Implementation of Design and Development Tensile Testing Machine for Application in Soft Material

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***Abstract*— Current technological developments produce various kinds of innovations and creations in all things, which goal to facilitate all human activities. There are various kinds of tools for testing, ranging from tensile testing, compressive testing and hardness testing. In this case, this research designs and develops miniature tensile test kits. Our goal is to do tensile testing to find out the yield strength, elongation, tensile strength and elastic modulus. This tensile test equipment is designed using a servo motor with 3 AC in put, 105 v, 0.7 A with 100 watt out put and 3000 rad / min motor rotation comparable (477.46 rpm), power transfer using fan belt. This servo motor is controlled by a servo amplifier that goal is to send a signal to control the motor speed, motor rotation direction. The servo ampifier is then connected to a laptop / computer to regulate the amplifier, and describes the test results in the form of stress and strain graphs that occur in tensile test specimens. The component of the tensile test equipment analyzed in this study are; specimen pin, grip and grip holder). The goal is to determine the maximum stress that occurs so it can be categorized as safe or not used for testing aluminium (Al) and Copper (Cu) specimens. To find out the component is safe or not with the help of the Solidworks 2014 software. By analyzing the maximum von Mises stress that occurs in each component analyzed for use in aluminium (Al) and Copper (Cu) specimens.**

Keywords*— *Miniature tensile testing machine. von Mises. Solidworks 2014

I. INTRODUCTION

Tensile testing machine is a machine used to test specimens, by pulling the specimen until it breaks. the results of the tensile test is a phenomenon of the relationship between stress-strain that occurs during the tensile testing process. Tensile test is a method that is used to test the strength of a material / material by giving a forceful style load [1]. Tensile testing machines are often used in manufacturing industries to determine the mechanical properties of a material because mechanical properties are the most important part of all engineering designs. Besides that, a tensile test tool is one of the tools that is very important in supporting the learning process and teaching in the laboratory.

In engineering design and analysis, tensile stress-strain relationships are frequently needed. From the relationships of the material, various mechanical properties, such as the ultimate tensile and yield strengths, Young's modulus, Poisson's ratio, the elongation, and reductions in area can be obtained. Also, the true stress-strain properties, strain hardening and tensile toughness can be calculated by means of conversion using special equations from the stress-strain curve [2]. It proposes miniature disc-type tensile specimens and fixtures to hold specimens with the help of a rigid pin to predict the mechanical properties of materials. They verified the feasibility of the sample geometry using finite element method (FEM) [3].

These were analyzed by using Finite Element Analysis (FEA) software in order to identify their advantages and disadvantages as well as their behavior under loading. To validate the results from the FEA, 3D printed models were carried out, and their kinetic functionality was observed [4]. A new stand-alone biaxial testing machine with out-of-plane loading system has been developed to study the anisotropic plastic behavior of metal sheets on cruciform specimens. In this apparatus a single screw driven actuator is used and the variation of the load ratio along the two main directions is achievedby adjusting the geometry of a link mechanism [5]. To facilitate the study of deformation mechanisms and mechanical properties of bulk materials with feature size of centimeter level, a novel tensile devicecompatible with scanning electron microscope (SEM) was designed and built.Integrating the servo motor and three-stage reducer, the device could realizequasistatic loading mode with a loading speed of 10 nm/s [6].

The purpose of this study is to focus on the design and development of tensile testing equipment for soft material applications namely Aluminium (Al 6061) and Copper (Cu) Material, with economical and practical prices with small sizes without reducing the testing standards that have been set. The components of the tensile test equipment that will be designed are the frame, specimen holder and the stand of the tensile test equipment and the acquisition data.

II. DESAIN OF THE TENSILE TESTING MACHINE SPECIFICATION

The performance requirements of the machine were established for breaking using Copper (Cu) and Aluminium 6061 plate specimen with a thickness of 2 mm. In terms of the loading capacity of the testing machine, the specimen preparation and handling processes, thin miniaturised specimens are suitable. The functional requirements of the machine are as follows ; Sample size: 2 mm thick, gauge cross selection area of 3 mm gauge length of 50 mm, maximum stroke: 30 mm and maximum tensile force: 5.0 kN.

III. DESAIN CONCEPT

This machine was designed and developed for tensile testing. One end of the specimen is pulled, while the other end was attached to the chuck. maximum load to pull specimen 5.0 kN. to pull the specimen without using torque, the rotation of the servo motor that was passed to the drive shaft with pulleys and belts. So that the resulting rotation was to change the motor rotational motion to up and down movements. Figure 1 shows the overall structure of the tensile testing machine. Analysis of model is done with help of Solidwork software.

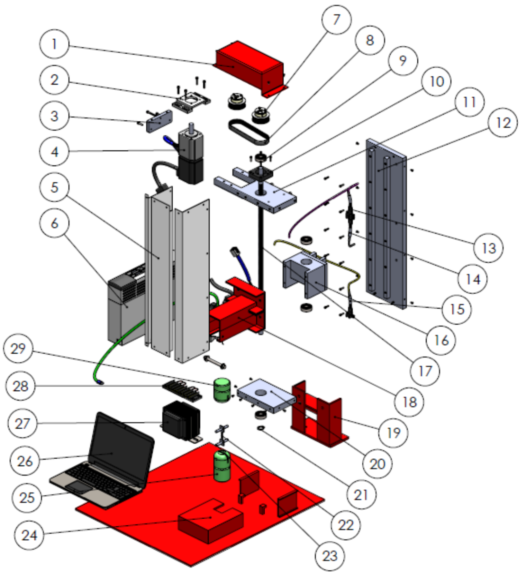


Fig. 1. *Design Part of the tensile testing machine*. (1). Pulley cover (2). Motor holder, (3). Retaining Plate, (4). Servo motor, (5). Body cover, (6) Controller, (7). Pulley, (8) .Belt, (9). Bearing, (10). Bearing cover, (11). Top body, (12). Rear body, (13). Socket X21, (14) .Socket D002, (15). X20 socket, (16). Threaded drive shaft holder , (17). Threaded drive shaft, (18). Top grip holder, (19). Rear guarde, (20). Botton body (21). Ring spi, (22) Specimen, (23). Specimen pin, (24). Botton grip holder (25). Botton grip, (26). Computer, (27). Transformer, (28). Terminal, (29). Top grip.

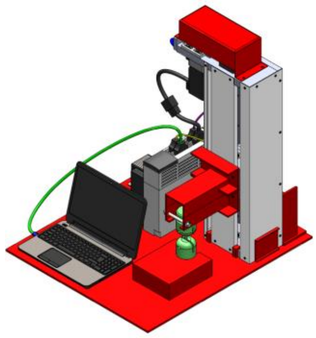


Fig. 2. *Tensile Testing Machine Model*

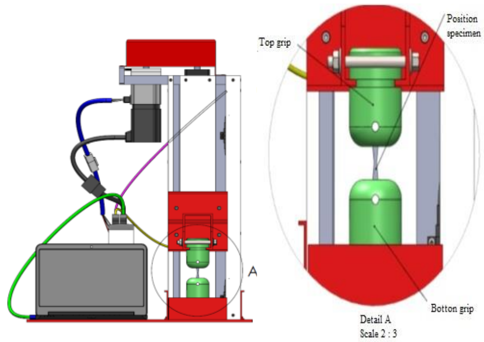


Fig.3. *Position of the Specimen*

The assembly in Fig. 1 (1) The pulley cover is made of aluminum which is bonded by 4 bolts (2) The holder is a servo motor (3) The function is to resist the movement of the servo motor (4) The servo motor is a power source to drive the tensile test (5) Covering a body made of steel plate to cover parts of tensile test equipment such as screw shaft, bearing etc. (6) A control device is a device used to give commands or signals to servo motors (7) Pulley is as a place belt position (8) Fanbelt as a successor to the rotation or power of a servo motor (9) Bearing type 6000Z its function is to keep the shaft from splicing directly on the bearing housing (10) The house is a seat position bearing (11) The upper body is the seat of the motor anchors and bearing housings (12) The rear body is the part that closes and connects the body cover (13) X21 socket (14) D22 socket (15) X 20 socket (16) Measured threaded shaft a diameter of 10 mm and a 2 mm module made of ASTM A6 is the part that moves the rising trunk of the top specimen holder (17) The vise drive is a place of stressful position tightened by a bolt (18) The top grip holder is a top grip place. (19). the rear support is the backrest of the pull test frame which is tightened by 4 bolts (20).Bottom is anchored by 4 bolts made of aluminum alloy to connect between the rear body and the cover cap (21) The ring spi serves to hold the shaft from moving out (22). The specimen is the material that will be tested, (23) Locking the specimen is to hold geometric specimens, (24). The botton grip holder is a botton grip place, (25). The botton grip is a place to hold the botton of the specimen (26).Computer is a tool used to execute commands to the control so that the control runs the device as desired, with the help of software, (27).Step up and down transformers are to increase voltage, (28). The terminal is a place to connect the line of the control circuit and the 3-phase motor in the conversion to 1 phase current (29). The top grip is a place to hold the top of the specimen.

A. Analysis of Design

For Analysis of Design 5.0 kN is applied on tensile assembly & check whether design is safe or not. there are several components that will be carried out the stress analysis that occurs between them; grip holder, pin or specimen pin and specimen grip. table.1 shows the mechanical properties of the component mater Recommended font sizes are shown in Table 1.

TABLE. 1. ` MECHANICAL PROPERTIES OF MATERIAL FOR THE TEST COMPONENT

Material	Elastic Modul (Mpa)	Poisson's Ratio	Shear Modulus (Mpa)	Mass Density (kg/m^3)	Tensile Strength (Mpa)	Yield Strength (Mpa)	Gloss
ASTM A6	210000	0.28	77000	8027,17	988	335	Grip holder
ASTM A36	200000	0.26	79300	7850	400	250	Specimen pin
AISI 1045	200000	0.29	80600	76861,093	565	310	Grip Specimen

In figure.4 shows from the simulation test conducted on the specimen pin, Aluminium 6061 tensile test specimen material (Al 6061), the maximum stress that occurs on the specimen pin is 2.524e + 001 Mpa.

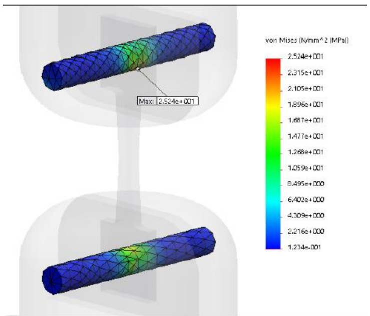


Fig .4. *Stress Concentration Result of Pin for Al 6061*

In figure.5 show from the simulation test conducted on the specimen pin, specimen material of the copper tensile test (Cu), the maximum stress that occurs on the specimen pin is 8.052e + 001 Mpa.

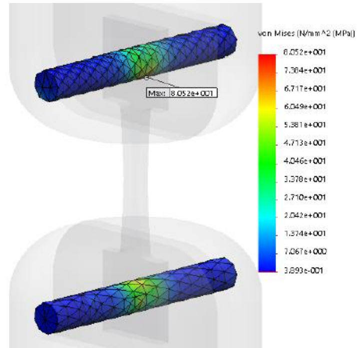


Fig.5. *Stress Concentration Result of Pin for Copper (Cu)*

In figure.6 shows from the simulation test conducted on the specimen pin Aluminium 6061 tensile test specimen material (Al 6061), the maximum stress that occurs on the grip holder is 1.348e + 001 MPa.

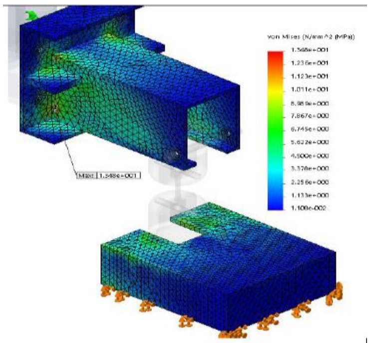


Fig.6. *Stress Distribution on the Grip Holder for AL 6061*

In figure.7 shows from the simulation test conducted on the specimen pin, copper tensile test specimen material (Cu), the maximum stress that occurs on the grip holder is 4.522e + 001 Mpa.

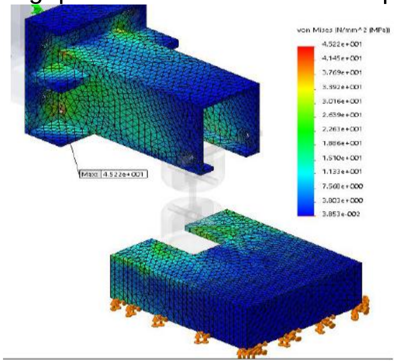


Fig.7 *Stress Distribution on the Grip Holder for Copper (Cu)*

In figure.8 shows from the simulation test conducted on the specimen pin, 6061 Aluminium tensile test specimen material (Al 6061), the maximum stress that occurs on the grip is 1.996e + 001 Mpa.

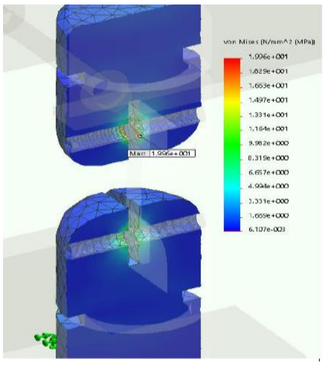


Fig.8. *Stress Distribution on the Grip for Al 6061*

In figure.9 shows from the simulation test conducted on the specimen pin, copper tensile test specimen material (Cu), the maximum stress that occurs on the grip holder is 6.232e + 001 Mpa.

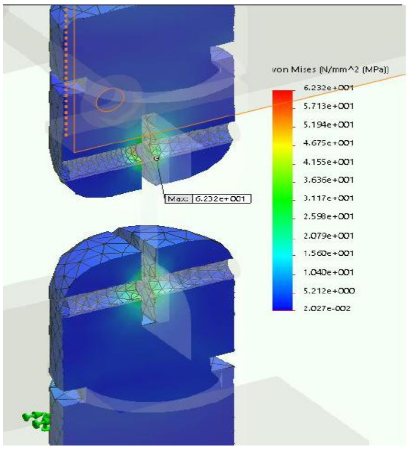


Fig.9. *Stress Distribution on the Grip for Copper (Cu)*

IV. SPECIMEN TESTING

In this paper, a miniature specimen is designed, as shown in Figure 4. The size and dimensions of the specimen were miniaturised, based on a conventional standard tensile specimen. In order to make many specimens inexpensively for students, a punching process was adopted. A die in the same shape as the specimen is punched on a thin plate with a thickness of 2 mm, as shown in Figure 10. The procedure for making this specimen is much easier compared with those of conventional tensile test specimens, which require a number of machining operations.

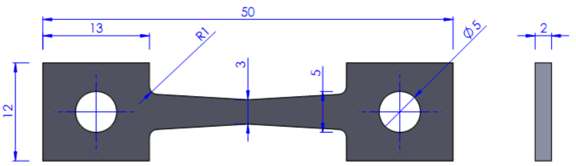


Fig10. *Dimensions of Specimen*

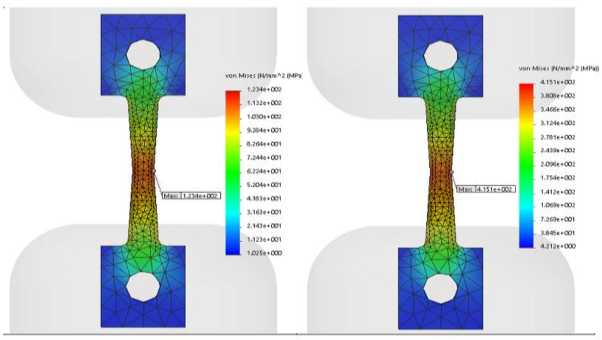
V. TENSILE TESTING AND RESULT

A. Test of Specimen

Tensile testing was carried out on a 2 mm thick specimen with a steep upward movement starting with a distance of 0, 01 mm. in the table. 2 shows mechanical properties of tensile test specimens namely 6061 aluminium material plate (Al 6061) and copper (Cu). Table.2 shows the mechanical properties of material specimens.

TABLE. 2. MECHANICAL PROPERTIES OF SPECIMEN

Material	Elastic Modul (Mpa)	Poisson's Ratio	Shear Modulus (Mpa)	Mass Density (kg/m^3)	Tensile Strength (Mpa)	Yield Strength (Mpa)
Al 6061	69000	0.33	26000	2698,791	2700	124,08
Copper	110000	0.37	40000	8900	394,38	258,65



a. Material of Al 6061 b. Material of Copper (Cu)

Fig. 11 *Stress Distribution of the Specimen*

From the results of tensile testing two specimens, aluminium 6061 and copper of the same size. for aluminium specimens the tensile test results with a test distance starting with 0.01 mm, producing a voltage of 9.91 MPa, with a distance of 0.065 mm producing a maximum voltage of 129.4 Mpa. While for copper specimens tensile testing with a 0.01 mm test distance, resulting in a tensile stress of 25.89 Mpa, at a distance of 0.16 mm produces a maximum voltage of 415.1 MPa. From tensile testing with different test specimens and the same size, where from the test results with the same starting point between the aluminium 6061 specimen and copper, the fast break was aluminium specimen compared to copper. as shown in table 3.

TABLE. 3. TENSILE TEST RESULT ON VARIOUS DISPLACEMEN (ALUMINIUM 6061 AND COPPER)

Displacement		Stress - Von Mises (MPa)		Equivalent Strain	
Al 6061	Copper	Al 6061	Copper	Al 6061	Copper
0.01	0.01	19.91	25.89	2.558e-004	2.150e-004
0.02	0.04	39.82	103.6	5.117e-004	8.601e-004
0.03	0.06	59.73	155.4	7.675e-004	1.290e-003
0.04	0.08	79.64	207.3	1.023e-003	1.721e-003
0.05	0.1	99.55	259.1	1.279e-003	2.152e-003
0.055	0.12	109.5	311.0	1.407e-003	2.582e-003
0.06	0.14	119.5	362.9	1.535e-003	3.013e-003
0.062	0.15	123.4	389.1	1.585e-003	3.231e-003
0.065	0.16	129.4	415.1	1.663e-003	3.446e-003

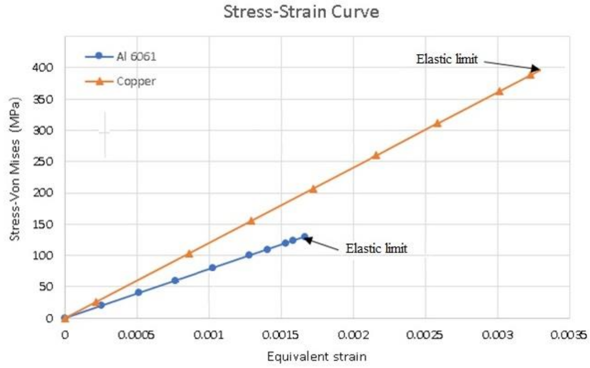


Fig. 12. *Stess - strain curve for aluminium 6061 and copper*

VI. CONCLUSIONS

This paper explains the results of testing two different specimens of the same size, namely aluminum 6061 and copper specimens. Then several components of the tensile test apparatus which are subjected to tensile stress tests such as; pin or locking the specimen, grip specimen and grip turns out that from the simulation test the component is safe and suitable for use, so that for further research, it can develop this tensile test equipment.

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