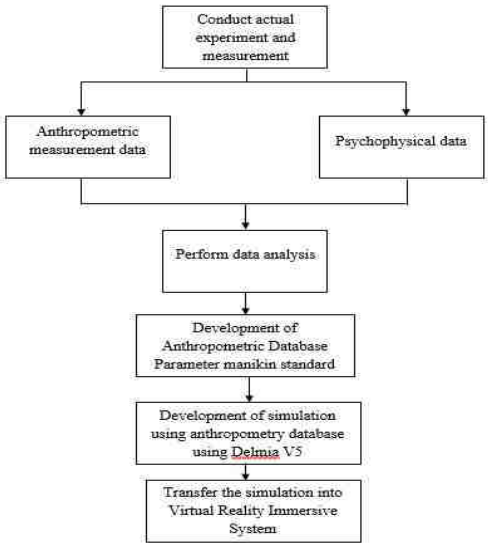

Figure 2 Flowchart of the study

3. RESULTS AND DISCUSSION

The usage of DELMIA V5 software is to provide the simulation of the lay up process. DELMIA V5 can be used to redesign the lay-up process and also the addition of human manikin to do the work with respective postures. The manikin will be using the average anthropometry measurement in the workers in the aerospace industry. This feature can be used with CATIA V5 software, however, DELMIA V5 has simulation features. Hence, it could stimulate the best posture possible for the workers to have and best anthropometry measurement for the specific task. VR is one type of simulation that allows the user to practice their work procedures according to the real situation but virtually. Hence, it could reduce the loss of wastage during training and help workers to be more experienced in their work specification without having to be injured on doing their jobs. This working process will be similar to piloting simulation training, but more on the manufacturing side.

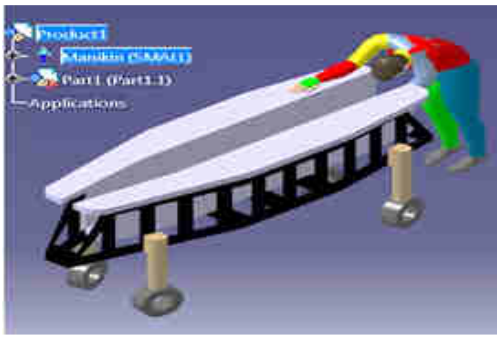

Figure 3 Posture while doing layup process by DELMIA V5

4. CONCLUSIONS

In the aerospace industry, most of the manufacturing activities are done by manual handling compared to electronics manufacturing. Many reported discomforts by workers as stated by the HSE department causing many sick leaves and health insurances to be paid. Since new workers had to be employed to replace the old and fired worker, they provide leverage to the company by increasing waste of the materials. High-end manufactures of aerospace industry need zero defect products, hence, rejected parts will cause an increase in the wastage materials and reduce the productivity of the company. The development of VR simulation training is expected to reduce the wastage of materials because the trainees will use VR instead of reality training. VR also will increase the productivity of industry as workers are trained to do their respective jobs in accordance with the proper postures and procedures.

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Development of cutting technology and assisted jig for polymer foam cutting

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Keywords: Cutting technology; jig; machine tool

ABSTRACT – This paper presents the development of cutting technology in the form of Vertical Bandsaw Machine (VBM) and assisted jig for manufacturing polymer foam. The main function of the cutting technology is to cut large foam with minimum of 2 m (width) x 1 m (length) x 0.0254 m (thickness). Several processes involved including establishment of the design concept, determination of machine specifications and fabrication of the cutting technology. Further, the cutting technology has been tested to cut according required dimension. The results show that the machine developed capable to reduce the thickness of foam with proper control during material feeding. Several suggestions were discussed to improve the machine.

1. INTRODUCTION

Polymer foam is made up from solid and gas phase mixed together to form a foam. Since it has lots of gap inside the structure, this material widely applied as heat insulator and sound barrier [1]. In advanced structural application, such structure with entrapped gap is used as a damper for the automotive or aerospace body part since it has lightweight characteristics [2-3]. In the industry that we refer, the polymer foam is prepared with the size around 1 m (width) x 2 m (length) and 0.0254 m (thickness). The polymer foam then will be cut into custom size according to the suitability of the application.

One of the machines that suitable to cut the respected polymer foam is Vertical Bandsaw Machine (VBM). Polymer foam can be cut with the high rotating blade that shears the foam into the required dimension [4]. Usually the operator loads the workpiece through the cutting blade by manual using their hands. Unfortunately, commercial VBM is too small and unable to cut the large size of this material for the large size of 1 m (width) x 2 m (length). Such machine need to be customized built. In addition, the large size of polymer foam requires special jig to hold firmly the product.

Early idea of cutting innovation has been presented at [4]. The VBM machine was built with has been produced combining customization of several commercial components taken from the existing small band saw including upper and lower frames and pulleys, blade guide. Custom aluminium bar, blades and platform stand were also installed together. This research focused on the improvement of VBM intended to cut the polymer foam with the dimension 2 x 1 x 0.0254 m. Modifications have been made with the addition suitable DC motor and assisted jig to hold the polymer foam that assembled together to facilitate the polymer foam cutting. The processes that involved in developing this machine were drilling, cutting, sawing and assembly.

2. METHODOLOGY

2.1 Concept Design of VBM

Figure 1(a) shows the concept design of the VBM developed in this study. There are 5 parts involved in the component design, including upper and lower frames, pulley, DC motor, blade guide, v-belt and blade. Figure 1(b) is the completed VBM with illustration of blade lines. The VBM and assisted jig developed in this study is an extension from previous research [4].

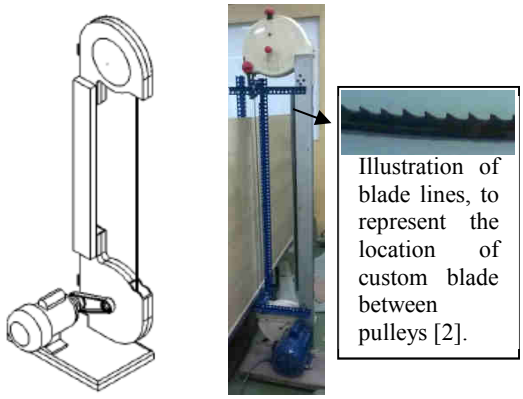

Figure 1 Design concept (a) and completed VBM (b) [4]

2.2 Assisted Jig

Figure 2 shows a jig that used to hold the polymer foam during cutting. The jig is made of plywood for a frame structure and steel for the platform. A big frame is needed as a guide to support the specimen during cutting. A supporting beam is screwed in to ensure the frame position is always perpendicular to the platform. The platform is covered with wood table to balance the frame weight. By supporting the specimen, an additional operator is no longer required to hold the specimen after it being cut.

Figure 2 Assisted Jig to hold the polymer foam

3. RESULTS AND DISCUSSION

3.1 Analysis of Functionability

In order to evaluate the cutting ability of the machine, the polymer foam material is placed near to the jig (feeding table) before pushed forward. Figure 3 shows the polymer foam material that placed at the jig. Such structured components and assisted jig are required to avoid damage of the machined part through chatter and vibration [5]. The cutting process occurred when the blade touch the polymer foam material. The operator must maintain the feeding speed during the cutting process to produce flat surface, as shown in Figure 3. The material was pushed until the whole polymer foam totally cut as shown in Figure 4. As the cutting process completed, the polymer foam unloaded from the jig.

Figure 3 Fabrication and assembly procedure of the jig

The functionality of the VBM can be improved if the automated system embedded in the structure. Automatic system could be added to replace the manual manpower that could be inconsistent throughout the process. From our observation, to cut the polymer foam with the size 2 x 1 x 0.0254 m, it took about 2 hours. During this period, the manpower that operated the jig could possibly exhausted, resulting inefficiency to cut the product. Automatic system can be applied in the form of automatic motorized motor that have consistent load and movement to push the material.

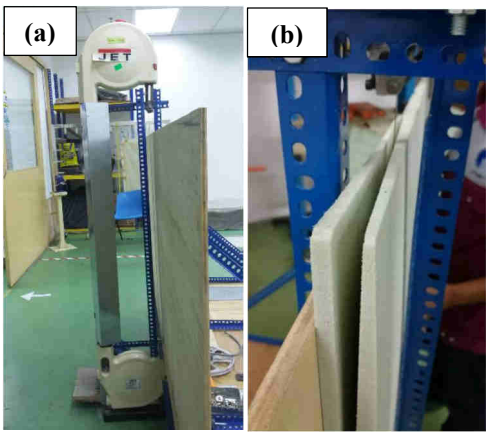

Figure 4 Completed cutting technology (a) side view, (b) close-up view

4. CONCLUSIONS

This paper presents a cutting of a large size polymer foam material using a vertical bandsaw machine and assisted jig. The machine consisted an integration of upper and lower frames, pulley, DC motor, blade guide, v-belt and blade. This newly developed machine could facilitate a large polymer foam cutting with less manufacturing cost, improved flexibility, and a minimum used of human energy if operated in an automatic mode.

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A review of BNT-BT ceramics for piezoelectric applications

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Keywords: BNT-BT, rare-earth, morphology, electrical properties

ABSTRACT – Bismuth sodium titanate (Bi,Na)TiO_3 or known as BNT is a ABO_3-type perovskite material. BNT has been studied as it possesses high temperature dielectric constant without the presence of lead. Interestingly, the electrical properties of BNT were further improved by mixing them with another ABO_3 compound, i.e. known as barium titanate ($BaTiO_3$), BT. As a further extension, the combination of BNT-BT was modified with rare-earth doping to have better electrical properties. This paper reviews research activities on BNT-BT with further improvement of electrical properties by doping with rare-earth oxides.

1. INTRODUCTION

Lead-based piezoelectric, such as PZT, caused harm in the environment and human health as they tend to release toxic elements at the high vapour pressure during the sintering process. In this matter, lead-free material is the most sought after solution amongst researchers to resolve this pollution [1]. A lead-free piezoelectric ceramics with a perovskite structure, such as ($Bi_{0.5}$ $Na_{0.5}$) TiO_3 (BNT), $BaTiO_3$ (BT), and ($K_{0.5}$ $Na_{0.5}$) NbO_3 (KNN), have been widely studied due to their good piezoelectric properties as revealed in previous studies [2,3].

Bismuth sodium titanate, (Bi Na)TiO_3, or known as BNT, is an ABO_3-type perovskite material [4]. BNT is the most studied in the past because it has a high temperature dielectric constant and its ability to work well without the addition of lead, or known as lead-free material [2]. Besides, bismuth is known as non-toxic in its oxide forms [5]. Therefore, BNT is considered to be a favourable topic in the field of lead-free piezo-ceramics because of its large remnant polarization (Pr ~ 38μC/cm2) and high Curie temperature (Tc ~ 320°C) among various lead-free piezoelectric ceramics as revealed in previous studies[3,5,6].

Most significantly, it can be prepared under ordinary processing conditions. Thus, to improve the electrical properties of BNT, either by doping with some suitable rare-earth dopants at the A- sites or A and B-sites, both by mixing them with other ABO_3 type compounds, such as $BaTiO_3$ [6–11]. In previous studies, $BaTiO_3$ is a well known lead-free ferroelectric material with perovskite structure that has good piezoelectric and dielectric properties[8,12]. BT has relatively low Curie temperature (Tc =120°C), along with the orthorhombic tetragonal (O-T) phase transition about 5°C led to temperature stability of the electrical properties[8] . So, for further application of BT ceramics, it is necessary to increase the Curie temperature and shift the O-T phase transition away from the application temperature range. By doping BNT into BT, it can increase the Curie temperature and the phase transition also gradually disappeared with increasing amount of BNT as stated in a previous study [12].

2. EFFECT OF RARE-EARTH DOPING ON MORPHOLOGY AND ELECTRICAL PROPERTIES

In previous studies, in order to avoid the volatility of Bi_2O_3 and obtain high density at low temperature, rare-earth such as La, Nd or Gd have been substituted on A-site in BNT system and acted as modifier that also enhanced the electrical properties [2,4,13]. The various dopants that are available for the modification of BT make it as chosen materials for many dielectric applications. The doping technique is believed to be an effective way to improve ferroelectric and piezoelectric properties of BNT-BT. Thus, rare-earth doped BNT-BT is believed to improve the electrical properties with a proper sintering technique [14]. Numerous studies have attempted to observe the effects of rare earths integration to lead-free piezoelectric ceramics.

In other works, researchers had conducted a research on BNT doped with Nd to study the structure and ferroelectric properties of BNT ceramics [4]. It was found that the XRD patterns for all the specimens showed single phase formation with rhombohedral structure. The grain growth was inhibited significantly with Nd content. As the increased of Nd concentration, the depolarisation temperature was found to be decreased whereas temperature of maximum dielectric constant 'Tm' was then increased.

So, in order to achieve high density BNT-BT, most researchers used variable sintering techniques. It was found that solid phase sintering of BNT6.5BT ceramics exhibited a single perovskite structure with the co-existence of the rhombohedral and tetragonal phase with XRD patterns. The increase of the sintering temperature up to 1180-1200°C induced significant grain growth with the appearance of coarse grains and the dielectric constant-temperature curves of the compositions exhibited strong dispersion with increasing temperature.

Moreover, the dielectric loss increased dramatically with temperatures over 230°C [6].

It was found that BNT-BT doped with rare-earths have been studied to improve the electrical properties of BNT-BT. Another report stated that the rare-earth elements are useful functions of stabilizing and lowering dissipation factor in dielectric ceramics [14]. Many works have been done and reported on the rare-earth doping in BNT-BT prepared by various techniques such as semi-wet method and spark plasma sintering, [2,4,7]. As an example, the substitution of Gd in BNT by a semi-wet technique showed that all the samples produced single phase with a rhombohedral symmetry at RT in the XRD patterns. Besides that, Gd^{3+} doping has shown a significant effect on the grain growth in previous study [2].

Previously, it was also reported on the density of pellet-like samples with different sintering temperatures. As reported that the bulk density was gradually increased with sintering temperature from 750 to 1150°C. There relative density at above 92% at 1150°C suggesting that all samples are well sintered at this temperature. It is understood that the modified BNT with BT and BKT possesses a greater density than pure BNT by adding K^+ and $Ba^{2+.}$ The highest amount of the relative density (96.64%) pertains from the sample is consistent with the SEM image of indicating presence of a liquid phase on the surface of the sintered ceramics yielding smaller porosity and greater density [15].

3. CONCLUSION

We have described the following points:

i- BNT-BT can be a compromising lead-free piezoceramics and other alternatives to PZT in piezoelectric application.

ii- Numerous study of rare earth doped with BNT-BT demands more efficient and good properties of piezoceramic materials for various application.

iii- A review on BNT-BT may inspire other researchers to expand on development and their efficiency for useful piezoelectric application.

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