

Innovation of Elbow Fixture Welding Process Based on Design for Manufacture and Assembly (DFMA)

Novri Yunus^{a,*}, Anita Susilawati^b

^{a)} Laboratory of Technology Production, Mechanical Engineering Departement, Universitas Riau, Indonesia

^{b)} Mechanical Engineering Departement, Universitas Riau, Indonesia

* Corresponding author(s): novri.yunus@student.unri.ac.id, anitasusilawati@yahoo.com,

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ABSTRACT

The elbow fixture in the welding process is a supporting tool to holder the work-piece in the welding process. This tool is made in Do It Yourself (DIY) in micro-business. However, in its application there are problems. The solution provided to overcome these problems is the development of tools with the Design For Manufacture and Assembly (DFMA) method. The goal is to create a portable device design that is easy to carry and to calculate the time and cost of the manufacturing process and welding fixture assembly. The development of tools is carried out by looking for more complex problems through a consumer need questionnaire and a product development questionnaire. Data obtained from the development questionnaire can be used as a concept design (sketch) for analysis based on DFMA. The DFA (Design For Assembly) is carried out to simplify the assembly design and facilitate the assembly process. The choice of material is the basis for the quality of the product. The DFM (Design For Manufacture) is done to determine the component manufacturing process design, calculate the cost of materials and manufacturing costs. From the DFMA process, an innovation design for the welding process consists of 22 components with 12 different types of components. The design of innovative elbow aids in the welding process is called adjustable angles welding fixture. The cost used to manufacture this tool is Rp. 87,953 and the assembly and manufacturing time is 97 minutes 47 seconds.

KEY WORDS: *Design, fixture, DFA, DFM, DFMA.*

1.0 INTRODUCTION

On equipment and equipment that are around, very often found steel with a connection, especially the elbow connection. The connection certainly requires good angular accuracy, in general to measure the strength of the joint the elbow ruler is used. If this is done at a Micro Small and Medium Enterprises (UMKM) welding workshop that often performs welding at an angle of the elbow with an elbow ruler, then using an elbow ruler is very time consuming when setting it. Of course it will make the product production costs increase because the processing time is relatively longer, therefore an elbow fixture is made in the welding process.

The elbow fixture is a tool to form an angle of 90o with flatness of the floor in the welding process. Examples of elbow aids in the simple welding process can be seen in Figure 1. In the process of use, this tool is very helpful in production but there are still problems, among them; can not connect at the bottom of the workpiece, the base plate is subject to expansion, the remaining electric welding dirt accumulates on the base, and can only hold at an angle alone can not be universal. Departing from that problem, it is necessary to innovate elbow tools in the welding process by applying the Design For Manufacture and Assembly (DFMA) method.

The elbow fixture in the welding process is designed to be used in UMKMs that are more towards microenterprise. The design of this tool uses the Design For Manufacture and Assembly (DFMA) method in selecting production equipment, calculating costs during production, calculating manufacturing and assembly times, and making assembly procedures.

The research objective is to calculate the time and cost of manufacturing and assembly during the production process and to design portable devices that can be easily carried to work locations.

2.0 FUNDAMENTAL THEORY

2.1 Fixture Welding

Fixture is a production equipment used to place, hold and support workpieces [1,2]. There are two types of fixture namely single fixture and modular fixture [3].



Figure 1: Elbow Fixture

2.2 DFMA

DFMA (Design For Manufacture and Assembly) consists of design for manufacture (DFM) and design for assembly (DFA) [4,5,6]. DFM aims to simplify the manufacturing process of each component making up the product and DFA aims to simplify the product structure so that the assembly process is shorter [6].

On many needs DFMA is used for three main activities [4], there are:

1. As the basis for concurrent engineering studies to provide guidance to the design team in simplifying the product structure, to reduce manufacturing and assembly costs, and to quantify the improvements.
2. As a benchmarking tool to study competitors' products and quantify manufacturing and assembly difficulties.
3. As a should-cost tool to help negotiate suppliers contracts.

Stages made when using DFMA during design. The DFA analysis is first conducted leading to a simplification of the product structure. Then, using DFM, early cost estimates for the parts are obtained for both the original design and the new design in order to make trade-off decisions. During this process the best materials and processes to be used for the various parts are considered. In the example, would it be better to manufacture the cover in the new design from sheet metal? Once final selection of materials and processes has occurred, a more thorough analysis for DFM can be carried out for the detail design of parts. All of these steps are considered in the following chapters [4]. DFMA flowchart is in Figure 2.

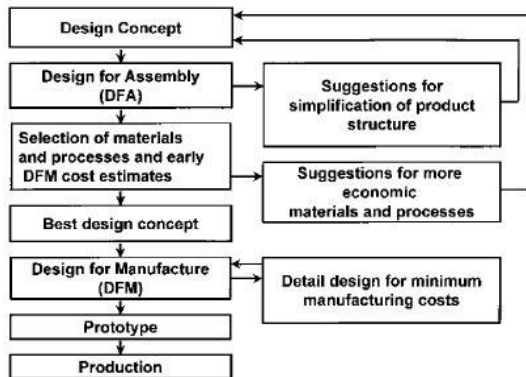


Figure 2: DFMA Process Flow Diagram [4]

2.3 DFA

DFA (design for assembly) is one of the assembling planning systems, which analyzes the design of components and products as a whole, which starts from the beginning of the design process, so that assembling difficulties can be overcome before components are produced. This system aims to simplify the assembly process so that the time and cost of assembling can be reduced. The advantage of this DFA is to reduce the number of design changes and indirectly reduce costs and time, while meeting customer needs [7].

2.3 DFM

DFM (design for manufacture) is the practice of developing manufacturing through a product development process that can be done by reducing materials, reducing the number of components, reducing assembly costs and reducing production support costs [8].

3.0 METHODOLOGY

3.1 Research Flow Chart

In the research of elbow fixture innovation in the welding process based on Design for Manufacture and Assembly (DFMA), several stages are carried out, while the research stages are in the flowchart in Figure 3.

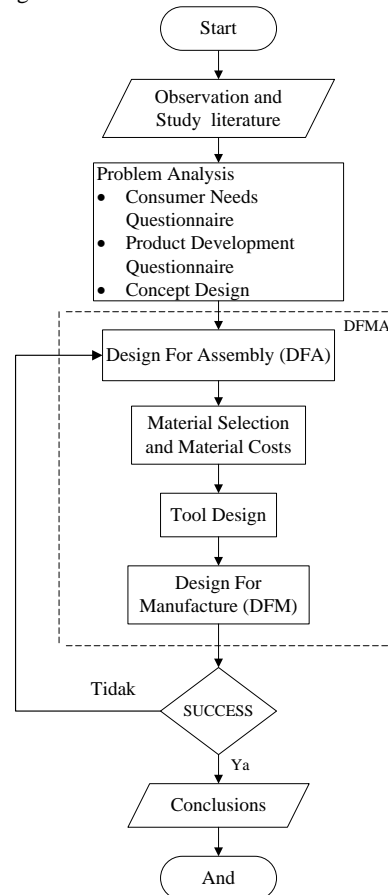


Figure 3: Research Flow Chart

3.2 Observation and Study of Literature

Literature observations and studies were conducted to obtain preliminary data that is used as a reference for conducting research.

1. Observation

The observations observed in this study were the elbow fixture in the welding process as shown in Figure 1. The observed observations were;

- a. The specifications of the instrument being observed are geometry and mass.
- b. setting process time on the welding process which reaches 15 seconds.
- c. This tool is only able to connect with the angle of the elbow with half the circumference of the welded object sandwiched on the tool.
- d. The base is deflected and there are many welding impurities.
- e. The cost of making this tool is said to be Rp. 20,000.

2. Study of research

Study of this research literature by collecting data from books, journals, and the internet that discusses welding fixture and DFMA.

3.3 Problem Analysis

Analysis of research problems based on data obtained from field observations is one of the initial data problems that exist in UMKMs regarding this research. To get more complex data about elbow fixture in the welding process, a questionnaire was made to analyze the needs of consumers by offering 3 design tools that are on the market. After the questionnaire was distributed, a design which was used as product development was obtained, and from that development a design concept was obtained.

3.4 DFMA Analysis

DFMA analysis is a method for evaluating the design of a product so that it is easy to assemble and produce. Determination of the best design is carried out to improve some aspects of DFA and DFM.

DFMA analysis was done in several stages, as follows:

1. *Design For Assembly* (DFA)
2. DFA functions as a convenience and simplification of the assembly and also calculates the estimation and assembly costs.
3. Material selection and material costs
4. Material selection can be seen from the tool components in the market and material costs can be budgeted by looking for price data in the market place.
5. Design the best concept
6. The best concept designs are made from sketch design, DFA, and material selection. So we get a new tool design with complex geometry details and component material dimensions in the market.
7. *Design For Manufacture* (DFM)
8. The DFM is to facilitate the process of making each component making up the product. In this case, what must be taken into account is the equipment used and the cost of production.

3.5 Conclusions and suggestions

This stage is the final stage of the research that is drawing conclusions obtained from the elbow fixture innovation research in the welding process based on DFMA in accordance with the research objectives and suggestions that can be given by the author to improve this tool.

4.0 RESULT AND DISCUSSION

4.1 Problem Analysis Results

In this study, the problem analyzed is the need for the welder of the angle joining fixture during the welding process. Analysis of this problem was carried out using a questionnaire survey of 10 people who were subjected to the need for this tool. The population in this study is the citizens of Pekanbaru City. Samples taken for this study were 10 people by Accidental Sampling. The minimum amount of data is said to be valid if based on the opinion of at least 10 people. This becomes the basis in taking a sample of 10 by Accidental Sampling [9].

The results of the questionnaire obtained that the products that are often done by UMKM are canopy and bars and materials that are often used 60% iron steel. A product made from 60% to 80% is machined welded, and more than 80% is welded by angular angles. Every part of the angle to be welded is measured first with the angular ruler with an elbow ruler and partly held by a clamp, even it is said that some welder in the trali is measured on the diagonal only because not all of the kunsen is at the angle of the elbow.

The elbow angle welding process carried out by UMKM welder 50% also there are difficulties, generally this is due to the size of the workpiece length such as making billboards that are more than 4 meters. However, the demand for this product is only 20% in UKM, and the time needed for the setting is more than 30 seconds because the clamps are used for the holder. When viewed from the data, the average setting time required by the welder is 1 second to 10 seconds, but when the welding process takes longer than 30 seconds, this is because at first the welding process is ticked by the connection and then carried out welding overall to overcome deflection.

Problems that occur are made into data such as the needs of the UMKM welder. So, there are some pictures of the elbow angle welding fixture on the market. From the survey results obtained 5 respondents chose magnetic welding fixture as a tool which is expected to facilitate the setting of the workpiece.

4.2 Tool Design Results

After analyzing the needs of the welder with the use of welding fixture, a simulation of the equipment that is needed from the welder needs to get an updated design from the old device.

The analysis was carried out by means of a questionnaire survey of 10 subjects, namely UMKM welder. This questionnaire aims to get the design tools needed by UMKM welder.

This research was carried out by bringing the products and materials tested. Data obtained from the results of this study that 70% of UMKM welder is helped by the existence of elbow fixture in the welding process, because the setting time required is 1 second to 10 seconds.

When asked about the shortcomings of this tool 30% welder complained about the position of the workpiece holder which is

only held from the outside can not be from the openings in this tool. 30% welder also experience difficulties when removing tools from welded workpieces due to the magnetic tensile strength.

Making equipment is expected to reduce production costs because the expected cost of welder is Rp 100,000 to Rp 300,000. If the cost of producing the tool is successfully achieved nominally, then 70% of UMKM welder was satisfied with this tool.

The elbow fixture design in the welding process by considering the data that is expected to meet the needs of the welder, the design is made as shown in Figure 4.

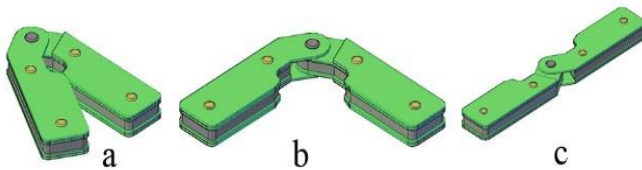


Figure 4: Design Fixture Welding

The welding fixture design in Figure 4 (a) is a maximum closed position with a minimum angle opening of 30°, Figure 4 (b) is a position at an angle of 90°, and Figure 4 (c) is a position at an angle of 180°.

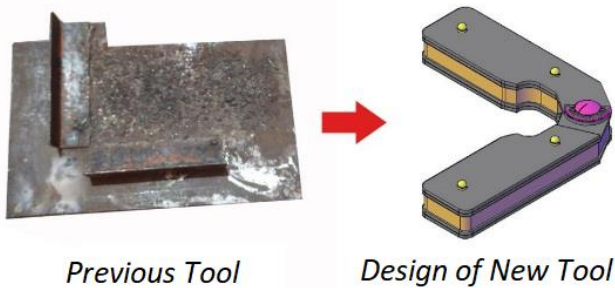


Figure 5: Differences in Geometry of Tools after Innovation

After doing innovation elbow fixture of welding process, there are some geometrical changes (Figure 5) and also the advantages and disadvantages of this tool. The differences in the specifications of the tools that have been done are found in Table 1.

Table 1: Differences in Tools after Innovation

No	Specification	Old Fixture	New Design
1	Dimension (mm)	205 x 230	125 x 95
2	Clamp	No	magnetic
3	Work angle	90	30 - 220
4	Massa (kg)	1,4	0,5

4.3 DFMA Analysis of Elbow Fixture Welding Process

4.3.1 Analysis DFA

The elbow fixture in the welding process has a total of 22 components with 12 different components. The components of the elbow (fixture) welding process are shown in Figure 6 and table 2.

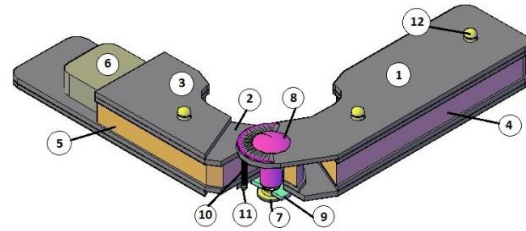


Figure 6: Components Parts of Elbow Fixture Welding Process

Table 2: Components Elbow Fixture Welding Process

No	Part Item	Amount
1	Rotary plate handle	2
2	Fixed Plate handle	2
3	Plate handle	4
4	Rotary handle support	1
5	Fixed handle support	1
6	Inside thread locking bolt	1
7	Magnet	2
8	Button head socket screw	1
9	Ring 16mm	1
10	Spring Press	1
11	Steel ball 2mm	2
12	Rivet nails 5mm	4
Total		22

Welding process elbows are assembled in 11 stages, with a total assembly time of 107 seconds or 1 minute 47 seconds calculated using a stopwatch. Assembly fee assumed to be Rp. 506, as it is known that the Pekanbaru City Minimum Wage (2020) according to Riau Governor Decree Number: Kpts. 1198 / XI / 2019.

4.3.2 Analysis DFM

Welding process elbows consist of 12 different types of components, for dimensions and materials used are contained in Appendix 3, and each component is made from a different process. The components manufactured from the elbow fixture in the welding process are shown in table 3.

Table 3: Components of the Elbow Welding Fixture Manufacturing Tool

No	Part Item	Amount/Component	Material Cost
1	Rotary plate handle	2	Rp 1,884
2	Fixed Plate handle	2	Rp 1,884
3	Plate handle	4	Rp 3,768
4	Rotary handle support	1	Rp 313
5	Fixed handle support	1	Rp 313
6	Inside thread locking bolt	1	Rp 1,331
Total		11	Rp 9,493

Components for elbow welding fixture produced were 11 components with a material cost of Rp 9,493. Material from the tools is then made using several tools, the cost of producing tool components is Rp. 52,305 with 96 minutes of work time, details of costs and tools used in the production process of each component are in table 4.

In addition to the 6 types of parts that are manufactured, there are also components that are already on the market (non-manufacturing). The components on the market are in table 5.

Things that must be considered in the manufacture of this tool

is the availability of non-manufactured goods in accordance with the dimensions designed, so as not to change the design dimensions of the components. If the manufactured product has been made but non-manufactured goods are not available, it is necessary to redesign it by adjusting the components in the market.

The total cost of materials and production for welding process elbows with DFM is summed from the total cost of materials, production, and non-manufacturing components is Rp 87,447.

Table 4: Details of Production Costs

No	Machining	Time Production (minute)	Production costs / minute	Machining Cost	Production costs / pcs	Qty	Total Production	Total Time (minutes)
1	Hand grinding	10	Rp 284	Rp 2,840	Rp 3,840	2	Rp 7,680	22
	Drill	1	Rp 1,000	Rp 1,000				
2	Hand grinding	10	Rp 284	Rp 2,840	Rp 3,624	2	Rp 7,248	23
	Drill	0.5	Rp 1,000	Rp 500				
	Files	1	Rp 284	Rp 284				
3	Hand grinding	5	Rp 284	Rp 1,420	Rp 1,920	4	Rp 7,680	22
	Drill	0.5	Rp 1,000	Rp 500				
4	Sawing	3	Rp 284	Rp 852	Rp 1,352	1	Rp 1,352	3.5
	Drill	0.5	Rp 1,000	Rp 500				
5	Sawing	7	Rp 284	Rp 1,988	Rp 2,488	1	Rp 2,488	7.5
	Drill	0.5	Rp 1,000	Rp 500				
6	Turning	15	Rp 1,667	Rp 25,005	Rp 25,857	1	Rp 25,857	18
	Tapper	2	Rp 284	Rp 568				
	Files	1	Rp 284	Rp 284				
Total							Rp 52,305	96

Table 5: Non-manufacturing Components of Elbow Fixture Welding

No	Part Item	Amount/ Component	Price	
			Item	Amount
1	Magnet	2	Rp 10,000	Rp 20,000
2	Button head socket screw	1	Rp 2,620	Rp 2,620
3	Ring 16mm	1	Rp 200	Rp 200
4	Spring Press	1	Rp 2,245	Rp 2,245
5	Steel ball 2mm	2	Rp 162	Rp 324
6	Rivet nails 5mm	4	Rp 65	Rp 260
Total		11	Rp 25,649	

5.0 CONCLUSION

The conclusion that the writer got from the research of elbow tool innovation in the welding process based on Design for Manufacture and Assembly (DFMA) is as follows;

a. Innovation of elbow welding fixture from the old tools with new tools namely; smaller dimensions so that it is easy to carry, there are clamps, welding work angles are more flexible, and lighter mass.

- b. The installation of elbow fixture in the welding process has a total of 22 components with 12 different types of components.
- c. Applying DFMA analysis from welding process elbow tools after calculating the cost of Rp 87,953 and assembly and manufacturing time for 97 minutes 47 seconds.
- d. The design of the innovation of the elbow in the welding process is called the angle welding process (adjustable angles welding fixture).

REFERENCE

1. Karad, A. A., Wagh, B., dkk. 2016. A Review on Design Consideration and Need of Fixture in Manufacturing Industries. International Journal of Engineering Research and General. Science Volume 4, Issue 2, ISSN 2091-2730: 428-432.
2. Syadda, A dan Fusito. Perancangan dan Pembuatan Alat Bantu Pegang (Fixture) Untuk Proses Pengelasan Sambungan-T. Unsri.
3. Susilawati, A. 2009. Modifikasi Modular Fixture Untuk Proses Milling. ISSN 0854-8471. Vol.3 No.2: 8-13.
4. Boothroyd, G., Knight, W., dan Dewhurst, P. 2001. Product Design for Manufacture and Assembly. New York: Marcel Dekker.
5. Faizal, A., Luthfianto, S., Nurwildani, F. 2017. Design Pengembangan Produk Wallshelf Menggunakan Integrasi QFD dan DFMA di UD. XYZ. Jurnal Universitas Pancasila Tegal. Vol.15 No.2 : 11-16
6. Kurianto, R.R, Wibowo, A., Prakosa, Tri. 2015. Penerapan Metoda Design For Manufacture ad Assembly pada Handle Transformer Hand Bike. Proceedig Seminar Nasional Tahunan Teknik Mesin XIV. Banjarmasin : T14.
7. Veranika, Rita M. 2014. Aplikasi Design for Assembly (DFA) Pada Perancangan Produk Vaccine Carrier. Jurnal Desiminasi Teknologi, Volume 2 No. 2.
8. Handoko, R. 2016. Perbaikan Fabrikasi Pallet Box dengan Design for Manufacture (DFM) Untuk Meminimasi Biaya Produksi dan Kualitas. Jurnal Teknik Industri ISSN: 1411-6340 hal. 85-92.
9. Ulrich, Karl. T. dan Eppinger, Steven. D. 2012. Product Design and Development. Fifth edition. McGraw Hill.