Advances in Social Science, Education and Humanities Research, volume 647
International Conference on Applied Science and Technology on Social Science 2021 (iCAST-SS 2021)

Academic Research Role in Encouraging the Use of Affordable 4.0 Technology in SME's Product Design Development

(Case Studies : The Use of Manual Two-sided Machining Method on 3-Axis CNC Milling Machine for Wooden Wristwatch Prototype Making)

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***Abstract*—The 4.0 Technology is proven to be able to give benefits for modern industry in many aspects. The technology commonly used by large scale industries due to the high cost and advanced skill needed to operate the industry. The use of 4.0 technology needs to be encouraged in the SMEs, but the readiness of the SMEs need to be put as consideration. This paper examine the role of university research in making the technology ready to be used in the SMEs, with the case studies of the use of 3-axis milling machine for wooden watch prototype making. The research method consist of 4 stages including the identification of SMEs needs, the identification of suitable 4.0 technology that match the SMEs readiness, Designing function optimization of chosen technology, and Trying the method in real production process. The result of the research is a manual method that can be used to do two-sided machining process on 3-axis CNC Milling Machine is offered as a solution in encouraging the use of 4.0 technology in the SMEs due their lack of capital abilities and technical skills.**

Keywords—University Researches; 4.0 Technology; 3-Axis CNC Milling Machine; SMEs

I. INTRODUCTION

4.0 Technology has been an interesting topic in the recent years. 4.0 technology is said to be the next industrial revolution that elevate the industrialization to the next level and change the attitude and characteristic of production processes [1]. 4.0 technology has provide so many advantages for the modern production and manufacturing processes including in Product Design Development processes. One of the advantage of the technology is in term of automation, in which it is possible to make products in a more controlled standard for a repeated product production [1]. By digitalization it is also more possible for product design development department to develop the existing product design [2][3], by adding minor changes and even radical improvement using previous product as the base. The 4.0 technology at the moment commonly used by the large scale industries, since the technology is consider to be expensive [4]. But high cost is no longer an issue for the technology since recently there are much research conducted in order to provide the technology in a more affordable price. Affordable 4.0 technology means that it would be possible for industries with limited capital abilities to be able to access the 4.0 technology, including the Indonesian Small Medium Enterprises (SMEs). But budget is not the only issues for the Indonesian SMEs. Most of the Indonesian SMEs is lacking of knowledge in advanced technology including the 4.0 technology [5][6][7]. Most of them don't see the technology as practical tools to improve their product design development and/or their production line. In this, the University had the

responsibilities to take part in making the 4.0 technology more familiar and usable for the Indonesian SMEs through academic researches [8][9], The collaborative strategy develop by the government will also give a good contribution in the case [10]. The paper examines how academic research can contribute to make 4.0 technology to be ready to be used for the Indonesian SMEs, by case studies in the use of 3-axis milling machine for wooden watch product design development.

II. Literature Review

2.1 Industry 4.0

The term 4.0 Industry firstly Introduced in German, which refers to the Industry that is connected via digital media. [11]. Industry 4.0 is Industry that allow production to be done smartly, efficiently, effectively, individual and customized at reasonable and competitive cost [1]. Industry 4.0 can be described to have 7 concepts : smart factories, improved system in procurement and distribution, a combination of cyber and physical system, self-organization, new product development and services system, customized adaption to customer needs and corporate social responsibility [12].

In order to be able to adapt to the 4.0 industry revolution, Indonesia should be familiar with the use of IoT, AI, Robotic and sensor technology, 3D Printing technology, and Human-machine interface [13].

2.2 Measuring SMEs readiness for 4.0 Technology

Research suggest that comfortability of technology use should be the main consideration in choosing suitable 4.0 technology for certain Industry. Internet infrastructure, customer focused-innovativeness, Hardware and software connection, Insecurity factors of the users, compatibility with technology that already used, support from the management, modularity, Existing technical skills of the Human Resources, Capital capabilities, competition among similar industries, global engagement, supply chain management and collaboration, customer expectations, sustainability [14]. SMEs are considered to have a high awareness of the benefit of the 4.0 technology, although it must be admitted that they still need to struggle in term of technical skills and capital resources[15]. Some research shows that “cost” and “smart factory” become the main interest for the SMEs before considering to adapt the 4.0 technology [16]. Aside of capital issue, the human resource readiness is also need to be examined [17], since the competence of the Human Resources can ensure the usefulness of the technology for the SMEs [18][19].

III. Methodology

This study uses qualitative methods. An analysis model is formulated in order to conduct the research. The analysis model consist of four stages of process. The four stages are : 1. Identifying SMEs Needs, 2. Identifying Suitable 4.0 technology for the SMEs, 3. Designing Function Optimization Method of the 4.0 Technology, 4. Trial.

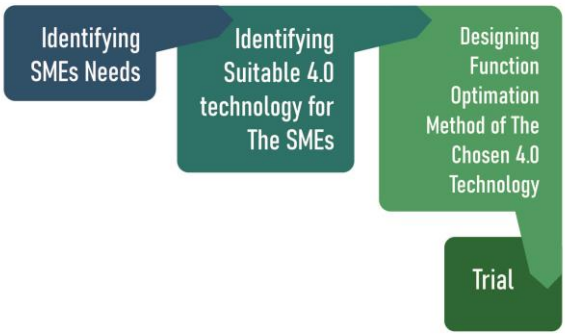

Fig.1 Analysis Model of University Research Role in Encouraging the Use of 4.0 Technology for SMEs

3.1 Identifying Needs

The first stage includes assessment to identify the needs of SMEs. It is need to be put to consideration that companies have different degree of readiness regarding the 4.0 digital technology adoption [20]. The product design development process in a SME’s wood working workshop that make wooden product is analyzed to find out in which stage of product design development or production is the 4.0 technology needed an possibly used. SMEs need to examine their practices and needs in order to made the best decision in choosing the most relevant 4.0 technology to be adapted to their production chains [21]

3.2 Identifying Suitable 4.0 Technology

The second stage is an analysis to find the suitable tool that match the SMEs needs. After the needs is identified, suitable 4.0 technology is need to be carefully chosen; so that the SMEs really can get the highest benefits after using the 4.0 technology. The consideration must include several aspects as Affordability, Maintenance cost, Ease of Maintenance, Materials that can be handled by the 4.0 technology that is chosen. The term benefit versus investment still hold the major consideration in the process of adopting 4.0 technology in the SMEs [22]. The user of the technology must understand the state of the art of the technology [23]

3.3 Designing Function Optimization Method

The third Stage is where the tool that is considered suitable with the SMEs needs then brought as academic research, in which some production method

is created to improve the use of certain 4.0 technology and to make it more familiar to use for the SMEs. The chosen 4.0 technology might still has limitation, thus academic researcher can play its role to provide method that can optimize the 4.0 technology that has certain function limitation to be able to perform as the SMEs needs.

3.4 Trial

The function optimization method is then tested if the method is proven to be successfully fulfil the purpose. After it is proven to successfully fulfil the purpose the method then used made a product prototype.

IV. FINDINGS

The four stages of analysis as shown in the model are conducted with the case studies for the SMEs that produce small sized products such as wooden wristwatch and give results as follow :

4.1 Identifying Needs

The 4.0 Technology needed by the SMEs that made wooden wristwatch is the 4.0 technology that provide the ability to carve in medium made of wood or another material that has similar characteristic and hardness. The machine / 4.0 technology also needs to be able to provide the workspace that suits the common product size produced by the SMEs.

4.2 Identifying Suitable 4.0 Technology

In identifying suitable 4.0 technology to be used by the SMEs several things needs to be considered. The first consideration is affordability, meaning that the 4.0 technology needs to be able to meet the comfortability of the user on the use of the 4.0 technology and SMEs capital ability.

The 4.0 technology that meets the considerations above are the CNC Milling machine. CNC milling machine can be classified by the number of axis used in the machine. The more axis used the more expensive the machine. These days many researches already successfully conducted to make affordable CNC milling machine [24-30]. One of the most affordable CNC milling machine that can gave quite wide varieties of use is the 3 axis milling machine. The 3 axis milling machine existed in various price and quality. The varieties ranging from the advanced products provided by major brands, the product made by less known brands, and even custom made machine made by home industry. In term of comfortability, 3 axis milling machine working principles are more or less quite similar with the common manual milling machine, which commonly used by the wooden craft industry. That means that this technology relatively more familiar for the SMEs. Thus the 3-axis milling machine is chosen to be introduced to the SMEs.

4.3 Designing Function Optimization Method

One of the disadvantage of the 3-axis milling machine is that the machine can only do one sided machining process. To do two sided machining process the machine commonly used is the 4-axis milling machine that has rotary axis as an addition to the 3 axis used in 3-axis milling machine.

The disadvantages would really be a turn-offs for the SMEs to consider the use of the machine for their business. Most of the products made by the SMEs in the case studies are carved in both side (front and bottom). One method that can be proposed is that the 3-axis CNC Milling machine can be use to do front side carving, while the bottom side can be done manually. But it would be great if the milling machine can do both side. Therefore academic research needs to be conducted to create a method, preferably manual method that enable the machine to do two sided machining process.

The research proposed a method that includes the making of 4 (four) points markings and series of Offset checking processes. The main purpose of the method is to keep the x and y axis reference on the front side of material is relatively in the same position as the x and y axis reference on the back side of the material.

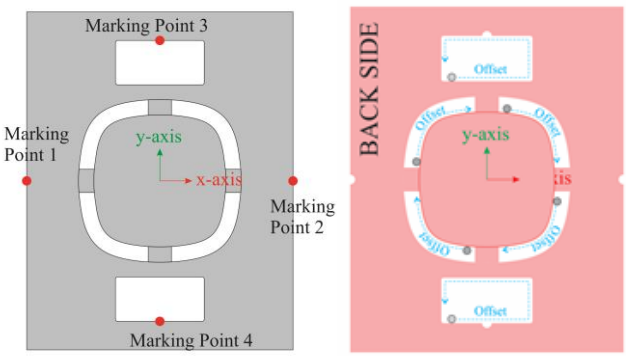

Fig. 2 Four Points Markings and Offset Checking Method

The first step of the method includes the making of 4 marking points after the front side machining process is done and two rectangular hole over the top and bottom of the main product is made. The 2 marking points are made along the x-axis at the tip of each side of the material. The other 2 marking points are made along y-axis at the tip of rectangular hole made at the top and at the bottom of the main product.

The marking points are made by drilling the material with a endmill tool from the top of the material to the bottom part of the material and feed a little more downward to the paltform. A platform made of MDF or Plywood or another soft material is

added between the machine table and the material to make the four points markings, the platform then fastened to the machine table.

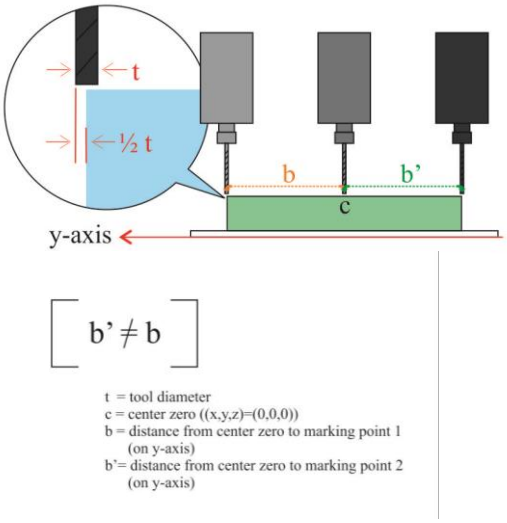

Fig. 3 X-axis two Markings Position Setting

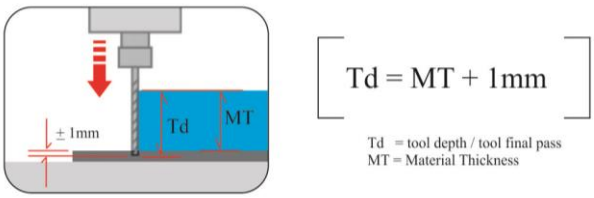

Fig. 4 Tool Feed Depth

After the making of 4 marking points process are done the material can be flipped to do the back side machining process. The marking along x and y axis on the side of the material are then adjusted to the marking points carved on the platform in order to keep the position of the x and y axis at this side of the material to be relatively at the same position as the x and y axis position at the front material.

In order to check if the x and y axis is already at the precise desired position the next step involving several offsetting process is conducted. The first is to do two offsetting process each at the top and bottom rectangular hole that is made over the top and bottom of the material at the depth of 1mm from the top of the material. The offset marking than checked if there are visible changes in the position of the marking. If there are visible signs of changes the x and y axis 0, 0 position is then adjusted manually. The process then repeated several times by adding 1mm in depth of the offset process until there are relatively no visible signs of incorrect x, y axis position.

For the final checking process, outer offset process is done to the main body of the product, to ensure if the x and y axis already at the desired position. After the series of offset processes is done, the back side machining can be started.

5 Trial

a. The designed method is then tried in order to make sure if the method can be successfully fulfil its purpose. The first trial is only performed to check if the method is working by making simple product.

- Performing front side machining

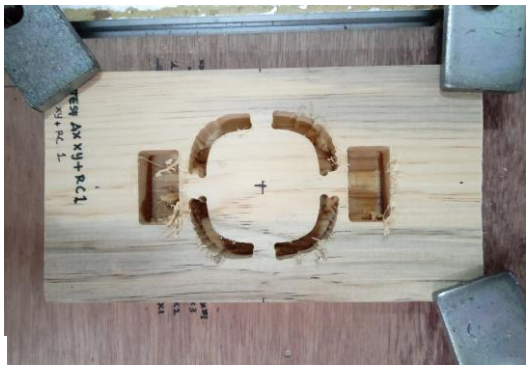

Fig 5. Front Side Machining Process Result

Adding four point markings

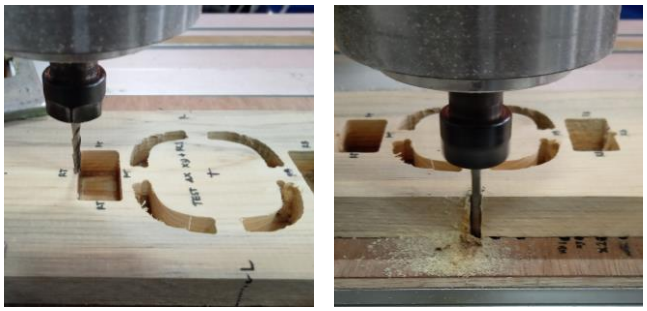

Fig 6. Marking Points Position

Fig 7. Four Marking Points Making Result

- Adjusting back side position

Fig. 8 Placing Markings carved on The Material to the Reference Markings on the Platform

Fig 9. The Position of the Material After The Markings Adjusted to the Reference Markings Position

- Offset checking

Fig 10. Offset Checking Process on the Rectangular Hole

Fig 11. Offset Checking Process on the Product

- Performing back side machining

Fig 12. Performing Back Side Machining Process

- Results

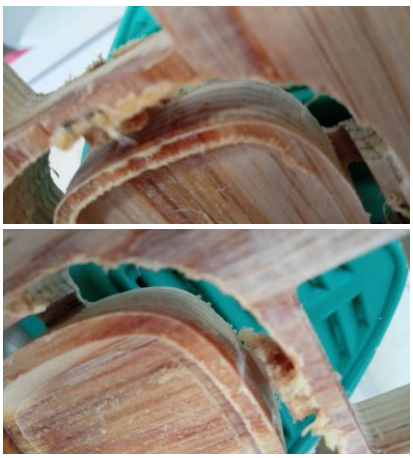

Fig 13. Results Of The Process Using The 4 Marking Points and Offset Checking Method for 3-axis CNC Milling Machine Function Optimization

Fig 14. Final Results Of Trial Process

b. The designed method is then used to make wooden wristwatch body case.

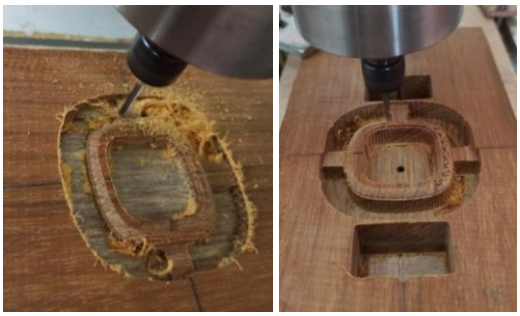

Fig 15. Using the designed method to make real Product Design Prototype

Fig 16. Final Result of Wooden Wristwatch Case Made with the Designed Method

The Function Optimization Method for 3-axis CNC Milling Machine designed through the Academic Research is proven to successfully perform Product Design Prototype making process and ready to be use by the SMEs. At this point, if the research is used by the SMEs, It would ensure the development of the SMEs through the use of 4.0 technology.

V. CONCLUSION

The difference in SMEs readiness for adopting the 4.0 technology needs to be assessed in order to ensure the successfulness of the technology to give benefits for the SMEs. Academic University Researches can be used as a tool to make the 4.0 technology more ready to be adopted by the SMEs. In the case study of wooden wristwatch prototype making, 3-axis CNC Milling machine is chosen to be the suitable 4.0 technology for the SMEs. The 3-axis milling machine is quite affordable yet the technology is more similar with the conventional milling machine commonly used by the SMEs. But the 3-axis milling machine has limitation that it is not able to do 2-sided machining process. Adding 4th axis to the machine is possibly done, but might rise the technology price as consequences. The 4-axis technology might also give extra problem due to lack of operator skills.

Through this academic research, certain manual method can be added to improve the function of 3-axis CNC milling machine. The method would be familiar enough for the operator, and wouldn't add any cost that might make the technology more expensive. The academic research result would then be one of encouragement for the SMEs, to start adopting the 4.0 technology in their production line, that which in te end leading the SMEs to a have a more competitive production system in the digital era and increasing the quality of their products through a more advanced product development system.

Similar research can be conducted for different case studies. The aspect to be considerate can be vary due to the difference in each SMEs needs. The four stages of analysis as modeled in the methodology, can be used as guidance in developing the steps in doing similar researches.

ACKNOWLEDGMENT

We would like to give our greatest appreciation and thanks to Polytechnic Samarinda for enthusiastically funding, supporting and assisting the research.

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