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Multi-Functional Clamping Device

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Abstract: This paper present the design and details of a Multi-functional Clamping Device suitable for benchwork and machine work. The device was intended for clamping metals and plastic materials like square blocks, round bar, steel pipe and PVC (Poly-Vinyl Chloride). This device can be mounted on top of bench table, drilling machine and milling machine table for further benchwork, drilling, and machining operations. The diversity of the function of Multi-Purpose Clamping Device will suit to the current needs of universities, machine shops, and even in industries in its most affordable price.
Keywords: multi-functional, clamping device, benchwork, machine work.

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Introduction

Nowadays, the biggest challenge in most fabrication set-up, machine shop, and even laboratory shops of industrial technology is the availability of tools and equipment that could optimize and aid their production and projects. According to Walker (2000), without the aid of any clamping device no machining process could advance to its realization. One of the variables that need to consider in selecting clamping devices is its suitability to its intended processes. As cited in the work of Ramachandra *et al.,* (2015), the first issue that needs to address in machining operations is the workpiece holding device to ensure the machining accuracy of specific dimensions as well as correct positioning and immobilization of workpiece during machining operation. Thus, clamping devices play an important factor in ensuring production quality and reducing production cycle time. Machining stage requires a clear plan of appropriate clamping devices suitable to the process. Deciding on what specific appropriate clamping device will be used in a job is a highly complex and intuitive process, which require differ knowledge to the process and machineries.

Proper selection of clamping devices is crucial for developing product quality in terms of accuracy, quality of surface finish and precision of the workpiece (Pachbhai *et al.,* 2014). Clamps is responsible in securely holding the workpiece firmly, reducing or eliminating the

possibilities of non-conformance to the required accuracy, safety of worker, and the machine itself. Clamping system should be rigid to sustain various forces develop during the operation. Clamping devices must address problems is vibrations and chatter during the cutting operation (Kundu, 2014).

A vise is a general-purpose workholding device that is equipped with two jaws that holds the work in position during the operation. Fixture is one of many workholding devices designed in positioning the part comparative to the machining operations, better production rates, and convenient to use by the operator (Groover, 2007). Clamps are aided by screws, levers, toggles, wedges and combination of them to achieve to provide sufficient strength in holding parts. Methods of clamping workpiece must be movable allowing faster adjustment with full consideration to accurate alignment to fixtures (Sclater, 2011).

To address the needs for a cheaper clamping device that could be used for benchwork and machine work suitable for mechanical laboratory shops, small and medium scale machine shops, and other mechanical fabrication, the project aimed to design and construct a Multi-functional Clamping Device. Specially the study aimed to achieve the following objectives: design a multi-functional clamping device; estimate the cost of supplies and materials needed in the construction of the project; construct a multi-functional clamping device; and test and evaluate the functionality of the completed project.

Materials and Methods

The realization of this Multi-functional Clamping Device is intended to hold and clamp workpiece like round bar, plastic/ metal pipe, square and rectangular materials with the aid of material clamp support assembly, U-clamp, and plate and screw assembly. The device was conceptualized upon identifying the needs of mechanical shop laboratory for an alternative clamping device which can be useful for either benchworking or machining process. Plan was carefully laid out the step by step procedures in order to complete this project which is widely discussed in the input, process, and the output of this endeavor as best shown in figure 1.

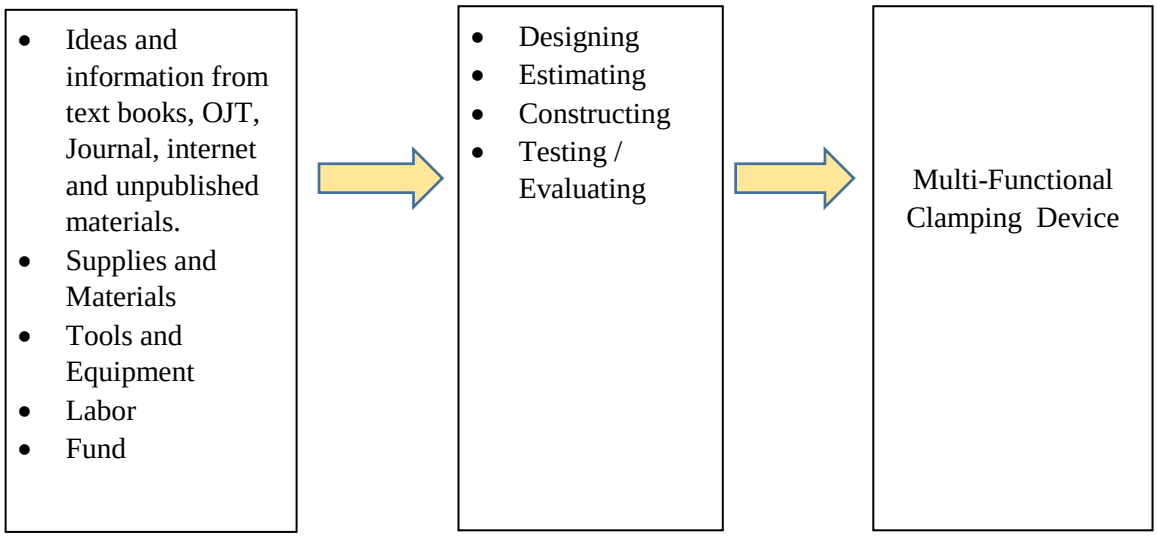

Figure 1. Conceptual Paradigm of a Multi-functional Clamping Device

The design of the Multi-functional Clamping Device was conceptualized from the idea and principles of the existing clamping device and other related studies. Through the substantial

information referred from different textbook, the researchers were able to create a clamping device which can able to apply for either cylindrical, rectangular and square shapes of materials from plastic to metal. Series of adjustment were conducted to improve the design of this project. Likewise, proper tolerancing were also considered to assure the functionality of this project. The researchers consult different expert in the field of mechanical works for the realization of this device. The researchers utilized NX for Engineering Design to achieve the best result of their blueprint. The project underwent different stages shown in figure in order to achieve the completion of the project.

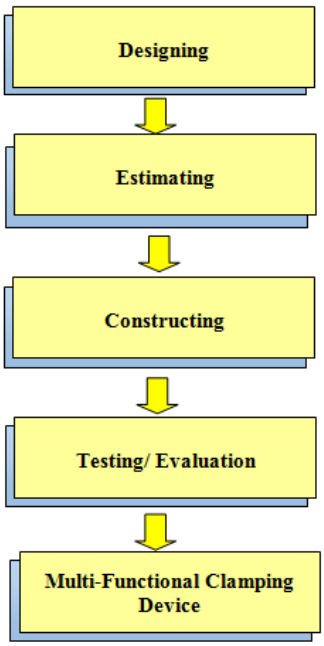

Figure 2. Design Stages of the Project

The project developmental process were breakdown to different activities to make sure that the project is constructed and within the time frame allotted for each work activities. The Table 1 shows the time frame allocated for each activity to complete the project.

Table 1. Work Sequence of Activities and Corresponding Duration

Work activities	Number of weeks							
	1	2	3	4	5	6	7	8
Designing								
Estimating								
Constructing								
Testing/ evaluating								

This project development study is divided into different proportion and major activities to complete the device. It includes measuring, cutting, drilling milling, lathe, machining, buffing, welding, grinding, painting, assembling, and testing and evaluating. Each major activity is needed into the production of sub-assembly of parts and accessories. The general procedures in the construction of the project per process are as follows:


1. Preparation the tools and materials needed in the construction of project.

2. Laying out of the design and sizes directly to materials using scriber and steel rule

3. Cutting of round bar using power hacksaw

4. Squaring of metal plates and metal blocks using milling machine

5. Drilling of metal plates and blocks using milling machine

6. Threading of holes and shafting using tapping and die tools

7. Buffing of sharp edges and irregularities to the materials

8. Welding the sub-assembly of clamp support guide using arc welding machine

9. Coating the sub-assembly using spray paint

10. Assembling the parts of the project

Table 2. Cost of Supplies and Materials

Qty	Unit	Description	Unit Price (PHP)	Total Price (PHP)
3	pcs.	Bolt M16 x 2.0 (300mm long)	300.00	900.00
12	pcs.	Bolt M8 x 1.25 (50mm long)	15.00	180.00
20	pcs.	Bolt Nut M10 x 1.5 (40mm long)	20.00	400.00
1	pc.	Electrode	100.00	100.00
1	pc.	End Mill ø16 mm	1200.00	1200.00
1	pc.	End mill ø10 mm	700.00	700.00
1	pc.	End mill ø12 mm	800.00	800.00
1	pc.	Fly cutter/face mill ø6	2500.00	2500.00
1	pc.	Drill size ø6.7 mm	95.00	95.00
1	pc.	Drill size ø8.4 mm	153.00	153.00
1	pc.	Drill size ø12 mm	100.00	100.00
2	pcs.	Metal plate 10x100x60 mm	120.00	240.00
2	pcs.	Metal plate 20x12ox160 mm	320.00	640.00

1	pc.	Metal plate 20x120x240 mm	480.00	480.00
1	pc.	Metal plate 20x120x150 mm	300.00	300.00
2	pcs.	Metal plate 80x100x200 mm	1100.00	2200.00
2	pcs.	Metal plate 10x50x120 mm	100.00	200.00
2	pcs.	Metal plate 10x100x150 mm	150.00	300.00
3	pcs.	Metal plate 10x30x200 mm	100.00	300.00
1	kl	Welding electrode	100.00	100.00
Total Cost				**Php11,888.00**

The total cost of the finished project is composed of different variable which includes expenses in supplies and materials, labor cost, and miscellaneous cost is reflected in table 3.

Table 3. Total Cost of Project

Project Expenses	Variable Cost (PHP)
Supplies Materials	11,888.00
Labor Cost	3,000.00
Miscellaneous Cost	5,000.00
Total Cost	Php 19, 888.00

The structure of the completed project includes all the major parts of the assembly vital to achieve the top most efficiency of the device. This includes base plate, clamping support assembly, clamping support guide, left and right clamping assembly, reversible V-block, U-frame, clamping plate and screw, and clamping bolt. The whole feature of this invention is made of metal that can stand stress and retain its strength capabilities for long term used.

The base plate (101) serve as an attachment for the milling and drilling machine table where all parts are mounted allowing wider range of operation to perform. This is made up of metal plate with a size of 60cm X 16cm X 10mm. It has threaded holes allowing the attachment of clamping support assembly and reversible V-block

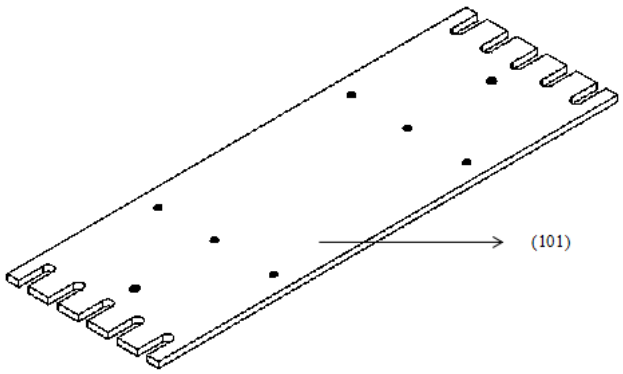

Figure 3. Schematic View of the Structure of the Base Plate

Clamping support assembly (102) are a rectangular poles supporting the material clamp support guide and left and right material clamp assembly. This is made up of rectangular metal pipe with a size of 5.0cm X 5.0 cm X 27.94 cm. The clamping support guide is fixed on the edge of these rectangular poles and the other edge has a threaded hole allowing this assembly to attach on base plate.

Clamping support guide (103) is a threaded blocks mounted on top of the two clamping support assembly and responsible for guiding the movement of left and right material clamp assembly.

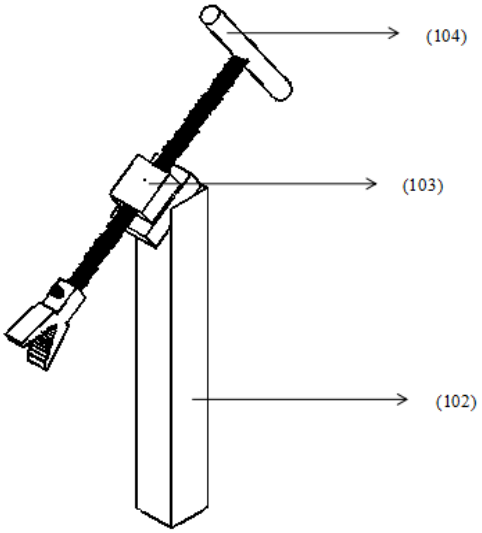

Figure 4. Schematic view of the Structure of the Clamping support Assembly and Clamping Support Guide

Left and right clamping assembly (104) grips and holds the mounted material, pressing it against the surface of v-block. This is made of threaded shafting with horizontal handle for easier manipulation of tightening and loosening of clamping assembly against the material. This assembly contain a removable V-jaw allowing to grip cylindrical workpiece. This left and right clamping assembly has a total length of 38 cm.

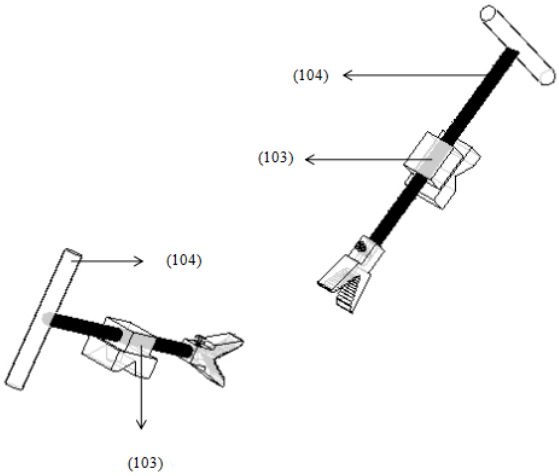

Figure 5. Schematic View of the Structure of the Left and Right Clamping Assembly

U-Frame (105) is used to support and hold the small size of cylindrical material mounted on top of v-shape opening. This attachment resemble to U-shape form with a threaded hole on the center of the oblique surface to allow a clamping assembly to fit into its threaded hole. The thickness of this U-frame is 1cm with a clamping assembly of 38cm long equipped with a detachable V-jaw.

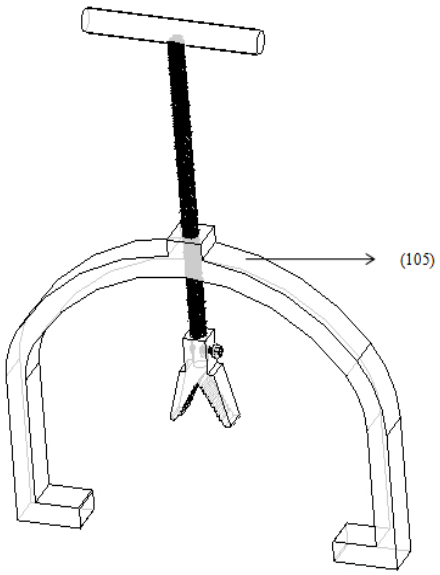

Figure 6. Schematic view of the structure of the U-Frame

Reversible V-block (106) it is an invertible blocks allowing to grip cylindrical workpiece on top of v-shape opening and square or rectangular workpiece mounted on top of rectangular opening once the v-blocks is inverted. It has a two slotted grove on both sideways allowing a seat for the U-frame. Both top and bottom surfaces has threaded holes for inverting option. This reversible V-block is made up of solid tool steel metal with a dimension of 25.4 cm X 5.91 cm x 20.32 cm.

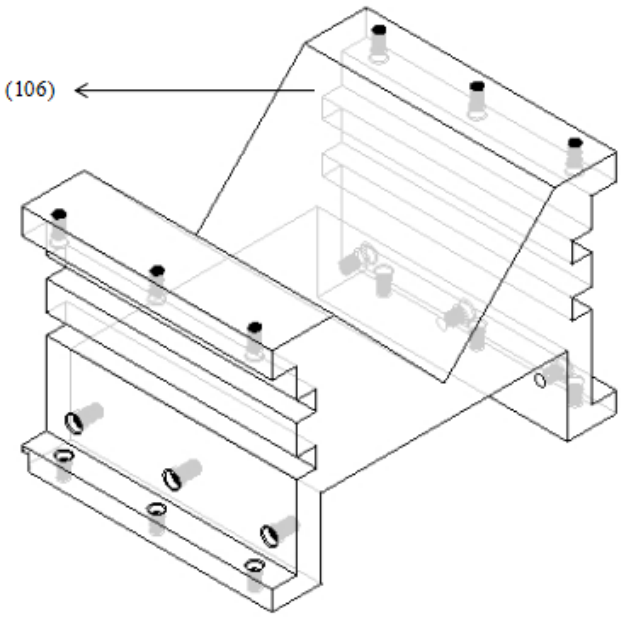

Figure 7. Schematic View of the Structure of the Reversible V-Block

Clamping plate and screw serve (107) as a clamp and support materials for rectangular shape materials or block form. It is made up of tool steel with a dimensional feature of 25.4 cm X 7.62 cm X1.0cm. This clamping plate has a threaded hole on the center surface allowing a clamping assembly with V-jaw to fit into its threaded hole. This also has threaded holes

allowing its assembly to be fixed on the top surface of the reversible V-block to grip the mounted material.

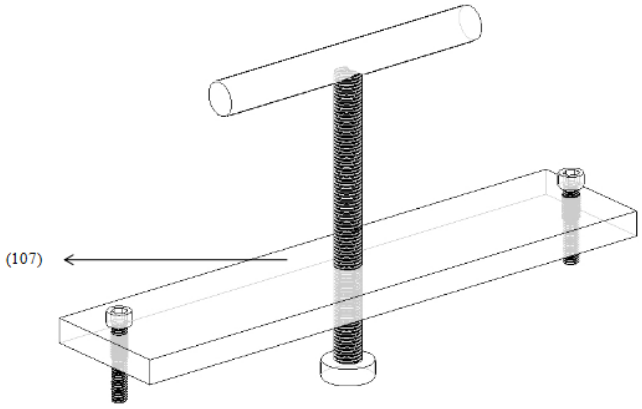

Figure 8. Schematic view of the structure of the Clamping Plate and Screw

Clamping bolts (108) are made of tool steel allowing gripping to the materials on the square jaw of the reversible v-block to clamp the materials sideways.

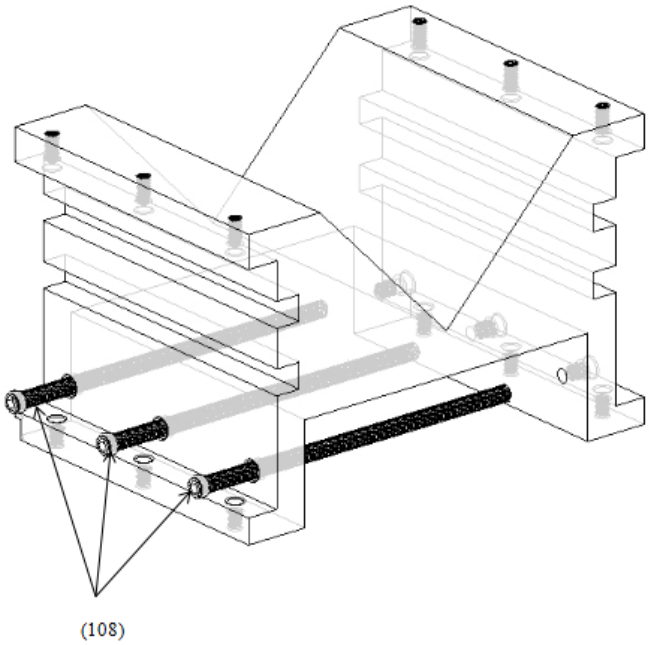

Figure 9. Schematic View of the Structure of the Clamping Bolts

The completed assembly of the project base on the result of vital processes involved in the development of this project is shown in figure below

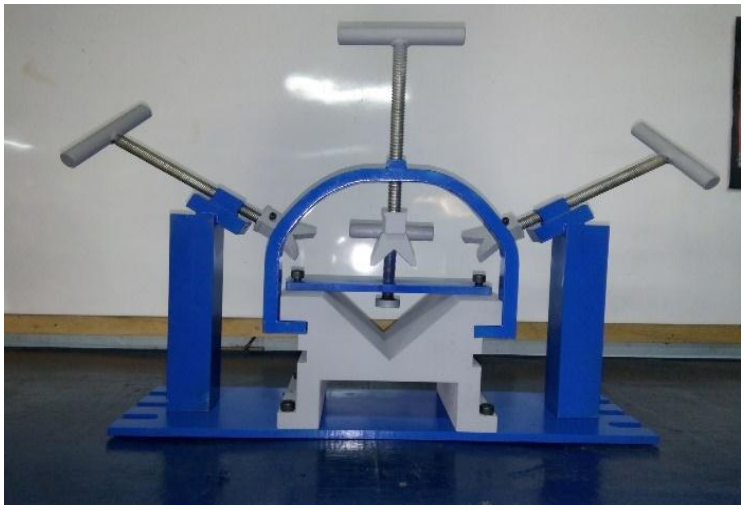

Figure 10. The Completed Assembly of Multi-Functional Clamping Device

Results and Discussion

The Multi-Functional Clamping Device was simple device is intended for clamping metals and plastic materials like square blocks, round bar, steel pipe and PVC (Poly-Vinyl Chloride). This device can also be mounted on top of bench table, drilling and milling machine table for further benchwork or machining operations. This device offers an option of three clamping system depending on the size and shape of materials to be clamp to facilitate further operations needed. This three clamping system is suitable for clamping smaller and bigger diameter of work. The device has a dimension features of 60 cm X 16 cm X 30 cm and can able to grip materials ranges from 1.27 cm to 15.3 cm for cylindrical object and 15.0cm for rectangular metal or plastic blocks. The left and right clamping assembly can grip cylindrical materials ranging from 8.8cm to 15.3cm. The u-frame can grip cylindrical workpiece with a size ranging from 3.4 cm to 15.3cm. The third clamping system is the clamping plate and screw which allows to grip cylindrical workpiece in V-opening with a diametral range of 1.27 cm to 7.2 cm. More than the prescribe limit per clamping system is highly discourage in order to maintain the usability and lifespan of this device as well as for the safety of the user.

Based on the analysis conducted, the researchers came up with the following results.The conceptualization of this device was base on the different ideas on ways on how to clamp cylindrical and solid blocks properly. The estimated cost of supplies and materials in the construction of the project was eleven thousand eight hundred eighty eight (Php 11,888.00). The project was constructed through the different ideas and utilization of different measuring tools and mechanical equipment.The Multi-Functional Clamping Device was tested and evaluated for its safety and usefulness.

Based on the findings of the study, the following conclusions were drawn. The design of the project was simple and practical. The total cost of the project was nineteen thousand eight hundred eighty-eight (19,888.00). The Multi-Functional Clamping Device was constructed. The project was safe and useful from clamping cylindrical and solid block materials.

Based from the findings and conclusions, the researchers came up with the following recommendations. It is recommended to use the Multi-Functional Clamping Device for gripping cylindrical and solid block materials for either benchworking, milling and drilling operations. Improvement and modification of this device is also recommended by modifying the U-Frame and reversible V-block into an adjustable type for better performance and bigger

range of clamping clamping application. The device is recommended to use by machines shop owners, school laboratory shops, and fabrication shops. This project contains originality and may apply for possible patenting.

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