ISSN 2278-3091
Volume 9, No.1.4, 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse4291.42020.pdf
https://doi.org/10.30534/ijatcse/2020/4291.42020

The Critical Factors for Built Up Edge Formation in Stainless Steel Milling

Zirawani Baharum[1]*, M. N. Taufiq Affandi[1], Azliza Yacob[2]*, Rafidah Ali[1]
[1]Technical Foundation, Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur
Persiaran Sinaran Ilmu, Bandar Seri Alam, 81750 Johor Bahru, Malaysia. zirawani@unikl.edu.my
[2]Faculty of Computer, Media & Technology Management, TATI University College, Teluk Kalong, 24000, Kemaman, Terengganu, Malaysia. azliza@tatiuc.edu.my

ABSTRACT

Built-up edge (BUE) is an accumulation of the workpiece material against the rake face of cutting tools. The existence of BUE can caused tool wear and also led to bad surface finishing on the workpiece during the milling process, whereas some part of the workpiece is removed mechanically. Formation of BUE requires the rework on the workpiece. It is unfavorable to manufacturing industry as it will consume more cost and time. Therefore, the determination of critical factor of BUE formation during stainless steel milling are important to be investigated. This research aimed to determine the critical factor of BUE formation in stainless steel milling. Initially, several journal and articles were reviewed to find the possible causes that lead to BUE formation in stainless steel milling process and content analysis was performed to list down all possible causes. Next, ten individualists that expert in stainless steel milling are also involved in data collection. After the data collection, Shapiro-Wilk analysis (normality test) and analysis of variance (ANOVA) test were performed to analyze the data and determine the critical factor that lead to BUE formation in stainless steel milling. Lastly, the data will be examined and conclusion was being finalized. As a result, there are six identified critical factor of BUE formation in stainless steel milling. The critical factors are cutting speed, tool rake angle, cutting temperature, microcrack formation, feed rate and tool rake temperature. The finding of this research can contribute to any party that interest in this field to develop new technology or system that can completely prevent BUE formation during stainless steel milling process, thus avoid rework which are cost and time consuming.

Key words : BUE, ANOVA, cutting, normality test, Shapiro-Wilk Test

1. INTRODUCTION TO BUE FORMATION

Stainless steel become one of the dominance materials in manufacturing industry due to its physical and chemical properties. It is widely used in many manufacturing sectors from architecture, construction, automotive, medical, heavy industries and even in food and catering sectors.
However, the material needs to be changed into desired shaped first before it can be applied to the need of manufacturing industry. This can be done by machining the material where part of the workpiece is removed mechanically and will enable the manufacturer to design the shape, surface of material and size of the workpiece material into their desired specifications.

Milling is one of the machining methods that are commonly used for machining custom parts to precise tolerances. It is a method that uses a milling cutter to cut the part of the material from the surface of a workpiece. The cutter for milling is a rotating cutting instrument, regularly with various cutting points. Different with drilling, where the tool is shifted along its rotation axis, and the cutter in milling process is generally shifted vertical to its axis so that cutting take place on the circumference of the cutter. In order to cut the stainless steel, proper tools are required but tool wear and eventual tool failure however cannot be avoided. In the milling the workpiece, Built-up edge (BUE) tend to happen and somehow is getting worst. BUE is an accumulation of material against the rake face that seizes the tip of the tool, separating it from the chip.

BUE is also one type of undesired chip formation in manufacturing sector. The accumulation of BUE can cause tools wear when machining workpiece. Besides that, BUE also can lead to bad surface finishing to the workpiece, so, it is important to explore more about this phenomenon to determine the critical factors of BUE formation in order to avoid it completely. Figure 1 shows the formation of BUE during workpiece cutting. BUE is the build-up of workpiece material onto the rake face of the tools.

This phenomenon is one of the causes of tool wear occur when machining stainless steel workpiece [1].When the BUE is cut off, some of the tool stuff can be pulled with it. It can also cause fracture development, leading to the cutting off of the edge. The adhesion power between the BUE and the cutting tools affects the wear. The lives of the tool rely on whether the adhesion is powerful enough to be still connected to the surface of the cutting instrument when being sheared off. If the strength of the cutting tool or the coating attachment is lower than the adhesion strength, it can be broken off and at the end causing tool damage and shorten the period of the tool life.

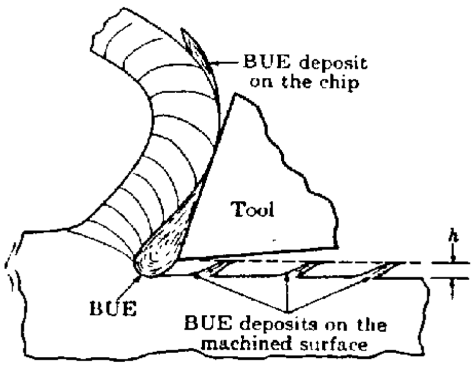

Figure 1: Formation during workpiece cutting

A study by [2] on impacts of wear and geometry response of the cutting tool on machinability of super austenitic stainless steel also conclude that adhesive and abrasive wear were founded on tool wear due to the existence of BUE formation when milling the workpiece using AL-6XN SASS machine.

2. BUE FORMATION FOR STAINLESS STEEL

Negative stress gradient from the rake face into the chip as being the main cause of built up edge formation [6]. Much stress and temperature develop in the secondary deformation zone at the chip-tool interface in ductile metals such as steels with long chip-tool contact length. Under such elevated pressure and heat between two smooth metal surfaces, powerful bonding can occur locally owing to welding-like adhesion. Such bonding will be encouraged and accelerated if the chip tool materials have mutual affinity or solubility. The welding begins to form at the most advantageous location as an embryo and thus gradually grows as BUE formation. The force, F also increases gradually with the growth of the BUE due to the wedging action of the tool tip together with the BUE formed on it. Figure 2 shows the schem on BUE formation for stainless stell. Whenever the force exceeds the BUE's bonding force, the BUE is broken or shaved off and the flowing chip is removed. Then again BUE begins to form and grow.

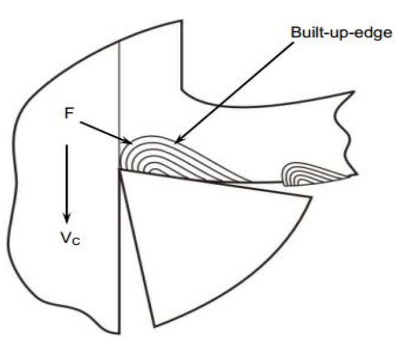

Figure 2: The scheme of BUE formation

Built up edge (BUE) is formed when workpiece fabric adheres constantly to the cutting edge of the workpiece surface. It was identified as a problem in machining industry. Even a trace formation of brittle and hardened structure formed on top of the tool edge, could changes the chip load, produces ad hoc and uneven material stream patterns [4]. When this happen, the geometric of the tool and the surface of the cut material will change due to removed placement of cutting edge. Pressure welding adheres the material, which means that the material is gradually accumulated under high pressure. This occurs in the stagnation zone, which is developed by pressing the workpiece material against the tool.

Since the workpiece material has to move either to the rake or flank face, there is a stagnation point where there is no relative movement between the workpiece and the tool. Thin pieces of workpiece material are introduced one by one, forming a BUE ultimately [5-7]. The method depends on temperature and requires a specific and optimum temperature. The built-up edge is made of extremely deformed workpiece material that has become more difficult than the initial workpiece. The BUE develops to a critical magnitude where it becomes volatile. When the stresses on it become greater than its shear force, it is cut off and the BUE follows along with the chip or passes along the face of the flank and is placed on the machined surface. The cutting tool design can be altered sufficiently to change the edge line.

2.1 Causes of BUE formation In Stainless Steel Milling

To identify the possible causes that influence the formation of BUE in stainless steel milling, review have been made to several journals and articles and content analysis have been performed to list out all the causes. According the data collection there are sevaral main causes that lead to BUE formation in stainless steel milling with some of levels, as following:

- Cutting speed:
    - sfm 250-393
    - sfm 400-673
    - sfm 700-1200
- Use of cutting fluids
    - Vegetable oil
    - Neat oil
    - Semi-synthetic oil
- Tool rake angle
    - +ve
    - _ve
    - zero
- Cutting temperature
    - Low
    - Medium
    - high
- Micro crack formation
    - intergranular cracking
    - trans-granular cracking

- Feed rate
  - 0.1-0.6
  - 0.8-0.16
  - 0.19-0.25
- Tool rake temperature
  - Low
  - Medium
  - high
- Ductility of material
  - Low
  - High

3. THE METHODOLOGY

The research methodology of this study includes four phases. Start with problem identification where problem statement and data parameter are defined. Then it continues with data collection. After the data collected, the data is analyzed and lastly conclusion and recommendation made based on research finding. Figure 3 shows the general research methodology for this research. The formation of BUE also can cause other problem.

Figure 3: The research method

BUE also generally considered to cause surface finishing issues during milling operation[4],[8-11]. It can influence the texture of the workpiece surface as the BUE may formed sideways of the edge. The cutting tool's geometric form is changed which impacts the machined part's tolerances as the machining precision deteriorates. This can contribute to poor precision, particularly when completing the milling operation.

Another result is when the BUE is removed and deposited on the freshly machined surface. Study shows workpiece material have relatively better surface quality values if BUE does not occur [5][12]. It is unfavorable to manufacturing sector if BUE occur as it requires rework on the workpiece. Rework on the workpiece is a waste because it is time consuming and add additional cost to the process. Therefore, it is important to determine the critical factor for built up edge formation in stainless steel milling to reduce and prevent BUE formation when milling stainless steel in the future, thus reduce tool wear, prevent poor surface finish and rework on the workpiece.

3.1 Problem Identification

The first phase methodology for this research is problem identification. Its goals are to understand the problems and issues related to BUE formation in stainless steel milling process. Besides that, mission, objective, scope and significant of research also identified in this phase. The problems that happen in manufacturing sector such as the existence of BUE when milling stainless steel workpiece identified.

Literature review is description of literature related to interested topic. There are many sources of literature review for instance like journals, articles and previous case study. An Inclusive review on previous research and several journal researches give wider viewpoint on the problem occur when machining the stainless-steel workpiece.

3.2 Data Collection

Sampling method used in this research is Delphi method. This method is a broadly recognized technique of structured and systematic information gathering from a group of experts (Delphi Panel) on a specific topic using a series of questionnaires [13]. This sampling technique generally consist three rounds. Unlike first two round, the third round is optional for the researcher [9].

For this research, in the first round, the experts were asked to provide their opinion on the impact of BUE formation in manufacturing industry. For second round, the expert will be disclosed about the secondary data that have been identified before which are possible causes that lead to BUE formation in stainless steel milling. Through the data, statement is generated and the expert will be asked to provide their opinion through Likert scale technique. For Delphi method, there is no consensus on the scale of panel size Delphi studies and there are no guidelines or unambiguous descriptions for small or large samples. Many Delphi studies have been conducted using panels of 10–100 or more panelists [13]. Some published studies in Delphi preferred less than 10 members in their panels [15].

3.3 Data Analysis

After the data collected, the data is analyzed by performing sequence of tests and analysis. There are two analyses that have been used in this research. The first one is normality test which is Shapiro Wilk test. This test is suitable for this research because the sample size is less than 50 respondents [16]. Shapiro-Wilk test involve hypothesis testing. The null-hypothesis of the test claimed that population is normally distributed. If the p value is less than the alpha rate which is 0.05, the null hypothesis will be rejected and there is proof that the data evaluated is not distributed normally. If the p value is bigger than the alpha rate, then the null hypothesis that claimed the population is normally distributed is accepted.

After the data is confirmed to be normally distributed, the second analysis is F-Test analysis or also known as ANOVA test will be done. This test is chosen because each factor has more than one level. It is a powerful set of technique to test differences among means of three or more samples [17-21]. ANOVA is chosen to test the hypothesis claimed in this research. Hypothesis test help to make decision easier whether to accept or reject the factors as critical factor for BUE formation during stainless steel milling.

3.4 Conclusion

The last step in this research methodology is conclusion and. After the data has been analyzed, conclusion will be made based on finding using hypothesis testing in ANOVA test. The objectives of this research are expected to be meet at the end of this research which means all causes and critical factor for BUE formation in stainless steel milling is likely to be identified.

4. RESULT OF FINDINGS

Content analysis involving journals and articles was performed to determine the possible causes of BUE formation in stainless steel milling. As a result, there are eight causes identified as possible causes of BUE formation during stainless steel milling. The causes are cutting speed, use of cutting fluid, cutting temperature, tool rake angle, and micro crack formation, ductility of material, feed rate and tool rake temperature.

4.1 The Root Causes

The levels for each factor are chosen based on content analysis conducted in chapter two. Every factor has three levels except for two factors which are microcrack formation and ductility of material. By identifying those levels, statements are generated and used in second round of Delphi method. Every level for each factor has been coded with simple acronym as shown in Table 1.

4.2 Normality Test (Shapiro-Wilk)

The first statistical test that have been used in this study is Shapiro – Wilk test. For every research, data collection is the most vital task and longest time-consuming compare to the other task. The data collected reveal the issues in a real case study. Due to that reason, all the data collected must be from the right source that present the actual survey of this research. As for this study, expertise in stainless steel milling is chosen as the correct respondent to generate the input data needed for this study. Lack quality of the input data will produce inaccurate and wrong output for the study. The result from the analysis will be far from the actual finding. To prevent the diverting data, normality test is conducted in this study. The objective of normality test is to ensure the input data collected displayed the real issues in this research. Normality test determined whether the data collected drawn from a normally distributed population. It is also a crucial test before the data for each variable can be used for next data analysis which is analysis of variance (ANOVA). There are two widely used normality test which are Kolmogorov Smirnov and Shapiro – Wilk test. In this research, Shapiro – Wilk test is chosen to test the normality of the data.

Table 1: Code Definition for each levels (The root causes)

Factors	Codes	Levels
Cutting Speed	CS1	250 sfm - 393 sfm
	CS2	400 sfm - 673 sfm
	CS3	700 sfm - 1200 sfm
Use of Cutting Fluid	CF1	Vegetable Oil
	CF2	Neat Oil
	CF3	Semi-synthetic Oil
Cutting Temperature	CT1	Low
	CT2	Medium
	CT3	High
Tool Rake Angle	TA1	Positive rake angle
	TA2	Negative rake angle
	TA3	Zero rake angle
Microcrack Formation	MF1	Intergranular cracking
	MF2	Transgranular cracking
Ductility of Material	DC1	Low ductility
	DC2	High ductility
Feed Rate	FR1	0.1 mm/rev - 0.6 mm/rev
	FR2	0.8 mm/rev - 0.16 mm/rev
	FR3	0.19 mm/rev - 0.25 mm/rev
Tool Rake Temperature	TT1	Low
	TT2	Medium
	TT3	High

This test is suitable test to analyze the normality of the data in this research because the sample size of this research is small and less than 50 respondents. Kolmogorov – Smirnov test is not suitable for this research as the requirement to use the test is the sample size must be large and must surpass at least 50 respondents. To run the test on the data collected, Statistical Package for Social Sciences (SPSS) software is utilized. The alpha rate and confidence interval for this test are 0.05 and 95 percent respectively.

Table 2 shows the result of test conducted via SPSS software as following. For Shapiro – Wilk test, null hypothesis claimed that the all the data is normally distributed and the alternative hypothesis claimed that all the data is not distributed normally. From Table 2, p-value for each variable is greater than alpha rate which is 0.05. In order to accept null hypothesis, p-value for each variable must not less than 0.05 [22]. Therefore, null hypothesis cannot be rejected and all the data gathered from the respondents are normally distributed.

Table 2: Result of Normality Test

Variables	*p- Value*
CS1	0.152
CS2	0.191
CS3	0.074
CF1	0.074
CF2	0.152
CF3	0.177
CT1	0.149
CT2	0.149
CT3	0.287
TA1	0.152
TA2	0.152
TA3	0.074
MF1	0.152
MF2	0.258
DC1	0.245
DC2	0.287
FR1	0.152
FR2	0.149
FR3	0.152
TT1	0.536
TT2	0.194
TT3	0.01
CS	0.154
CF	0.198
TA	0.52
CT	0.352
MF	0.072
DC	0.088
FR	0.077
TT	0.352

4.3 Analysis of Variance (ANOVA)

The second analysis used in this research is ANOVA test. Through this test, all possible values and parameters will be analyzed to verify the actual input. This test will be run with software known as Statistical Package for the Social Science (SPSS). After all the data has been collected from the expertise, F-test also known as ANOVA used to diagnose the data. Analysis of variance is considered to be proper analysis as their existence and initiation. Regardless of that, F-test is competence to define the significance level of causes and effects by evaluating their hypothesis [23-26], such as causes and effects of indecisions or uncertainties.

The derivation from the analysis and the approximations themselves are taken after a confidence level of 95 percent is defined in line with the solutions to evaluate important factors [27]. Thus, any causes of BUE formation in stainless steel milling with p less or equal with 95% will be considered as significant factors. Every level for each factor will be test with this F – Test. If there is at least one level lower or equal to alpha rate which is 0.05, the factor for that level is considered as critical factor. It indicates that there is certain level in that factor that cause BUE formation when milling stainless steel material.

After analysis, p value for each level will be examine. If there is one or more p – values <=0.05 exist for in the levels of a factor, then it is decided that the factor is a critical factor that cause BUE formation when milling stainless steel material. Table 3 shows the result of ANOVA analysis.

Table 3: Result of ANOVA

Levels for Each Factors	***p*- Value**
CS1	0.541
CS2	0.078
CS3	0.021
CF1	0.475
CF2	0.714
CF3	0.306
CT1	0.593
CT2	0.08
CT3	0.047
TA1	0.032
TA2	0.538
TA3	0.013
MF1	0.048
MF2	0.039
DC1	0.308
DC2	0.062
FR1	0.019
FR2	0.028
FR3	0.689
TT1	0.536
TT2	0.194
TT3	0.01

4.4 The Critical Factors of BUE Formation

As the result obtained from ANOVA analysis, there are six factors that have been identified as the critical factor that lead to BUE formation during stainless steel milling. The six factors have one or more levels in them which their p-value are lower than the alpha rate. The critical factors are cutting speed, tool rake angle, cutting temperature, microcrack formation, feed rate and tool rake temperature. Table 4 demonstrate the critical factors for BUE formation in stainless steel milling.

Nevertheless, the finding delivers a general framework on the critical factors that lead to BUE formation in stainless steel milling. The usage of analysis of variance (ANOVA) verify that there is a relationship between the uncertainties and their outcomes. The data derived from the survey was entirely based on estimation and opinion of the individual expertise in this research scope. For this reason, the confidence interval was set to 95% ($\alpha = 0.05$).With ANOVA analysis, there are significant evidences that there are six critical factor that lead to BUE formation during stainless steel milling. However, this does not mean that those factors with p-values higher than alpha rate does not contribute to BUE formation in stainless steel milling. Rather, this simply means that the critical factors that have been determined have higher probability of resulting BUE formation in stainless steel milling process.

Table 4: Critical factors BUE formation in stainless steels

CRITICAL FACTORS	LEVELS	CODE	Sig.(p)
Cutting speed	700 sfm – 1200 sfm	CS3	0.021
Tool rake angle	Positive rake angle	TA1	0.032
	Zero rake angle	TA3	0.013
Cutting temperature	High	CT3	0.047
Microcrack Formation	Intergranular cracking	MF1	0.048
	Trans-granular cracking	MF2	0.039
Feed rate	0.1 mm/rev – 0.6 mm/rev	FR1	0.019
	0.8 mm/rev – 0.16 mm/rev	FR2	0.028
Tool rake temperature	High	TT3	0.01

5. CONCLUSION

The main objective of this research is to determine the critical factors of BUE formation during stainless steel milling. As mentioned in the first chapter, BUE is unfavorable to manufacturing industry as it causes wear tool, bad surface finishing and rework on the workpiece. In order to complete the research, many journals and articles that related to the topic were reviewed to gather more informative input and improve the understanding regarding the topic. Content analysis was conducted in this research to list down all possible causes that can lead BUE formation in stainless steel milling process. Based on the content analysis performed, there are eight possible causes of BUE formation during stainless steel milling. The possible causes are cutting speed, use of cutting fluid, tool rake angle, cutting temperature, micro crack formation, and ductility of material, feed rate and tool rake temperature. In addition, content analysis was also carried out to determine the level for each factor. As a result, every factor has three levels except for two factors which are microcrack formation and ductility of material. After all secondary data gathered, questionnaire was generated for the purpose of collecting data from the expert.

Delphi method was selected as the sampling method for this study. This sampling method is suitable for this research as this research depends on the expert opinion. Ten expertise in stainless steel milling were involved in the data collecting process. The data that have been gathered were organized properly in Microsoft Excel software before transferred to SPSS software for the purpose of analyzing the data.Two tests were conducted via SPSS software to analyze the data. The first one is normality test (Shapiro – Wilk) test. The result of the test concludes that all the data is normally distributed and reliable. After the data is verified to be reliable, second analysis which is F-Test also known as ANOVA was carried out in order to determine the finding for this research which are the critical factor of BUE formation during stainless steel milling process. As the result, six factors were identified as the critical factors. The factors are cutting speed, tool rake angle, cutting temperature, microcrack formation, feed rate and tool rake temperature.

ACKNOWLEDGEMENT

This work is supported by the Research and Innovation, Universiti Kuala Lumpur under the VOT: str17034

REFERENCES

1. Axel Andersson, Built-up edge formation in stainless steel milling, in Degree Project In Materials Science And Engineering, Second Cycle, 30 Credits Stockholm, Sweden, 2017
2. M. Alabdullah, A. Polishetty, and G. Littlefair (2016) Impacts of Wear and Geometry Response of the Cutting Tool on Machinability of Super Austenitic Stainless Steel, *International Journal of Manufacturing Engineering*, Volume 2016, pp. 1–9
3. Nomani, J., A. Pramanik, T. Hilditch and G. Littlefair (2013). Machinability study of first generation duplex (2205), second generation duplex (2507) and austenite stainless steel during drilling process. *Wear an International Journal on The Science and Technology of Fiction Lubrication and Wear,* Volume 304(1–2), pp. 20-28 https://doi.org/10.1016/j.wear.2013.04.008
4. Wang, Z., Kovvuri, V., Araujo, A., Bacci, M., Hung, W. N. P., & Bukkapatnam, S. T. S. (2016). Built-up-edge effects on surface deterioration in micromilling processes. *Journal of Manufacturing Processes*, Voulme 24, pp. 321–327

5. S. N. B. Oliaei and Y. Karpat, “Built-up edge effects on process outputs of titanium alloy micro milling,” Precis. Eng., 2017
6. Oliaei, S. N. B., & Karpat, Y. (2016). . *Journal of Materials Processing Technology*, Volume 235, pp. 28–40
7. Khidhir, B. A., & Mohamed, B. (2010). Machining of nickel-based alloys using different cemented carbide tools. *Journal of Engineering Science and Technology*, Volume *5*(3), pp. 264–271
8. D.Philip Selvarai, P.Chandramohan, M.Mohanrai (2013), Optimization of surface roughness, cutting force and tool wear of nitrogen alloyed duplex stainless steel in a dry turning process using Taguchi method. *Measurement*, Vol. 49, pp. 205-215
9. Pankaj Chandna, Dinesh Kumar (2015) Optimization of End Milling Process Parameters for Minimization of Surface Roughness of AISI D2 Steel. *World Academy of Science, Engineering and Technology International Journal of Industrial and Manufacturing Engineering*, Vol 9(3), pp. 512-517
10. A. K. Sahoo (2014) Application of Taguchi and regression analysis on surface roughness in machining hardened AISI D2 steel. *International Journal of Industrial Engineering Computations*, Vol. 5, pp. 295-304
11. K. P. Patel (2012) Experimental analysis on surface roughness of CNC end milling process using Taguchi design method. *International Journal of Engineering Science and Technology (IJEST)*, Vol. 4(2), pp. 540-545
12. Samad Nadimi BavilOliaei, YigitKarpat (2017) Built-up edge effects on process outputs of titanium alloy micro milling. *Precision Engineering*, Vol. 49, pp. 305-315
13. S. M. Bruinsma et al., (2017) Expert consensus document: Semantics in active surveillance for men with localized prostate cancer-results of a modified Delphi consensus procedure, *National Revision Urology*, Volume14(5), pp. 312–322 https://doi.org/10.1038/nrurol.2017.26
14. van der Duin (2016), Foresight in Organizations,Foresight Organ., Case Studies for Managing Rapid Change in Technology, Globalization and Workforce Diversity, INBUNDEN, Engelska
15. A. Habibi, A. Sarafrazi, and S. Izadyar (2014) Delphi Technique Theoretical Framework in Qualitative Research, *Internationl Journal of Engineering Science,* Volume 3(4), pp.8-13
16. B. W. Yap and C. H. Sim (2011) Comparisons of various types of normality tests, *Journal of Statistics Computer Simulation*, Volume 81(12), pp. 2141–2155, 2011
17. Sekaran, U., & Bougie, R. (2016). Research methods for business: a skill-building approach (7th ed.). Haddington: John Wiley & Sons
18. Baharum, Z., Hanif, M., Qureshi, M.I., Raidzuan, S.N.M., Mahdin, H. (2018) Simulation model on movement of goods in sea freight for small and medium enterprise. *Indonesian Journal of Electrical Engineering and Computer Science,* Vol. 11(3), pp. 1214-1222
19. Alfred K. Mbah & Arnut Paothong (2015) Shapiro–Francia test compared to other normality test using expected *p*-value, *Journal of Statistical Computation and Simulation*, Vol. 85(15), pp. 3002-3016
20. Hadi Alizadeh Noughabi & Naser Reza Arghami (2011) Monte Carlo comparison of seven normality tests, *Journal of Statistical Computation and Simulation,* Vol 81(8), pp.965-972
21. Zvi Drezner, Ofir Turel & Dawit Zerom (2010) A Modified Kolmogorov–Smirnov Test for Normality, *Communications in Statistics - Simulation and Computation*, Vol. 39(4), pp. 693-704
22. Z. Hanusz and J. Tarasińska (2015) Normalization of the Kolmogorov–Smirnov and Shapiro–Wilk tests of normality, *Biometrical Letter,* Volume 52(2), pp. 85–93
23. Zirawani Baharum, HairulNizam Mahdin and Fauziah Abdul Rahman (2019) The development of simulation logic model that dealing with uncertainty for piping construction industry, *Indonesian Journal of Electrical Engineering and Computer Science*, Volume 18(3), pp. 1311-1318
24. Oussama, Dardary. (2019). Engineering of a Training Device and Skills Through the Integration of New Information and Communication Technologies in the Field of Exact Sciences. International Journal of Advanced Trends in Computer Science and Engineering. 8. 294-299 https://doi.org/10.30534/ijatcse/2019/4581.42019
25. B. Zirawani, N. Mohd. Salihin and H. M. Noorfa, 2016. Measuring Uncertainties of Project Completion Late Delivery in Environmental Issues. *Information Technology Journal,* Vol.15: pp. 123-129
26. Irsyadi, Fatah. (2019). Interactive Educational Animal Identification Game for Primary Schoolchildren with Intellectual Disability. International Journal of Advanced Trends in Computer Science and Engineering. 8. 3058-3064 https://doi.org/10.30534/ijatcse/2019/64862019
27. Ekta Srivastava, Satish Sasalu Maheswarappa, Bharadhwaj Sivakumaran, (2017) “Nostalgic advertising in India: a content analysis of Indian Television advertisements”, Asia Pacific Journal of Marketing and Logistics, Volume 29(1), pp.47-69