Characteristic of metal magnetic memory signals under uniaxial fatigue loading for SAE1045 steel

Siti Norbaya Sahadan[1,2,*], Shahrum Abdullah[1], Azli Ariffin[1], Salvinder Singh Karam Singh[1]

[1] Centre for Integrated Design for Advanced Mechanical System, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi Selangor, Malaysia
[2] Fakulti Kejuruteraan Mekanikal, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

*Corresponding e-mail: norbaya@utem.edu.my

Keywords: Metal magnetic memory; stress concentration zone; tension-tension fatigue

ABSTRACT – The objective of this study is to evaluate changes in the metal magnetic memory method, MMM parameter during cyclic loading test from the beginning until fracture. Flat specimen with a notch made of SAE 1045 steel was used. MMM signals were collected during an experiment at one-hour interval using tester of stress concentration (TSC) device. From the experiment, it was found that the maximum value of magnetic flux leakage gradient $dH/dx_{(max)}$ is increasing as cycles number increase, and slightly decrease towards fracture. From this study, it shows that this method can detect a high-stress concentration zone on the material with high sensitivity.

1. INTRODUCTION

Detecting a high-stress concentration zone on a ferromagnetic component is crucial. It is due to the high-stress concentration zone is the potential position of damage. The conventional method only detects damage, that already developed. However, this method detects at an early stage of damage. In this study, the magnetic metal memory method (MMM) has been proposed to detect the high-stress concentration zone. At service loads condition where high strains on the elements will induce high metal magnetisation on the elements [1].

Fatigue failure occurred when components exposed to fluctuating service load leads to unforeseen failure. Parts with notch or holes have risen fatigue failure as this cause high concentration on components. Study by Yang et. al [2] found that decreasing of fatigue life and increasing of fatigue mean stress sensitivity due to notch. In this study, it is aimed to evaluate changes in MMM parameter during cyclic loading from the beginning until fracture.

2. METHODOLOGY

The tensile test experiment has been conducted to gather mechanical properties of the specimen. In this study, the specimen made of ferromagnetic material, SAE1045 which have much application in industry. The monotonic properties were tabulated in Table 1. Figure 1 shows the schematic drawing of the specimen with the scanning line. The distance between each line is 5 mm and the length is 100 mm. MMM signals collected at each of scanning line. For the cyclic test, the load used in this study is 65% UTS and stress ratio, R is equal to zero.

The 100kN servo-hydraulic universal testing machine used to conduct the cyclic test. A TSC device used to collect magnetic signals. Signals collected before loading, at one cycle loading and every one-hour loading cycles interval until specimen fracture. Figure 2 shows the arrangement of the UTM machine, the TSC device, and the specimen during testing. The collected signals stored in the TSC device and transferred to a computer and later analysed using a MMM 3.0 system software.

Table 1 Monotonic properties of SAE 1045.

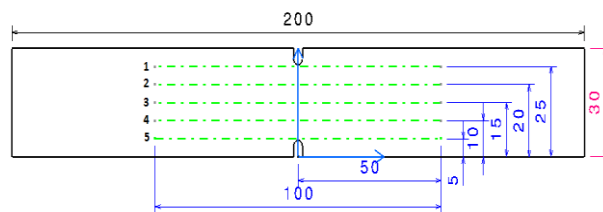| Properties	Data
Ultimate Tensile Strengh, σ_{UTS}	772.0 MPa
Yield Strength, σy	473.4 MPa
Young Modulus, E	169.7 GPa

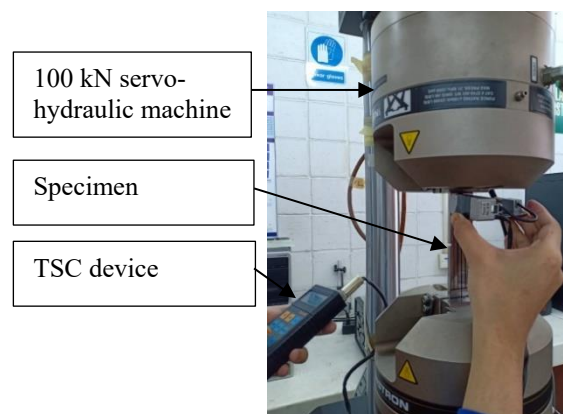Figure 1 Fatigue specimen and scanning lines.

Figure 2 Scanning process using MMM instruments – the TSC device.

3. RESULTS AND DISCUSSION

In this experiment, the specimen failure at 15969 cycles. MMM signals has been collected at 10, 100, 1000, 3600, 7200, 10800 cycles and 14400 cycles. Tabulation of magnetic flux leakage gradient dH/dx shows in Figure 3, the surface contour between dH/dx with the length of the scanning lines. In Figure 3, the dH/dx represents by the axis -y named as |grad H |. From

Figure 3, at the center of the scanning lines, at the length of 50 mm, it can be seen high-intensity color tabulation. From this color intensity, it demonstrates that there is high-stress concentration zone in that area. With comparison to the specimen, it is matched with the notch position on the specimen as shown in Figure 2. From these results it can confirm the ability of MMM method in detecting high-stress concentration zones in the specimen.
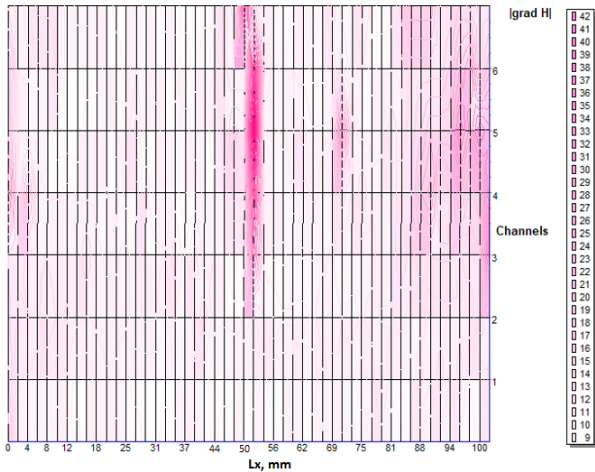

Figure 3 Surface contour mapping of *dH/dx* distribution along scanning lines.

Further analysis conducted to evaluates changes in the maximum value of magnetic flux leakage gradient $dH/dx_{(max)}$. Figure 4 shows the plot of $dH/dx_{(max)}$ with numbers of cycles. From Figure 4, the value of $dH/dx_{(max)}$ increased as the number of cycles increased during the experiment, until the number of cycles reaches 10000 cycles. However, as the experiment continues, the value of $dH/dx_{(max)}$ starts to decrease until the number of cycles reach 14400 cycles, given by the last MMM signal collected before the specimen fracture at 15969 cycles. The trend of this data tabulations is consistent with the previous study by Huang et al. [3] and Wang et al. [4]. Microstructure changes in ferromagnetic material given high impact to magnetic properties. Dislocation movement in ferromagnetic leads to the accrual of magnetic charge around the crack. As the cycles increased near to fracture, tabulation of magnetic charge distributed evenly at the length of the crack, that causes a decrease in $dH/dx_{(max)}$.
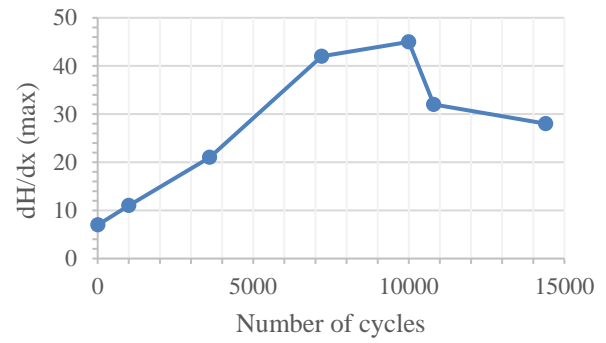

Figure 4 Changes in $dH/dx_{(max)}$ concerning the numbers of cycles.

4.   CONCLUSION

The metal magnetic memory used in this study has high sensitivity in detecting high-stress concentration zone during the cycling loading. High-color intensity given by surface contour mapping of *dH/dx* distribution at the length of 50 mm scanning. This position identified as the position of the notch on the specimen. By evaluating maximum changes in $dH/dx_{(max)}$ concerning the number of cycles, it is found that $dH/dx_{(max)}$ value increased as the number of cycle increased. Decreasing of the $dH/dx_{(max)}$ value indicated that, the specimen was near to failure as magnetic-charge distribution began to distribute evenly along the crack.

REFERENCES
[1] Vlasov, V. T., & Dubov, A. A. (2004). Physical bases of the metal magnetic memory method. *Moscow: ZAO "Tisso*, *424*.
[2] Yang, K., Zhong, B., Huang, Q., He, C., Huang, Z.-Y., Wang, Q., & Liu, Y.-J. (2018). Stress ratio and notch effects on the very high cycle fatigue properties of a near-alpha titanium alloy. *Materials*, *11*(9), 1778.
[3] Huang, H., Jiang, S., Yang, C., & Liu, Z. (2014). Stress concentration impact on the magnetic memory signal of ferromagnetic structural steel. *Nondestructive Testing and Evaluation*, 29(4), 377.
[4] Wang, H., Dong, L., Dong, S., & Xu, B. (2014). Fatigue damage evaluation by metal magnetic memory testing. *Journal of Central South University*, 21(1), 65.

Counterproductive work behavior, organizational support, personality traits and emotional intelligence among industrial workplace

Norida Abdullah*, Ali Hafizar Mohd Rawi, Mohd Firdaus Abdullah

Pusat Bahasa dan Pembangunan Insan, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

*Corresponding e-mail: noridaha@utem.edu.my

ABSTRACT – Employees who display Counterproductive Work Behavior (CWB) are more likely to develop stress related problems, intention to resign, experience low self-esteem, and increased lack of confidence at work. Various factors that may predict CWB. These include individual differences such as employees' personal traits, work stress, and emotional intelligence (EI). Therefore, the objective of this study is to identify the relationship among perceived organizational support, personality traits, emotional intelligence and counterproductive work behavior among technical staffs. Finding from this study will help the human resource management to propose the alternatives employee assistant program for the benefit of staffs at the industry.

1. INTRODUCTION

Research done previously found that various factors that may predict CWB. These include individual differences such as employees' personal traits and abilities, work stress such as difficult work conditions, harsh supervision, and emotional intelligence (EI). Other research suggested that organizational diversity could influence turnover intention [1]. Employee turnover refers to a group of employee movements that create a vacancy within the organization unit. Turnover intention is defined as an employee's intent to find a new job with another employer within the near future. Employees' turnover always implies a high cost to companies, seriously hindering efficient, effective customer service and undermining competitiveness. Ponniah et al. [2] found that organizational diversity and diversity programs could decrease turnover intention and the actual turnover rate.

Based on the study done on productivity and profitability, concluded / indicated that factors contributing to the deficit in organizations' profitability due to physical and /or emotional health problems, stress, burnout of employees, poor management strategies, and lack of effective training programs [3]. Study done by Zain et al. [4] showed that when organization is concerned about the employees then employees would try to change their inner feelings to achieve organizational objectives. It means that if employees are emotionally intelligent, they can manage their emotions in a better way while interacting with others. In their study also found that emotional intelligent also moderates counterproductive work behaviors.

Employees with a high level of emotional intelligence can modify their inner feeling and emotions according to the situation due to which they can tackle counterproductive work behaviors in a better way.

Therefore, this study aims to identify the relationship among perceived organizational support (POS), personality traits (PT), emotional intelligence (EI) and counterproductive work behavior (CWB) among technical staffs.

2. METHODOLOGY

2.1 Objective of the study

To identify whether a relationship exists among perceived organizational support, personality traits, emotional intelligence and counterproductive work behavior among technical staffs.

2.2 Hypotheses of the study

The hypotheses postulated in this study are:
(a) Perceived Organizational Support (POS) influences Counterproductive Work Behavior (CWB) among technical staffs.
(b) Personality Traits (PT) influences Counterproductive Work Behavior (CWB) among technical staffs.
(c) Emotional Intelligence (EI) influences Counterproductive Work Behavior (CWB) among technical staffs.

2.3 Sample and Population / Participants

The population of this study consists of approximately 2,000 technical staff employed at CTRM of Melaka branch. The questionnaire distributed to 350 staff randomly and enough in order to generalize the results [5].

2.4 Instruments and Data Analysis

There are four instruments used to measures construct variables involve in this research such as, Counterproductive work behavior (CWB), Perceived Organizational Support (POS), Personality Traits (PT), and Emotional Intelligence (EI). Frequency analysis used to determine the demographic characteristics of the sample. Explanatory factor analysis used to test the construct validity of the measurement model while structural equation modelling (SEM) used to test the hypotheses.

2.5 Research framework

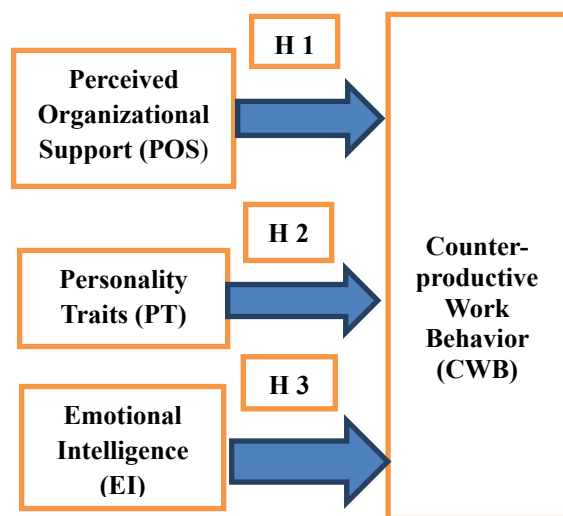Figure 1 illustrated the framework for this study.

Figure 1 Research framework.

3. RESULTS AND DISCUSSION

Based on previous literature review done by other researchers, found that Perceived Organizational Support (POS) influences Counterproductive Work Behavior (CWB), such as related with management strategies [3], strengthen employee' meaning of work [6], organization behavior and interest of organization [7]. For Personality Traits (PT) and CWB, previous study [6, 8, 4, and 9] found that personality has the potential to influence CWB process. Another study done by [4, 10, and 11] found that emotional intelligence moderates the CWB. Findings from this study will confirm the results as mentioned by other researchers in order to sustain the productivity for the industry to overcoming the psychological and emotional issues of the human capital development in the industry.

4. CONCLUSION

The present study intends to explore and examine the relationship among perceived organizational support, personality traits, emotional intelligence and counterproductive work behavior among technical staffs employed at CTRM of Melaka branch. Hopefully, the HRM at the industrial level will continue take the necessary action towards staff well-being at the workplace in order to sustain the productivity for the industry and for the nation. Focusing from the HRM based on the variables mention in the Employee Assistant Program (EAP) will not only help in overcoming the psychological and emotional issues but it has the potential to result in positive functioning of an individual of the human capital development in the industry.

REFERENCES

[1] Spector, P. E. (2010). The relationship of personality to counterproductive work behavior (CWB): An integration of perspectives. *Human Resources Management Review*, *21*(4), 342-352.

[2] Raman, P., Sambasivan, M., & Kumar, N. (2016). Counterproductive work behavior among frontline government employees: Role of personality, emotional intelligence, affectivity, emotional labor, and emotional exhaustion. *Revista de Psicología del Trabajo y de las Organizaciones*, *32*(1), 25-37.

[3] Zerbes, M. V., Cioca, L. I., & Neamu, V. S. (2019). Occupational health programs and workplace absenteeism. *Quality-Access to Success*, *20*, 129-134.

[4] Riaz, Z., Arif, A., Nisar, Q. A., Ali, S., & Sajjad, M. (2018). Does perceived organizational support influence the employees emotional labor? Moderating & mediating role of emotional intelligence. *Pakistan Journal of Humanities and Social Sciences*, *6*(4), 526-543.

[5] Var, I. (1998). Multivariate data analysis. *vectors*, *8*(2), 125-136.

[6] Akgunduz, Y., Alkan, C., & Gök, Ö. A. (2018). Perceived organizational support, employee creativity and proactive personality: The mediating effect of meaning of work. *Journal of Hospitality and Tourism Management*, *34*, 105-114.

[7] Ponte, D., & Rizzi, C. (2010). Understanding socialization practice: factors fostering and hindering its evolution. *Society and Business Review*, *5*(2), 144-154.

[8] Chang, K., & Smithikrai, C. (2010). Counterproductive behaviour at work: an investigation into reduction strategies. *The International Journal of Human Resource Management*, *21*(8), 1272-1288.

[9] Ferreira, M. F., & Nascimento, E. D. (2016). Relationship between Personality Traits and Counterproductive Work Behaviors. *Psico-USF*, *21*(3), 677-685.

[10] Deshpande, S. P., Joseph, J., & Shu, X. (2005). The impact of emotional intelligence on counterproductive behaviour in China. *Management Research News*, *28*(5), 75-85.

[11] Petrides, K. V., Frederickson, N., & Furnham, A. (2004). The role of trait emotional intelligence in academic performance and deviant behavior at school. *Personality and individual differences*, *36*(2), 277-293.

Improvement of work system through designing pedal control facilities for nenggala tactical vehicles in the workshop of the national Indonesian army equipment center

Rimba Krisnha Sukma Dewi*, Angling Sugiatna, Bedy Ubaedillah

Sekolah Tinggi Teknologi Bandung, Soekarno-Hatta St No.378, Kebon Lega, Bojongloa Kidul, Bandung City, West Java 40235, Indonesia

*Corresponding e-mail: rimbakrisnha80@gmail.com; rimbakrisnha@sttbandung.ac.id

ABSTRACT – The workshop of the army equipment center (Bengpuspalad) is an agency engaged in the improvement and design of combat vehicles and tactical vehicle and the manufacture of parts of combat vehicles in limited numbers. One of them is the prototype of tactical vehicle (rantis) Nenggala. Previously on Nenggala rantis there are problems related to the actual condition of the cabin that is less support the work activities carried out that is on the pedal pedals and technical pedals are used. The results of improvements to the work system is done to improve the size, angle and distance between the pedals and the addition of pedestal pedestal rest for left foot sole. On the technical aspect, there is improvement with brake type selection with the addition of brake booster and replacement of clutch drive system into fluid feeding coupling.

1. INTRODUCTION

T The Equipment Center Workshop (Bengpuspalad) is an agency under the auspices of the Indonesian Armed Forces Army (TNI AD). At its inception, Bengpuspalad was still in the form of a master workshop owned by the Dutch which at that time colonized Indonesia which was founded in 1920. Where bengpuspal was a storage industry from small industries that moved to Bandung and became one became a large workshop owned by the Indonesian government whose operations were carried out by the Army for military purposes in particular and the country generally.

Basically, Bengpuspalad's activities cover the actions or complete repairs of various types of combat vehicles, the complete manufacture or repair of combat vehicles of various types of tactical vehicles (rantis), weapons holders, combat vehicle parts and so on. Bengpuspalad, which has 546 members, occupies an area of 12 hectares, has a vision to support the movement and firepower of TNI-AD units, as well as the mission to assist the Directorate of equipment in maintaining and maintaining equipment maintenance up to level VI (the highest level of damage) and producing equipment or spare parts in a limited way to support their first duties.

As mentioned earlier, one of the products is a tactical vehicle (rantis). At this time for the first time the TNI army made a cargo type Rantis under the name Nenggala. Based on a preliminary study of the rantis as a whole, it was decided the study was carried out in the driver's cabinet with consideration of the main priority in driving lies in the driver, hence driver safety is very influential in the success of a mission. Where the vehicle and its contents must arrive at the destination safely and the driver feels comfortable to drive for a long period of time.

Based on the Nordic Body Map questionnaire, drivers experience complaints of discomfort with existing facilities. Complaints experienced by the driver during and after driving in a sitting position is aching pain, especially on the soles of the feet, ankles, calves, knees and thighs. This complaint is based on observations, caused by the pedal control system facilities used by the driver made with no regard to the dimensions of the driving body that does not match the pedal makes the driver have to lift his legs while braking and stepping on the clutch, besides the pedals do not take into account the angles formed by the legs feet so that the back of the foot is too bent inward and the calf feels tension because the angle formed is too pointed. The displacement distance that is too far away causes fatigue to appear too early because repetitive work will make the displacement distance more and more.

In addition to work facilities technical facilities also influence the performance of the driver even though the driver can adapt to the technical aspects of the pedal control system such as the brake system and clutch drive system. However, this condition has the potential to make the driver feel uncomfortable in driving. The brake system that uses drum allows for still movement during braking, this can lead to conditions that allow accidents to occur, as well as the clutch drive system, clutch locking is not perfect so the gear shift is repeated, this causes the clutch to often slip and the left leg is very tired because it has to step on the clutch many times. The braking process that occurs and is carried out by the driver is very strong causing the driver to get tired because the pressure given is very large, thus a tool is needed to reduce the burden of emphasis on the brakes.

The driver's performance in performance is greatly influenced by the conditions of the work system where the work is carried out. For that we need a pedal control system design that includes ergonomic and technical aspects in order to support the work activities carried out so that it is expected to provide comfort to the driver. Therefore the improvements made on the pedal control system in the Nenggala Rantis steering wheel are expected to be able to answer the needs of workers for a more effective, comfortable, safe, healthy, efficient (ENASE) working system condition, so as to improve worker performance. As for the conditions of the Nenggala Rantis pedal system can be seen in Figure 1.
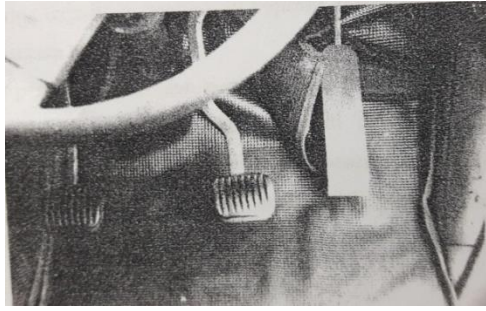
Figure 1

For this reason, the formulation of the problem of this research is how to improve the work system in the steering cabin by providing design suggestions for pedal control facilities along with technical aspects to improve the driver's comfort in carrying out his activities. Thus in accordance with the formulation of the problem, the purpose of this study is to: (1) conduct an analysis to find out the weaknesses of the steering cabin that have the potential to cause problems that can disrupt driving nets; (2) Provide a proposal for the design of the steering cabin which includes work facilities and technical aspects in accordance with the driver's needs and the activities carried out; and (3) Evaluating the design of the steering cabin system improvements proposed through ergonomic and technical criteria to determine the extent to which the repairs were carried out.

2. METHODOLOGY

This research method (Figure 1) uses a mixed method that is done by combining or combining quantitative and qualitative methods used together in a study to obtain more comprehensive, valid, reliable and objective data. In addition, this study uses ergonomic evaluation and technical evaluation in order to assess the results of the design.

3. RESULTS AND DISCUSSION

Data collection in this study was carried out through questionnaires accompanied by interviews with the aim of finding out the complaints experienced by the players at the time and after driving a tactical nenggala vehicle. The documentation study was carried out in order to obtain data such as the data cabin of the Bengali rantis steering wheel, work facilities, technical facilities and user anthropometry. The processing of data is done through the development of conceptualization of the proposed work system, namely the design of pedal facilities and the design of technical facilities. The design of the pedal facility is divided into testing for normal distribution, averaging the data, calculating the standard deviation, calculating percentiles, determining percentiles and dimensions of the pedals. While the design of technical facilities is divided into replacing the brake system, adding brake booster and replacing the clutch drive system.

Based on calculations from the results of improvements to the working system of the Naggala rantis vehicle pedal, improvements have been made to the size, angle and distance between the pedals and the addition of a pedestal pedal rest to the left foot with dimensions as shown in Table 1.
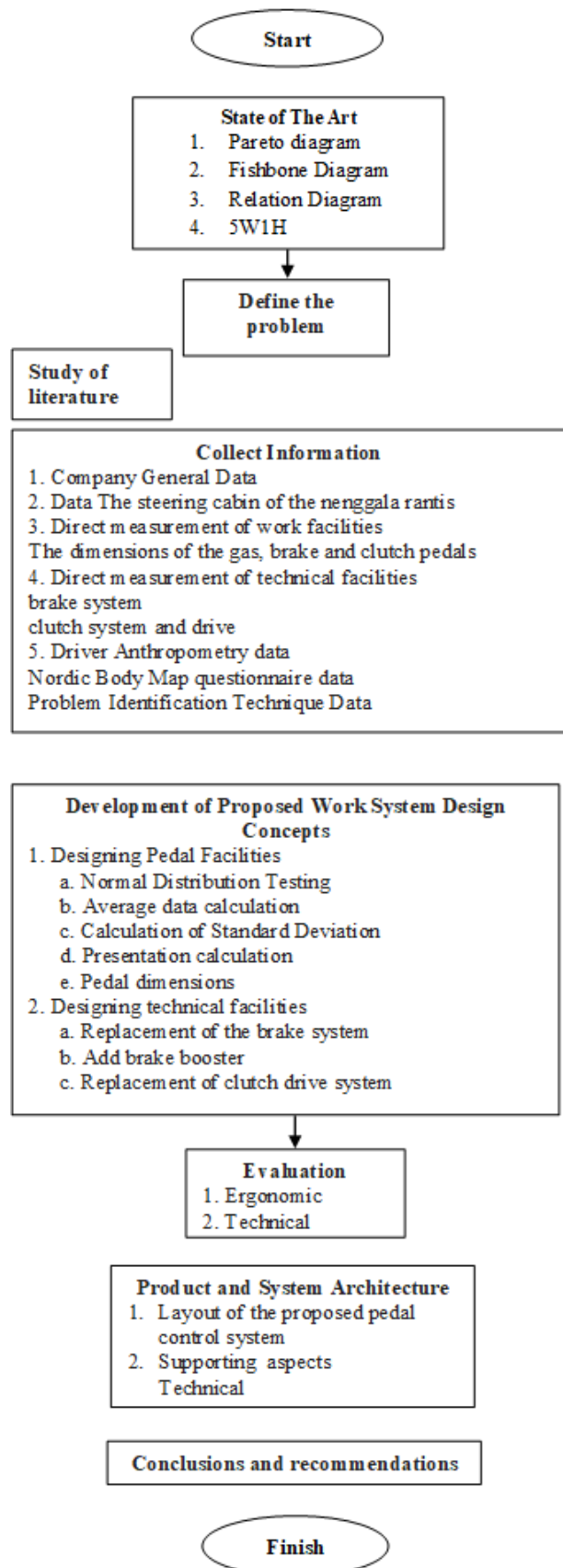

Figure 1 Flowchart of the methodology.

Table 1 Calculation results from work system improvement.

Pedal/Dim.	Gas	Brake	Clutch	Hanging pedal
Length (cm)	13	9	9	13
Width (cm)	8	5,75	5,75	5,75
Height (cm)	9,1	10	10	7,5
Corner of the leg (^{0})	25-45	25-45	25-45	35

From Figure 2, the results of the design evaluation show that the design can be useful in the operationalization of the Nenggala Rantis vehicle. This is based on an ergonomic evaluation where the dimensions of the pedal must follow the length of the sole of the foot so that the load can be evenly distributed on the thighs, calves and soles of the feet. This can also increase user comfort. In addition, the distance between the pedals is adjusted using the permitted rules to reduce the displacement carried out not to the extent that is carried out in actual conditions and reduce pain and aches in the thighs and calves.

Ergonomics evaluation on the control system also explains the principle of using leg-forming angles where the palms and legs form angles that are in good position with the legs and feet so that it can increase comfort and is good for health and can reduce pain or soreness in the ankles and palms feet. This is produced by making a resting place for the left foot allowing the left foot to be stretched out on the spot in an idle position without having to hang in front of the clutch pedal, when the clutch is intended / not used. As a result, the driver feels comfortable in a hanging position waiting for the clutch pedal to be used. Communication devices are used properly so that they do not disturb the main function of the pedal control system, where the activities carried out are in the portion that should be done by the driver and do not violate its main function.

The results related to technical evaluation are carried out by comparing the technical aspects of the actual conditions with the conditions after the repairs are carried out, which are expected to be better than the actual conditions or before repairs are carried out. In this result emphasize on the use of disc brakes because pengermanan occurs so that the condition of all wheels will be locked at the same time, causing the termination of road conditions or any terrain safer because of the stops that have better accuracy compared to the use of drum brakes as in actual conditions. The results also explain the use of a booster device on the proposed repair brake system can ease the work of the driver in operating the brakes on this vehicle. The money booster work reduces the burden during hatching, making the driver's feet do not get tired and reduce the risk of injury leading to the driver.

The results of this evaluation also revealed that the use of feeder fluid couplings in the proposed conditions has advantages over the mechanism of use where there are bumps on the side of the clutch making the locking process occur strongly. The use of a hydraulic system in the clutch drive also takes faster time compared to mechanical means.
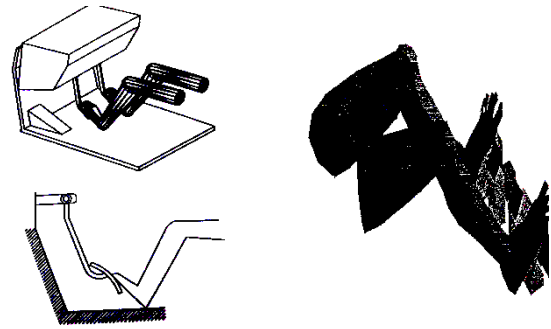

Figure 2 Results of the Nenggala Rantis pedal design.

4. CONCLUSION

Based on research carried out in the cabin pedal system of a nenggala tactical vehicle, conclusions can be taken as follows:

(a) Based on the system analysis carried out, the weaknesses of the most dominant actual work system are from the Nenggala Rantis work facility namely pedal control facilities and from the technical aspects of the vehicle which is the implementation or successor of the pedal control facility, namely the brake system, use of booster and drive system clutch.

(b) Improving the technical aspects is done by selecting the type of brakes namely disc brakes with the addition of brake booster in the technical part of the brakes so that the process can run better.

(c) Improvements are also made to the mechanical clutch system, namely the replacement of the use of a mechanical clutch system by using a hydraulic feeder fluid coupling so that the clutch gear locking process can help improve safety for the driving process with a tactical nenggala vehicle.

(d) Evaluation of the proposed design is an ergonomic evaluation and technical evaluation of the pedal system driver.

(e) Ergonomic evaluation is carried out by comparing the actual conditions with the proposed conditions, while the technical evaluation on the machining of the vehicle is the actual and proposed conditions.

(f) The evaluation results show the condition of the proposal is better than the actual conditions that exist.

Suggestions that can be given for future research are:

(a) This research can be further developed by improving the work system as a whole in the steering cabin of a tactical vehicle built by an army equipment center workshop. This research can also be developed by improving the layout of the entire section of the nenggala tactical vehicle to support a better work system.

(b) This research can be further developed by conducting an economic evaluation on the improvement of the work system so that the costs incurred can be known.

REFERENCES

[1] Ari Samadhi, T. M. A. (2011). *Diktat mata kuliah seminar tugas akhir.* Jurusan Teknik Industri. Bandung.

[2] Chaffin, D. B., Anderson, G. B. J. (2006). O*ccupational Biomechanics,* 2nd edition, John Willey and son Inc., New York.

[3] Daryanto. (2008). *Sistem Rem Mobil*, Bandung.

[4] Lesmana, N. *Usulan Rancangan Perbaikan Stasiun Kerja Penjahitan Melalui Perbaikan Fasilitas Kerja dan Lingkungan fisik di PD. Italia,* Bandung.

[5] McCormick, E., & Sanders, M. S. (1993). *Human Factor Engineering and Design*, McGraw-Hill, USA, 1993.

[6] MQPro, *Human Modeling System User Guide,* Mannequin, 2007.

[7] Nurmianto, E. (2007). *ERGONOMI Konsep Dasar dan Aplikasinya,* Surabaya.

[8] Pullat, B. Mustafa. (2002). *Fundamental of Industrial Ergonomics,* Wafeland Press Inc., USA.

[9] Sugiyono. (2007). *Statistika untuk Penelitian,* Bandung.

[10] Sutalaksana, I. Z., Ambhawisastra, R., Tjakraatmadja J. H. (2006). *Teknik Perancangan Sistem Kerja*, Bandung.

[11] Wignjosoebroto, S. (2003). *ERGONOMI Studi Gerak dan Waktu, Guna Widya,* Surabaya.

Determination of correlation between age and working period: a study of NIHL between case and control group

Rosniza Rabilah[*], N.I. Ismail, Mahfuzah Zainudin, Nor Shamimi Shaari, Nor Azirah Mohd Fohimi

Faculty of Mechanical Engineering, Universiti Teknologi MARA Pulau Pinang,
13500 Permatang Pauh, Pulau Pinang, Malaysia

[*]Corresponding e-mail: rosniza.rabilah@ppinang.uitm.edu.my

ABSTRACT – Noise-induced hearing loss (NIHL) becomes a major occupational disease for many years in Malaysia. This study investigates the relationship between age and working period among the two groups. The case group was workers who had exposed to noisy workplace and administration department workers as control group. The results showed that age and working period has no significant difference for both groups. The 73.3% workers of control group had normal hearing compared to case group. About 33.33% workers faced NIHL with working over 10 years. It was found that the incidence of NIHL increased when the working period increased.

1. INTRODUCTION

Noise exposure has been observed to be able to affect the quality of life on humans. High noise levels in the workplace are considered to cause hearing loss, affect workers safety and health and decrease labour productivity and job performance. However, occupational noise is being accepted as an integral part of the job. Occupational noise can lead to auditory and non-auditory effects. Examples of auditory effects are noise-induced hearing loss (NIHL), tinnitus and acoustic trauma. According to NIOSH [1], NIHL is caused by exposure to sound levels or durations that damage the hair cells of the cochlea. It can be divided into permanent and temporary hearing loss. Leensen et al. [2] found that duration exposure is more important compared to noise level. If the noise exposure is longer, then the hearing will take longer to return back to normal. Furthermore, a repeated or continuous noise exposure for a long duration leads to a permanent hearing loss. Mostaghaci et al. [3] stated that a high incidence of NIHL among workers in tile and ceramic industry. That study reported that the important of using hearing protectors and the hearing conservation program should be installed in order to reduce the hearing impairment. One study among quarry workers in Malaysia found that 57% workers experienced NIHL and they had poor knowledge about NIHL [4]. This study investigates the relation between age and working period of NIHL among case and control group.

2. METHODOLOGY

The noise levels at several locations in production floor and administration department were measured using sound level meter. Samples were randomly selected from population and they were divided into two groups. The case group was workers who had exposed to noisy workplace and samples workers in the administration department as control group. There were 15 workers in the production area as the case group and 15 workers of administration department as control group. The inclusion criteria were workers who had been working at the factory for minimal two years continuously and age between 20 to 45 years. The exclusion criteria were workers who had hearing loss, previously worked in noisy work area, workers with middle ear infection, brain injury, alcohol drinker, heavy smoker, ototoxic medication and systemic disease. The Chi-square test was used to determine the level of significant level in relation between working period and noise-induced hearing loss in the case group.

3. RESULTS AND DISCUSSION

The average noise level in the production floor was 102.4 dBA, above the permissible limit which is 90 dBA. While, in the administration room, the average of noise was 66.6 dBA. The area with noise level above 102 dBA and continuous exposure should be no longer than 1.5 hours per day [5]. The production workers and administration workers work 9 hours per day excluding break time. The production workers had to wear hearing protector, but most of them were unwilling to wear it. These factors contributed to NIHL especially to the production workers.

Average age of the case group was 31.13 year and average working period was 8.53 year. For control group, the average age was 31.07 year and average working period was 5.00 year. There was no significant difference between age and working period of the both groups. Case and control group showed the coefficient of correlation, r, were close to zero, so there was evidence of no linear relation between these two variables. To complement this statement, Harmadji and Kabullah [6] stated that average age and working period of a case group are 37.80 year and 16.76 year, respectively. It was reported that the average age was 36.12 year and average working period was 13.68 year of control group. From that study, it showed that age and working period has no significant difference.

Table 1 indicates the baseline audiogram resulted in the case and control group. About 66.7% workers had NIHL in the case group and only 6.7% worker of control group had NIHL. From this study, 73.3% workers of control group had normal hearing compared to case group which is 13.3% workers had normal hearing. This is because they always used ear protection during work at the noisy work area.

Table 1 Baseline audiogram.

Baseline audiogram	Case group	Control group
Normal hearing	13.3%	73.3%
NIHL	66.7%	6.7%
Non NIHL	20.0%	20.0%

Table 2 shows relation between working period and NIHL of the case group. Incidence of NIHL on workers was only 6.67% with 2 to 4 years of working period. For 5 to 7 years and 8 to 10 years of working period, 13.33% of NIHL occurred. About 33.33% workers faced NIHL with working over 10 years at the factory. From the study, it was found that the incidence of NIHL increased when the working period increased as well.

There was a significant difference in relation between NIHL and duration of work on the case group. This is in agreement with a study conducted by Hidayat et al. [7] that reported about 17% of NIHL on workers at textile factory with 10 years working period and 46% with 15 years working period. It is also supported in another study carried out by Suheryanto [8] that found 44% of workers experienced NIHL with 5 to 9 years, 67% with 10 to 14 years and almost 86% with 15 to 19 years of working period.

Table 2 Relation between working period and audiogram of case group.

Working period (years)	NIHL	Non NIHL
2 - 4	6.7%	20.0%
5 - 7	13.3%	0%
8 - 10	13.3%	13.3%
>10	33.3%	0%

The results of Chi-square test were shown in Table 3. From Chi-square for the level of significant, $\alpha = 0.05$ and the degree of freedom (dof) = 4, the critical value of the Chi-square obtained was 9.45. From Table 3, it showed that the test result was 20.25 and exceeded the critical value. With Chi-square test, there was a significant difference in relation between working period and noise-induced hearing loss in the case group.

Table 3 Results of Chi-square test between NIHL and working period of case group.

Working period (years)	O	E	$\frac{(O-E)^2}{E}$
2 - 4	1	4	2.25
5 - 7	2	1	1.00
8 - 10	2	4	1.00
>10	5	1	16.00
Total			**20.25**

4. CONCLUSION

The noise level in production plant was 102 dBA and the noise level in administration department was 67 dBA. Many workers are expose to continuous noise for long working period. Almost 70% of workers of case group have NIHL compared to only 7% of workers in control group. This study was found that there was no significant difference between age and working period of case and control group. However, Chi-square test found that there was a significant difference in relation between working period and noise-induced hearing loss in the case group. In conclusion, the incidence of NIHL increased as the working period increased. For recommendations, the management should provide effective and comfortable hearing protectors to workers in order to protect them and at the same time to reduce noise-induced hearing loss (NIHL) among the workers. The use of ear protection should be compulsory to all workers who are exposed to above permissible noise level. Furthermore, warning letter should be given to any worker who is not wearing hearing protectors so that they will alert with hearing protection.

REFERENCES

[1] National Institute of Occupational Safety and Health (NIOSH) Malaysia (1998). Ministry of Human Resource. Occupational Safety and Health.

[2] Leensen, M. C. J., Duivenbooden, J. C. V., & Dreschler, W. A. (2011). A retrospective analysis of noise-induced hearing in the Dutch construction industry. *International Archives of Occupational and Environment Health*, *84*(5), 577-590.

[3] Mostaghaci, M., Mirmohammadi, S. J., Mehrparvar, A. H., Bahaloo, M., Mollasadeghi, A., & Davari, M. H. (2013). Effect of workplace noise on hearing ability in tile and ceramic industry workers in Iran: A 2-year follow-up study. *The Scientific World Journal*, *2013*, 1-7.

[4] Nyarubeli, I. P., Tungu, A. M., Bråtveit, M., & Moen, B. E. (2019). Occupational noise exposure and hearing loss: A study of knowledge, attitude and practice among Tanzanian iron and steel workers. *Archives of Environmental & Occupational Health*, 1-10.

[5] Department of Occupational Safety and Health (DOSH) Malaysia (2010). Annual Report 2009: Occupational Diseases, Kuala Lumpur.

[6] Harmadji, S., & Kabullah, H. (2004). Noise induced hearing loss in steel factory workers. *Folia Medica Indonesiana*, *40*(4), 171-174.

[7] Hidayat, W., Suhardono, Rasyid, R., Haryuti, & Choiriyah, (1991). Penyakit akibat kerja melalui pendekatan epidemiologi. Penelitian gangguan kesihatan akibat kebisingan pada unit pintal dan tenun di fabric tekstil. *Badan Penelitian Dan Pengembangan Surabaya*, 1-5.

[8] Suheryanto, R. (1994). Pengaruh kebisingan mesin fabrik tekstil terhadap pendengaran karyawan.

Development of smart infant-wrap (*InfaWrap*) device for neonates

Mohd Azrul Hisham Mohd Adib[1,*], Mohammad Asyrul Abd Rashid[1], Nur Hazreen Mohd Hasni[2]

[1] Medical Engineering & Health Intervention Team (MedEHiT), Human Engineering Group,
Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
[2] Family Health Unit, Pahang State Health Department,
Jalan IM 4, 25582 Bandar Indera Mahkota, Kuantan, Pahang, Malaysia

*Corresponding e-mail: azrul@ump.edu.my

Keywords: Infant; ankle wrap; device; neonate; oximeter

ABSTRACT – Nowadays, with advanced technology, most of the parents choose to monitor their baby's health using a pulse oximeter device. However, the existing pulse oximetry device was a hassle for infant and this makes the monitoring process difficult. In this study, we focus on the development of smart infant wrap or so-called *InfaWrap* device for neonates in order to accommodate clinician and parents in monitoring the heart rate and oxygen level of the baby with advanced wireless network sensor. This device easier to use, fast and accurate readings of the baby's oxygen and heart rate.

1. INTRODUCTION

A study was conducted [1] where they found that 90% infant with congenital cyanotic heart disease were detected with the use of pulse oximeter for screening within several hours of birth. This data show there is a very serious issue related to cyanotic heart disease. Pulse oximetry was considered abnormal if oxygen saturation at room air or on oxygen therapy measured <90% [2]. This is due to issue with the heart valves, which are the flaps in the heart that make sure the blood flows through in the right direction, an interruption in the aorta, and abnormalities in the large blood vessels can occur congenital cyanotic heart disease

The Sudden Infant Death Syndrome ("SIDS") also can be related to congenital cyanotic heart disease. The main causes of SIDS may be difficult to determine [3], many parents do an extraordinary effort and are worried about checking their baby's health. For this reason, a simple but efficient system is required to monitor the conditions of the patient continuously. To help parents in this effort, nowadays various products to monitor the health of infants, especially when the baby is sleeping.

Currently in monitoring system hospitals used cable connections and the size and power consumption are often too large and not easy to carry [4]. The system becomes unsuitable in the development of today's technology. By applying the wireless health care technology there are many advantages one of them, people who carry the sensing devices can move around freely without the obstacle from complex connecting cables; and finally, doctors in the remote server center can watch the patient's health condition closely and hence provide real-time advice for the patients' recovery and long-term care [4,5].

In this paper, the smart infant wrap (*InfaWrap*) device is developed. One of the features of this device implements healthcare monitoring using wireless network sensor. This device need is equipped with several sensors such as oximeter MAX30100 and LM35 which can measure several parameters. Bluetooth HC05 is used to display the parameter result at smartphone. In addition, the buzzer and display are applying in this system to ensure physician and parent more alert if the parameter value at the system indicates a negative value.

2. METHODOLOGY

The *InfaWrap* device consists of three main components; ankle wrap, monitoring system, and mobile application as shown in Figure 1.
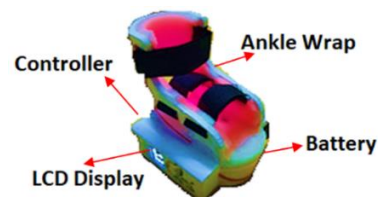

Figure 1 The smart infant wrap (*InfaWrap*) device.

For the *InfaWrap* device circuit of the project to connect all the component as shown in Figure 2. The details of each component are described in this subsection.
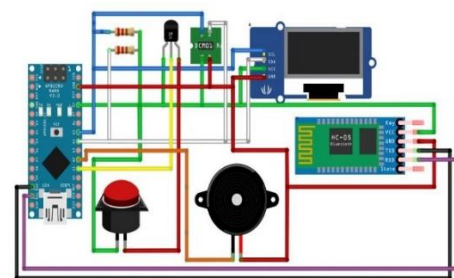

Figure 2 The *InfaWrap* device circuit.

2.1 Ankle Wrap

Consists of MAX30100 and LM35 sensor. MAX30100 is the combination of two LEDs, a photodetector, optimized optics, and low noise analog signal processing to detect the parameter of heart rate and SpO_2 level. LM35 is used to monitoring the body temperature of the infant. This sensor is safe for an infant because it does not emit any harmful electromagnetic wave to the infant. The main body of the device was developed using Flexible TPU filament and the inside of the ankle has been insulated using a sponge to protect the

skin of the infant.

2.2 Monitor System

In this monitoring system, the device displays the heart rate, SpO₂ and temperature level of the infant after receiving output feedback from the microcontroller. The buzzer was used to alert the clinician or parent if the parameter showing unhealthy reading. In order to develop this device. the microcontroller Arduino pro mini is used. This Arduino is chosen because of the size is easy to attach with the device.

2.3 Mobile Application

The mobile apps. is developed to record and display the heart rate, blood pressure and temperature data trend of the infant as shown in Figure 3. The data keep in the storage system as a black box function. These data will use as the emergency tread record or research activity.
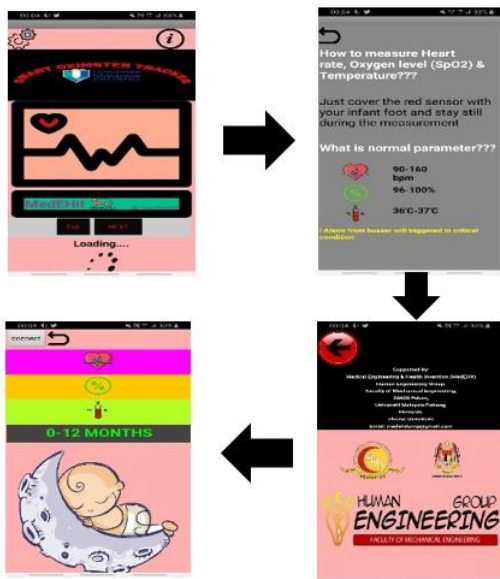
Figure 3 Illustrated the design of *InfaWrap* device mobile application.

3. RESULTS AND DISCUSSION

In this study, the *InfaWrap* device is well developed. Figure 4 clearly shows the stress analysis of the *InfaWrap* device developed using two differences material, between PLA and TPU. This analysis has been done to ensure the safety of the infant. According to the result for PLA material, the parts will not crack or bend when it is pressed. This is because the maximum stress for PLA material is only 1.084e+006 $N/mm2$. For TPU material shows a similar result with the PLA material but the mechanical properties for TPU is different which is the natural characteristic for this material is soft. To ensure the accuracy of this device, one ability test has been done for two hours without non-stop. Data from parameter device is taken for every 10 minutes. This test is very important to make sure after the occurrence of voltage drop, the battery output still remain the same and exactly as in starting reading. In Figure 5 clearly shows the accepted output parameters. The output value start changes in 100 minutes but the value still under the maximum limit.
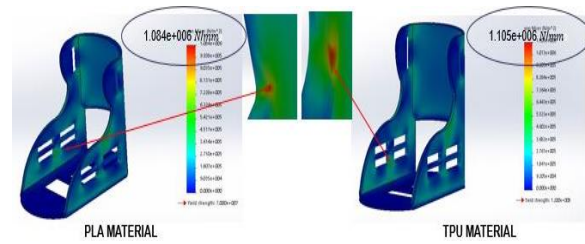

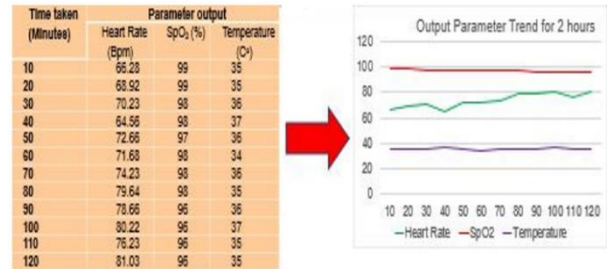Figure 4 Stress analysis: the comparison between PLA and TPU materials.

Figure 4 Demonstrated the output parameter value within two hours' test.

4. SUMMARY

As a summary, the proposed smart infant wrap (*InfaWrap*) device is well developed and really integrated with a mobile application. We forecast that the *InfaWrap* device has the potential to be used widely in Malaysia with affordable price.

REFERENCES

[1] Mathur, N. B., Gupta, A., & Kurien, S. (2015). Pulse oximetry screening to detect cyanotic congenital heart disease in sick neonates in a neonatal intensive care unit. *Indian pediatrics*, *52*(9), 769-772.

[2] Jortveit, J., Eskedal, L., Hirth, A., Fomina, T., Døhlen, G., Hagemo, P., ... & Holmstrøm, H. (2015). Sudden unexpected death in children with congenital heart defects. *European Heart Journal*, *37*(7), 621-626.

[3] Pradnya Kamble, P. G. (2017). Patient's vital sign monitoring system using a wireless personal area network. *Imperial Journal of Interdisciplinary Research,* 458-460.

[4] Gubbi, S. V., & Amrutur, B. (2014). Adaptive pulse width control and sampling for low power pulse oximetry. *IEEE Transactions on Biomedical Circuits and Systems*, *9*(2), 272-283.
Thomas, S. S., Saraswat, A., Shashwat, A., & Bharti, V. (2016, October). Sensing heart beat and body temperature digitally using Arduino. In *2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES)* (pp. 1721-1724).

Development of bilirubin jaundice (*BiliDice*) device for neonates

Mohd Azrul Hisham Mohd Adib[1,*], Mohd Hanafi Abdul Rahim[1], Nur Hazreen Mohd Hasni[2]

1) Medical Engineering & Health Intervention Team (MedEHiT), Human Engineering Group,
Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
2) Family Health Unit, Pahang State Health Department,
Jalan IM 4, 25582 Bandar Indera Mahkota, Kuantan, Pahang, Malaysia

*Corresponding e-mail: azrul@ump.edu.my

ABSTRACT – In Malaysia, generally the blood samples are taken and various laboratory experiments are performed to determine the exact jaundice level for newborn. As the process is repetitive, it causes trauma to infants and also requires experts to perform the test. In this paper, the bilirubin jaundice so-called *BiliDice* device is proposed. The device consists of three main components: RGB colour sensor, microcontroller, and LCD display. The advantage of this prototype is affordable and portable. This device is simple, easy to handle, fast and accurate readings for the bilirubin level of the newborn.

1. INTRODUCTION

Jaundice in neonates is mutual. When the red blood cells are wrecked down, a constituent called bilirubin is made. Primarily new baby liver is undeveloped and hence it cannot do the task efficiently [1]. Thus bilirubin level increasing which is the cause of jaundice. Bilirubin level will increase gradually if the severity is not detected within a proper time interval and if jaundice is left untreated. Once it exceeds a certain level there is the possibility of deafness or certain forms of brain damage may occur. Therefore, blood samples are taken, and various laboratory experiments are performed to access the exact bilirubin level [2].

In this paper, a portable hardware device which can detect the bilirubin level and jaundice state by non-invasive technique has been proposed. The successful bilirubin jaundice called *BiliDice* device using RGB color sensor is well developed. Using colour sensor (TCS230), an Arduino-Uno board based on microcontroller and an OLED display 0.96-inch unit have been used in manufacture this device. TCS230 is a colour sensor which programmable light to a frequency converter. There are sixteen photodiodes each for Blue, Green and Red filters. In [3], image analysis of stool colour is compared to colour grading by a colour card, and the stool bilirubin level test is done to detect cholesteric jaundice in infants. In [4], digital images are acquired in colour, in palm, soles, and forehead. RGB attributes are analyzed with diffuse reflectance spectra as the parameter to characterize patients with either jaundice or not, and those parameters are correlated with the level of bilirubin.

2. METHODOLOGY
2.1 Device Setup

At the beginning of the device setup, the TCS230 colour sensor has been organized to obtain suitable RGB values. Regarding this purpose, the three main colour of Red, Blue, and Green level printed on paper has been used. For the calibration of Red component, the value of Red set with "255" and the value of Black set with "0" have been plotted. The similar technique is followed for the calibration of the Green and Blue component. After that, the percentage of blue colour is assigned as the bilirubin level. Figure 1 shows the block diagram of the operation in *BiliDice* device.
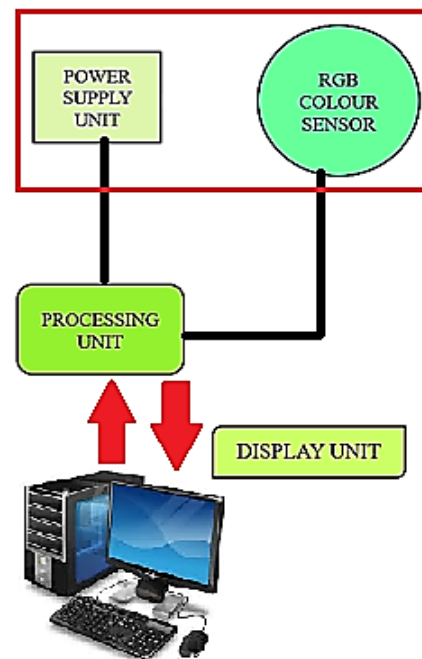

Figure 1 Block diagram of the operation in *BiliDice* device.

The power supply unit provides 9V DC supply to the processing unit. RGB colour sensor (TCS230) senses the RGB component of skin level processing based on Arduino Uno. The processing unit plots RGB value to precise values in order to arrange the colour sensor tracked by the percentage of blue taken from the colour sensor. Therefore the state of jaundice is determined and the result is transferred to the LCD display.

Figure 2 Final product of *BiliDice* device.

Table 1 Material specification.

Material	SUNLU PLA
Print Temperature	190-220^{0}C
Length	330mm

3. RESULTS AND DISCUSSION

In this study, the *BiliDice* device is successfully developed by using the non-invasive method as shown in Figure 2. The infected area is irradiated with light of specific wavelength and change in properties of light after reflection from the skin is noted. In order to detect neonatal jaundice, Light Emitting Diodes (LED) of a specific wavelength is employed as a source of light, which is an occurrence on baby skin. The light is reflected back and absorbed by photo-detector. In Table 1 show details the material specification of the *BiliDice* device.

Table 2 Implementation of colour level and bilirubin level [5].

Colour series (CS)	Label of colour	Bilirubin level (mg/dl)
CS-1		8
CS-2		11
CS-3		18
CS-4		22

The preliminary study on jaundice and non-jaundice was observed base on correlating the label of skin colour as shown in Table 2 and the decision making on jaundice and non-jaundice as shown in Table 3. The bilirubin level is intended conforming to a specific level. The physical process flow of an implementation of the *BiliDice* device as shown in Figure 3.

4. SUMMARY

As a summary, the proposed *BiliDice* device would use technique detection of jaundice by using a non-invasive method which can regularly monitor the bilirubin levels. The use of color sensor is a good alternative in detection of jaundice. However, this *BiliDice* device is still in the early development with positive progress. The device is also simple, and easy to use.
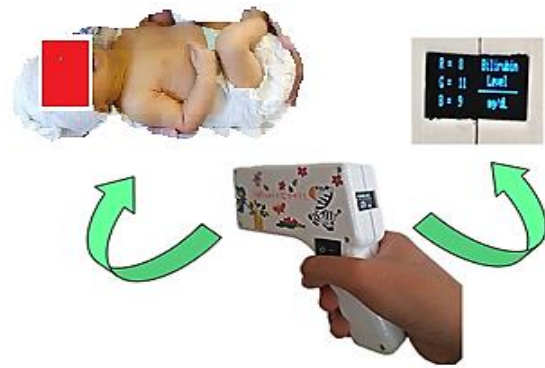

Figure 3 Process flow of an implementation of the *BiliDice* device.

Table 3 Reference for decision making on jaundice and non-jaundice.

Bilirubin level (mg/dl)	Jaundice level
BL < 5	Normal
5 < BL <11	Mild
11 < BL < 19	Severe
19 < BL	Critical

ACKNOWLEDGEMENT

REFERENCES

[1] Ku, L.C., & Lazim, N. S. M. (2017) Direct photometry non invasive bilirubin device. *International Research Journal of Engineering and Technology, 4*(5), 2372-2395.

[2] Ali, N., Muji, S., Joret, A., Amirulah, R., Podari, N., & Risep, N. D. (2006). Optical technique for jaundice detection. *ARPN Journal of Engineering and Applied Sciences*, *10*, 9929-9933.

[3] Reflective Color Sensing with Avago Technologies. (2015). *RGB Color Sensor*.

[4] Mohammadi, S. H., & Indikar, S. I. L. (2013). Embedded based preemies monitoring system with jaundice detection and therapy. *International Journal of Scientific & Technology Research, 2*(6), 153-162.

[5] Chowdhary, A. K., Dutta S., & Ghosh R. (2017). Neonatal jaundice detection using color detection method. *International Advance Research Journal in Science, Engineering and Technology*, *4*, 197-203.

Acoustic emission technology for monitoring die condition in sheet metal forming process

Ng Chuan Huat[1,*], Wong Hui Ing[1], Lai Chee Fung[1], Shamy Nazrein Md Yahaya[1], Rahizar Ramli[2], Sim Hoi Yin[2]

[1] Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia,
86400 Parit Raja, Johor, Malaysia
[2] Department of Mechanical Engineering, Faculty of Engineering, University of Malaya,
50603 Kuala Lumpur, Malaysia

*Corresponding e-mail: ahuat@uthm.edu.my

ABSTRACT – Condition monitoring system (CMS) on sheet metal forming had always been important. With an appropriate CMS, the quality of stamping dies and products can be maintained. This paper presents the application of acoustic emission monitoring system on sheet metal stamping process, obtaining a relationship between the signal amplitude and die condition. It was founded that die cavity with high surface roughness causes increasing of average amplitude. Apart from that, the clearance value within dies set would affect the varying of peak amplitude and the additional machining on the die edges was shown to reduce the peak amplitude acquired from sensor.

1. INTRODUCTION

Since Industry Revolution 4.0 (IR4.0) originated, acoustic emission (AE) testing has become much wider in scope. It is a well-matched with for IR4.0 as it can be used as condition monitoring system through analysing production data and identify patterns to predict issues before they happen [1]. By implementing industrial internet of things (IoT) technology and cyber-physical system, acoustic emission monitoring system can be optimized the maintenance schedules, and gaining immediate alerts to operational risks, allowing manufacturers to reduce service costs, maximizing uptime, and improving production output effectively [2]. In sheet metal forming process, a metal blank is transferred and plastically deformed between dies and acquired desired geometry without producing any scrap in short time. To gain the desired shape and properties in the product, the metal flow should be well controlled. Thus, the geometry of blank should be predicted before the stamping process is conducted.

The cost of dies signifies a major proportion of total costs associated with automotive parts production. Henceforth, dies replacement due to wear mechanism is very costly. When considered about the poor component quality, operation downtime and unscheduled maintenance of die wear issue; it is clear that economic impact of tool wear of dies is important [3]. Monitoring sheet metal forming process, it was not much be concerned and emphasized, compared to machining process and pipe leakage monitoring. Assessing tool wear and part quality by visual inspection can result in late detection of deterioration of tool wear. Therefore, an appropriate condition monitoring system for maintaining quality of die and products is necessary for every manufacturer. This paper applied the use of acoustic emission technology to monitor and identify the die condition in real time cold stamping process.

2. METHODOLOGY

For the material of metal blank, aluminium sheet has selected, with thickness of 0.25mm and diameter of 64mm. The dies and punch were made out of aluminium alloy 6061 (AA6061), with design diameter of 64.85mm, enough clearance for sheet deformation without disturbance of frictional effect. Two types of die geometry was prepared to study the effect of die design on signal condition, shown in Figure 1. From the figure below, the left die have just undergo CNC milling; whereas the die on right side have undergo additional machining to increase the die clearance and minimize the punch force from press machine.
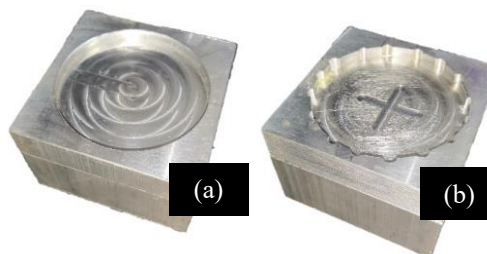

Figure 1 Two types of die geometry with (a) and without (b) additional machining.

The apparatus for this experiment consisted of hydraulic press machine, acoustic emission sensor and DAQ system. The punch and die installed on press machine to perform stamping process. KISTLER 8152C acoustic emission sensor was equipped to receive signal waves generated from blank deformation. KISTLER Piezotron Coupler Type 5125C was used to receive the high frequency outputs. DAQ system consisted of computer with LabVIEW software to collect and display the raw signal data from sensor and National Instruments PXI-1031 chassis as the medium between coupler and computer to synchronize the sensor signals. The entire apparatus setup for the experiment was shown in Figure 2.
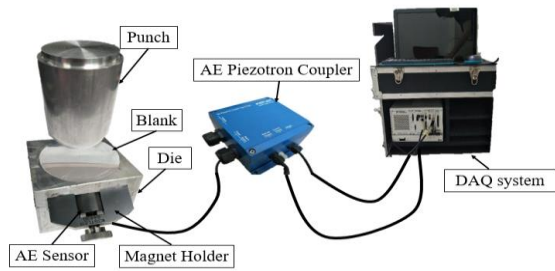
Figure 2 Overview of experimental work.

3. RESULTS AND DISCUSSION

The raw signal data that displayed from LabVIEW would further be processed through MATLAB. Eventually the graph of acoustic emission signals plotted again from MATLAB as the result for analysing and discussion. Both of dies with different geometry design have brought different range of amplitude. Four. The raw signal data of stamping operation was as shown in Figure 3.
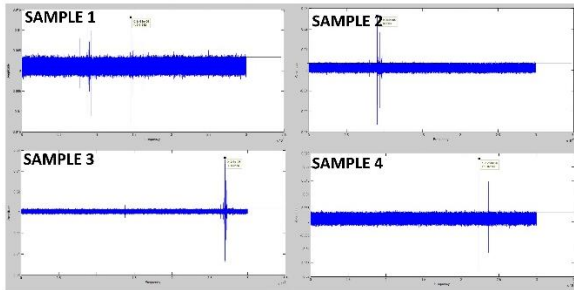

Figure 3 Raw Signal data of stamping operation.

For the ease of results analysing and discussion, the average amplitude and peak amplitude (the maximum amplitude in signal graph) were tabulated in Table 1, with respective workpiece condition as well.

Table 1 Summary of data.

	Die 1			Die 2		
	Avg	Peak	Cond.	Avg	Peak	Cond.
1	0.0034	0.0131	Tear	0.0052	0.0160	Good
2	0.0034	0.0264	Good	0.0053	0.0078	Tear
3	0.0034	0.0528	Tear	0.0050	0.0120	Good
4	0.0032	0.0230	Good	0.0055	0.0160	Good

Based on Table 1, the range of average amplitude emitted by die 1 was within 0.0032 to 0.0034 while for die 2, the range was within 0.0050 to 0.0055. Die 2 has higher average amplitude than die 1, which might be due to die surface roughness. Before conducting the stamping operation, scratches were added on die surface with the aid of sharp tool, hence the die surface of die 2 was rougher than die 1. Therefore, there is a possibility that with greater surface roughness, higher amplitude will be emitted [4].

However, the peak value emitted by die 1 during press forming was higher than die 2. This was due to the existence of additional clearance that in die 2. During the stamping process, the clearance between the die and punch were considered to reduce the effect of friction. The optimum punch-and-die clearance will maintain the

lifespan of tool. According to the research of Subramonian et al. [5], the severe wear was observed at the area with sharp edges and radii. The larger clearance allows the workpieces to be formed without large friction that leads to tear and wear occurrence. During experiment, die 2 has better geometry clearance while die 1 had smaller clearance and sharp edges that create greater friction when pressing process operate. As a result, workpieces formed by die 2 were in better condition than that of die 1. In die 1, the small clearance between die and punch leads to the tear occurrence for the aluminium sheet because great friction and shear had occurred at the moment of deformation. Due to the effect of tear, the signal of amplitude emitted was high which indicates the damage. The burst signal emitted during pressing of workpieces by die 1 was high due to occurrence of tear [6].

4. CONCLUSION

This research presented a technique to monitor the cold stamping process by means of acoustic emission signals that able to track the condition for both die and workpiece in order to avoid poor quality production. Several findings were concluded as follows:

(a) The existence of scratches on surface of die 2 has cause the greater average amplitude than die 1.

(b) Larger clearance due to the additional machining on the edges of die cavity in die 2 was observed to relieve the frictional effect hence reducing tore occurrence

(c) The relationship between die surface condition and amplitude from acoustic emission system were shown and observed.

(d) The reliability of acoustic emission system on monitoring sheet metal forming process was proven.

REFERENCES

[1] Shen, G., Zhang, Y., Dong, Y., & Liu, S. (2015). Development of High-Speed Wi-Fi Wireless Acoustic Emission System. In *Advances in Acoustic Emission Technology* (pp. 3-13). Springer, New York, NY.

[2] Nazarchuk, Z., Skalskyi, V., & Serhiyenko, O. (2017). *Acoustic emission: methodology and application*. Springer.

[3] Altan, T., & Tekkaya, A. E. (Eds.). (2012). *Sheet metal forming: processes and applications*. ASM international.

[4] Viera, M. A., Alexandre, F. A., Aguiar, P. R., Silva, R. B., & Bianchi, E. C. (2018). Correlation

between surface roughness and AE signals in ceramic grinding based on spectral analysis. In *MATEC Web of Conferences* (Vol. 249, p. 03003).

[5] Subramonian, S., Altan, T., Campbell, C., & Ciocirlan, B. (2013). Determination of forces in high speed blanking using FEM and experiments. *Journal of Materials Processing Technology*, *213*(12), 2184-2190.

[6] Shanbhag, V. V., Rolfe, B. F., Arunachalam, N., & Pereira, M. P. (2018). Investigating galling wear behaviour in sheet metal stamping using acoustic emissions. *Wear*, *414*, 31-42.