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MARMARA UNIVERSITY

ENGINEERING DEPARTMENT

DESIGNING AND MANUFACTURING OF COMPUTER CONTROLLED HYDRAULIC TENSILE TESTING MACHINE

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MECHANICAL ENGINEERING

THESIS

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ABSTRACT

DESIGNING AND MANUFACTURING OF COMPUTER CONTROLLED HYDRAULIC TENSILE TESTING MACHINE

What is a universal tensile testing machine, where are the used for what purpose, and the history of the types are assaied. In the following sections by considering the factors that should be considered when designing the machine is capable of 5tonf a tensile testing machine has been designed and manufactured, and is controlled with a computer. Chapter 1, the history of this machine, and created standards for tensile tests are discussed. In general, the preparation of these standards on the specimen geometry. Chapter 2 focuses on machine design issues must be considered. Affect the selection of equipment required for this machine to get the correct result. Chapter 3, information and documentation relating to the design are made and manufactured in compliance with the matters in the previous section. The results obtained and discussed in chapters 4 and 5 were necessary experience.

ÖZET

Üniversal bir çekme testi makinasının ne olduğuna, ne amaçla nelerde kullanıldığına, tiplerine ve tarihçesine bakılmıştır. İlerleyen bölümlerde makina tasarımı yapılırken dikkat edilmesi gereken hususlar dikkate alınarak 5tonf kapasitesine sahip bir çekme testi makinası tasarlanıp imal edilmiş ve bilgisayar ile kontrol edilmeye çalışılmıştır. Bölüm 1'de bu makinaın tarihçesinden ve çekme testi için oluşturulmuş standartlardan bahsedilmiştir. Bu standartlar genel olarak numune parçanın hazırlanması üzerindedir. Bölüm 2'de makine tasarımında dikkat edilmesi gereken hususlar üzerinde durulmuştur. Bu makine için gerekli olan ekipmanların seçilmesi doğru sonuç almayı etkiler. Bölüm 3'de bi önceki bölümdeki hususlara uyularak tasarım yapılmış ve imal edilmesiyle ilgili bilgiler ve dokumantasyonlar verilmiştir. Bölüm 4 ve 5'te elde edilen sonuçlar tartışılmış ve gerekli tecrübeler çıkarılmıştır.

TABLES

FIGURES

SYMBOLS

A_0 : Initial Area

a   : Thickness of specimen

b   : Width of specimen

d   : Diameter of rounded specimen

e   : Engineering Strain

e_p : The average plastic strain in the specimen

E   : Modulus of Elasticity

k   : Coefficient of specimen length

K   : The stiffness of the machine

L_0 : Initial Length

Lc   : Body Length

Lt   : Total Length

μ   : micro

P_0 : Specimen load rate

s   : Second

S_0 : Initial Cross Sectional Area

σ   : Stress

ε   : Strain

ABBREVIATIONS

ASTM : American Society for Testing and Materials

ISO : International Organization for Standardization

JIS : Japanese Industrial Standards

UTM : Universal Test Machine

UYS : Upper Yield Stress

LYS : Lower Yield Stress

YPE : Yield-Point Elongation

EL : Elastic Limit

APPENDIX LIST

CHAPTER I

I.1. INTRODUCTION TO TENSILE TESTING

THE TENSILE TEST is one of the most commonly used tests for evaluating materials. In its simplest form, the tensile test is accomplished by gripping opposite ends of a test piece (specimen) within the load frame of a test machine. A tensile force is applied by the machine, resulting in the gradual elongation and eventual fracture of the test piece. During the process, force-extension data, a quantitative measure of how the test piece deforms under the applied tensile force, usually are monitored and recorded. When properly conducted, the tensile test provides force-extension data that can quantify several important mechanical properties of a material. These mechanical properties determined from tensile tests include, but are not limited to, the following:

● Elastic deformation properties, such as the modulus of elasticity (Young's modulus) and Poisson's ratio
● Yield strength and ultimate tensile strength
● Ductility properties, such as elongation and reduction in area
● Strain-hardening characteristics

These material characteristics from tensile tests are used for quality control in production, for ranking performance of structural materials, for evaluation of newly developed alloys, and for dealing with the static strength requirements of design. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus,Poisson's ratio, yield strength, and strain-hardening characteristics.

I.2. HISTORICAL BACKGROUND

The knowledge of a materials ability to safely sustain a load before breaking has been of paramount importance to man ever since structures were first built. It is difficult to Conceive that the qualitative ranking of softwoods, hardwoods and stone were unknown in the Neolithic time, and the Greek, Egyptian, Roman and Norman civilizations clearly had an understanding of material strength perhaps purely based on experience. However it is not until the Renaissance period in the 16th century that documentary evidence from the writings of Leonardo da Vinci are found, which show that quantitative methods were employed to measure the differences in the material properties, Timoshenko (1953) and Gray (1988).

Thomas Young [1773-1829] is now associated with the measurement of the modulus of elasticity of materials although most modern day research workers would not recognise the description that he used to express the relationship between stress and strain:

'A modulus of the elasticity of any substance is a column of the same substance capable of producing a pressure on its base which is the weight causing a certain degree of compression as the length of the substance is to the diminution of its length.'

One of the earliest machines used for the systematic measurement of tensile strength was developed by a Dutch physicist Petrus van Musschenbroek (1692-1791) Figure I.1. The basic concept of a 'steel-yard' used to apply a load to the sample has subsequently been used in many designs of tensile testing machine.

George Rennie jun. (1818) also made a significant contribution to the understanding of the strength of materials and some of his correspondence with Thomas Young was published in the Phil. Trans of the Royal Society. This included details of a lever testing machine which was used to test a variety of materials, including cast & wrought alloys, wood, and stone (marble, limestone, granite etc) in compression and under tension Figure I.2.

William Fairbairn made a significant contribution to the systematic assessment of the strength of materials at high temperatures using the machine shown in Fig I.3 and Fig I.4. (Fairbairn, (1842) & (1856)). The sample could be heated up to 'red heat' in a liquid bath

heated by a fire grate, which would be removed when the desired temperature had been achieved. Loads up to 446 kN could be applied to the testpieces by the lever system (Smith, (1963) & Loveday,(1982)).

Prof Johann Bauschinger [1834 – 1893] is credited with the introduction of the double-sided extensometers, Figure I.5, which allow compensation for curvature or misalignment of the testpiece. This made a significant improvement to the measurement of tensile strain, and allowed sufficient precision of measurement to observe that yield stress is lowered when deformation in one direction is followed by deformation in the opposite direction. This is now known as the 'Bauschinger effect' (Bauschinger,(1881)).

Development of technology in the development of machines, tensile testing has been inevitable. Have become more sensitive and more easily controllable. One button testing machines have been developed, which the operator can make, and then print analysis. Besides this, the operator overlapping load partially reduced by including robotic technology. Fig I.6 that this process is the large number of samples to be performed, hours of parts Since it will test these parts on a shelf after they have been specially programmed robot, respectively, testing whether the process is started, and every piece of data stored. In addition, more than one machine and the different parts can be tested Fig I.6 This kind of manufacturing systems with the world's leading companies (Zwick, Instron, SCHÜTZ + LICHT Prüftechnik, etc.).
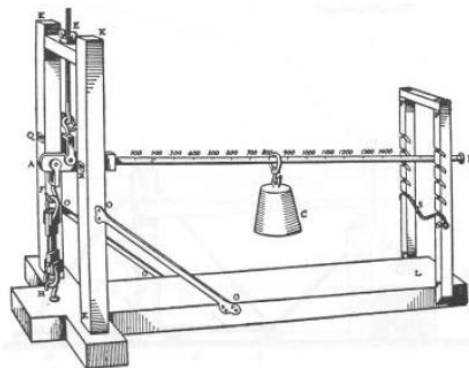
Figure I.1 - Petrus van Musschenbroek lever testing machine
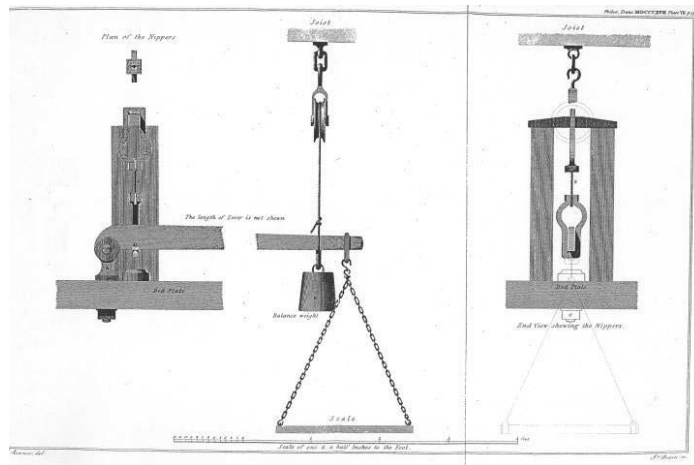
Fig I.2 - George Rennie's lever tensile testing machine. (Rennie, (1818))
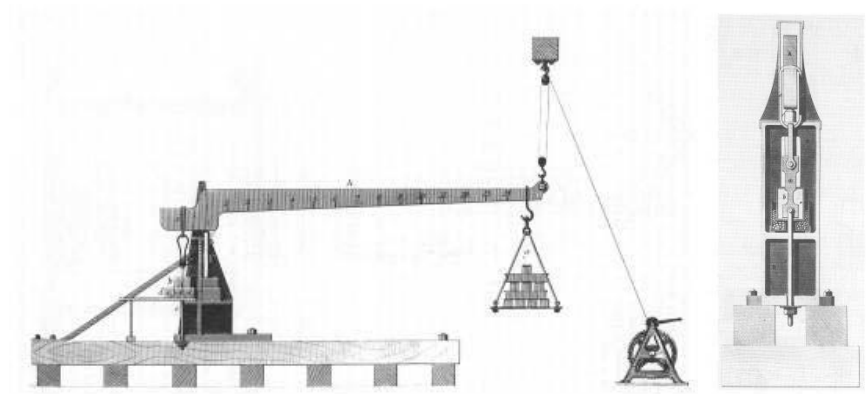
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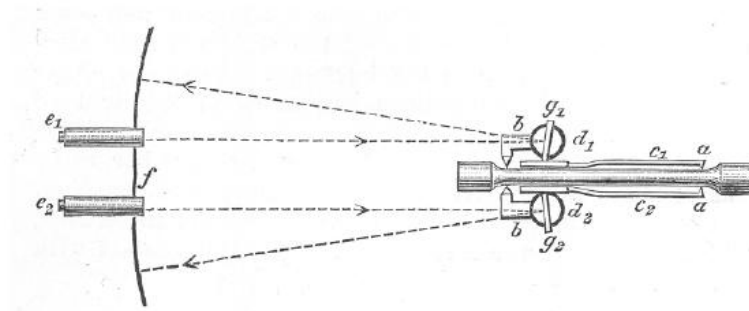
Fig I.5 - Bauschinger's Roller and Mirror Extensometer (Unwin (1910))
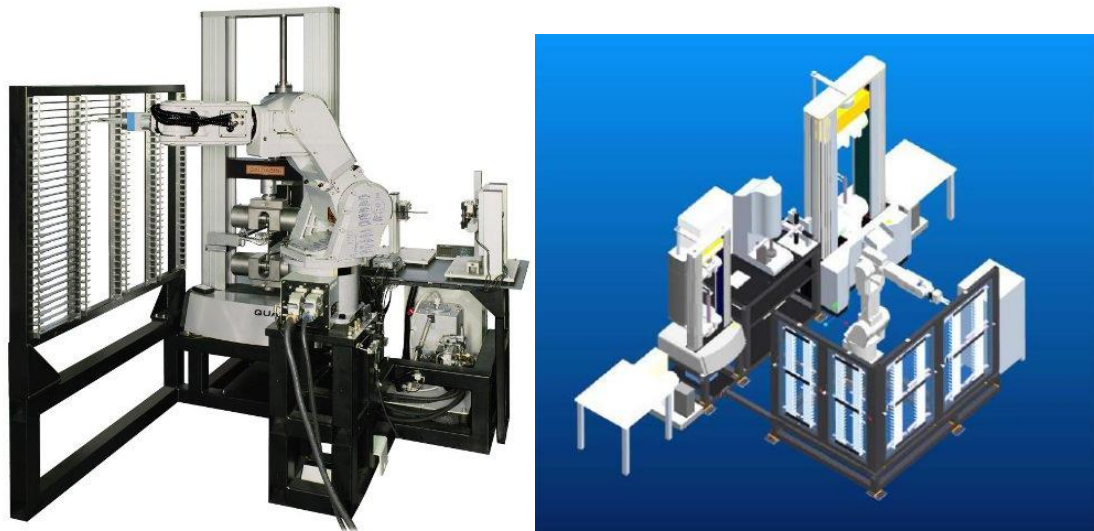
Fig I.6 - Robotic Tensile Test Machines and MULTI-Line with 2 integrated machines

I.3. TENSILE TESTING REQUIREMENTS AND STANDARDS

Tensile testing requirements are specified in various standards for a wide variety of different materials and products. Table 1 lists various tensile testing specifications from several standards organizations. These specifications define requirements for the test apparatus, test specimens, and test procedures. Standard tensile tests are conducted using a threaded tensile specimen geometry, like the standard ASTM geometry (Fig I.7) of ASTM E 8. To load the specimen in tension, the threaded specimen is screwed into grips attached to each crosshead. The boundary condition, or load, is applied by moving the crossheads away from one another.

Table I.1 - Tensile testing standards for various materials and product forms
Specification number - Specification title

ASTM A 770 Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications
ASTM A 931 Standard Test Method for Tension Testing of Wire Ropes and Strand

ASTM B 557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

ASTM B 557M Standard Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products [Metric]

ASTM C 565 Standard Test Methods for Tension Testing of Carbon and Graphite Mechanical Materials

ASTM C 1275 Standard Test Method for Monotonic Tensile Strength Testing of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Specimens at Ambient Temperature

ASTM C 1359 Standard Test Method for Monotonic Tensile Strength Testing of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Specimens at Elevated Temperatures

ASTM D 76 Standard Specification for Tensile Testing Machines for Textiles

ASTM E 8 Standard Test Methods for Tension Testing of Metallic Materials

ASTM E 8M Standard Test Methods for Tension Testing of Metallic Materials [Metric]

ASTM E 338 Standard Test Method of Sharp-Notch Tension Testing of High-Strength Sheet Materials

ASTM E 345 Standard Test Methods of Tension Testing of Metallic Foil

ASTM E 602 Standard Method for Sharp-Notch Tension Testing with Cylindrical Specimens

ASTM E 740 Standard Practice for Fracture Testing with Surface-Crack Tension Specimens

ASTM E 1450 Standard Test Method for Tension Testing of Structural Alloys in Liquid Helium

ASTM F 1501 Standard Test Method for Tension Testing of Calcium Phosphate Coatings

ASTM F 152 Standard Test Methods for Tension Testing of Nonmetallic Gasket Materials

ASTM F 19 Standard Test Method for Tension and Vacuum Testing Metallized Ceramic Seals

ASTM F 1147 Standard Test Method for Tension Testing of Porous Metal Coatings

BS EN 10002 Tensile Testing of Metallic Materials

BS 18 Method for Tensile Testing of Metals (Including Aerospace Materials)

BS 4759 Method for Determination of K-Values of a Tensile Testing System

BS 3688-1 Tensile Testing

BS 3500-6 Tensile Stress Relaxation Testing

BS 3500-3 Tensile Creep Testing

BS 3500-1 Tensile Rupture Testing

BS 1687 Medium-Sensitivity Tensile Creep Testing

BS 1686 Long-Period, High-Sensitivity, Tensile Creep Testing

DIN 53455 Tensile Testing: Testing of Plastics

DIN 53328 Testing of Leather, Tensile Test

DIN 50149 Tensile Test, Testing of Malleable Cast Iron

EN 10002-1 Metallic Materials—Tensile Testing—Part 1: Method of Test at Ambient Temperature

ISO 204 Metallic Materials—Uninterrupted Uniaxial Creep Testing Intension—Method of Test

ISO 783 Metallic Materials—Tensile Testing at Elevated Temperature

ISO 6892 Metallic Materials—Tensile Testing at Ambient Temperature

JIS B 7721 Tensile Testing Machines

JIS K 7113 Testing Methods for Tensile Properties of Plastics (English Version)

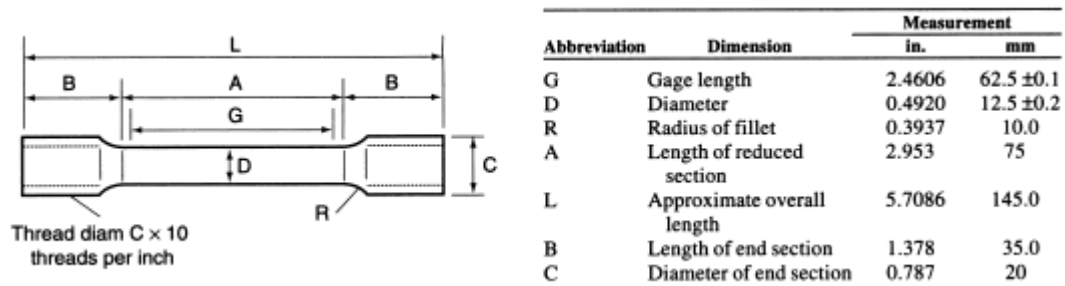| Abbreviation	Dimension	Measurement	
		in.	mm
G	Gage length	2.4606	62.5 ±0.1
D	Diameter	0.4920	12.5 ±0.2
R	Radius of fillet	0.3937	10.0
A	Length of reduced section	2.953	75
L	Approximate overall length	5.7086	145.0
B	Length of end section	1.378	35.0
C	Diameter of end section	0.787	20

Fig I.7 Standard ASTM geometry for threaded tensile specimens.Dimensions for the specimen are taken from ASTM E 8M (metric units), or ASTM E 8 (English units).

CHAPTER II

This chapter is about issue matters to be considered in the design of a tensile testing machine mentioned. First, the standard mesasurements for the test specimen should be prepared in which the part indicated. Then the tensile test specimens were examined and grips of a tensile test piece is connected incorrectly focused on what kind of conclusions emerged. Second tensile testing machines as the main subject discussed and how they are controlled drive systems on the investigation which are electromechanical and hydraulic systems. The most important topics which are the test speed and machine stifness are examined. The speed of testing is extremely important because mechanical properties are a function of strain rate. It is, therefore, imperative that the speed of testing be specified in either the tension-test method or the product specification. Finally, when the force applied tensile test machine did not affect only the sample pieces, the machine also is deformed and carried out an examination on this issue machines is known and has been sought for deformation.

In light of this information has been used and the average capacity a tensile testing machine has been designed and manufactured in the next chapter.

II.1. TENSILE SPECIMEN

The sample must be uniform along the length of the body sections. During that same cross-section measurements should be continued. How will the section, to samples of products from cross-section depends also on its own. Rounds of this circular cross-sections, square, rectangular and ring-shaped and in some cases can also be a special profile.

Specimen	Flat Specimen	Pipe	Wire, Rod	Rod	Profile
Specimen Geometry					
Thickness class	$0.1 < t < 3$	EN10002/1	$4 >$ thickness	$4 >$ thickness	$4 >$ thickness

Table II.1 - cross sections of semi-finished specimens

The test pieces are usually divided into semi-finished Its small sample size of elements can be turned or cast or forged parts. Constant cross-section Maule (profiles, rods, wires, etc.) with the bulk samples (cast iron, nonferrous alloys, etc.) may be tested before processing.

In the first cross-sectional area of the original gauge length of samples is proportional to the samples calculated according to $L_0 = k\sqrt{S_0}$ the formula. internationally accepted value of k is 5.65. The first measurement of the samples should not be less than proportional to the size $L_0 = 20\ mm$'. S_0 the first kesiy area of 5.65 when the coefficient k of the sample is too small for this rule is made, which is a higher value of k using a sample of the original gauge length of 11.3 or the $L_0 = 50\ mm$ veya 80 mm is disproportionate. Samples that are disproportionate to the original gauge length L_0 and the first cross-sectional area and S_0 are independent. Is present in samples per clutch, clutch head and body of the L_c samples of at least 12 mm radius (radius) must. The heads of the sample, if any, in accordance with the sample and extrusion machine can be chosen freely.

II.1.1. Between 0.1 and 3.0 mm thickness of the flat tensile test specimens of products Between 0.1 and 3.0 mm in thickness made of flat products must comply with the samples sizes in the figure. As can be seen that the long edges parallel to each other accepted.
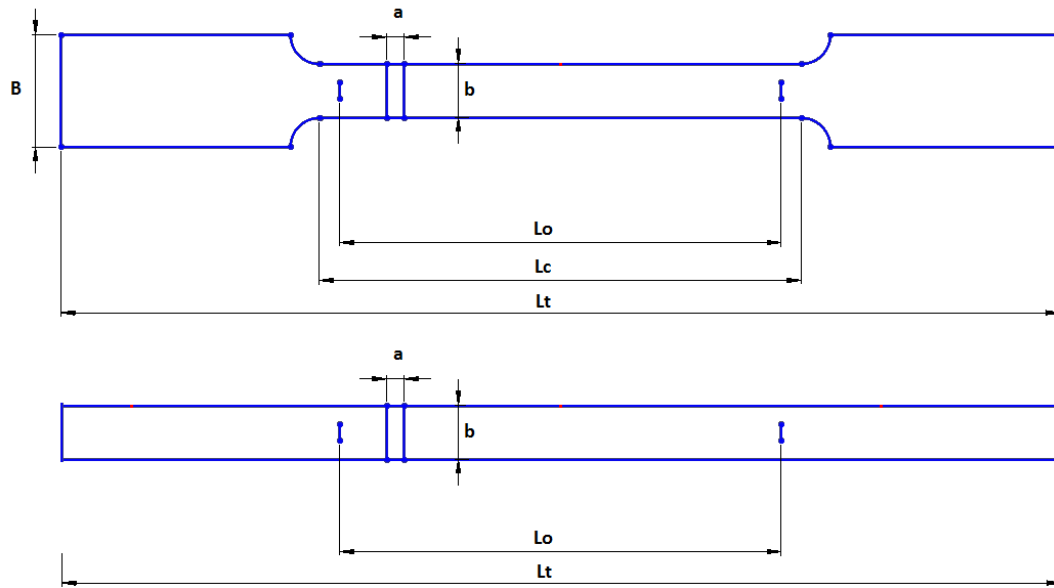
Fig II.1 - Headed and headless specimen of tensile testing

Lo: initial length, the sample centered in the body of the specimen without the notch marked on the felt-tipped pen or something similar.

Lc: body length, headed specimen gauge length where the shoulders length. Headless specimen gauge length where distance of grips of machine after instalitations.

Lt: total size of the specimen, the sample total last the length of the samples with or without head.

$$Lt > Lo + 4b$$

So: Initial cross sectional area, the thickness and width of the sspecimen is calculated based on measured immediately before the experiment.

Specimen Geo Number	Width (b mm)	Initial Length Lo mm	Body Length Lc mm	Distance of Grips mm	Fracture Length mm
Disproportionate specimen (Lo and So independent)					
1	12,5	50	75	87,5	A 50mm
2	20	80	120	140	A 80mm
Proportionate specimen (Lo = k$\sqrt{So}$)					
3	12,5	5,65 $\sqrt{So}$	Lo+2b	Lo+3b	A
4	20	5,65 $\sqrt{So}$	Lo+2b	Lo+3b	
5	12,5	11,3 $\sqrt{So}$	Lo+2b	Lo+3b	A 11,3
6	20	11,3 $\sqrt{So}$	Lo+2b	Lo+3b	

Table II.2 - 0.1-0.3 metal flat specimens

II.1.2. The diameter and thickness under 4mm wire, rod and profile materials, specimens Unprocessed samples are used directly as a sample cut and metal products. These headless samples.

Initial gauge length of specimen is marked as L_0=200mm or L_0=100mm. Specimen diametre d > 1 gauge length is L_0=11,3$\sqrt{So}$.

Normally distance length between tensile machine grips must be at least L_0+50 mm. L_0, this range is very-fine diametre samples to be equal. If the total length L of the sample of sufficient length should be (L> L_0, +150 mm) taken.

Range is required to determine an elongation at break of at least 50mm between the grips can be determined.
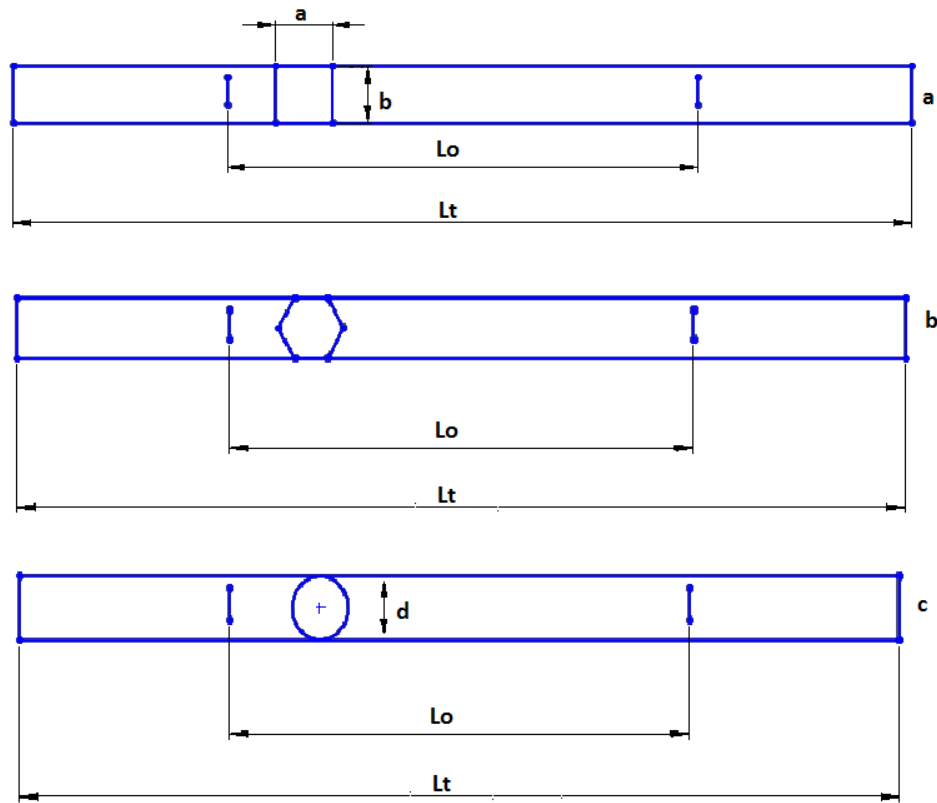
Fig II.2 - Headless tensile test specimen rod and wire

II.1.3. The thickness of 3mm or 4mm thicker than the outside diameter or larger than the thickness of flat products and wire, rod and profile materials tensile test samples.
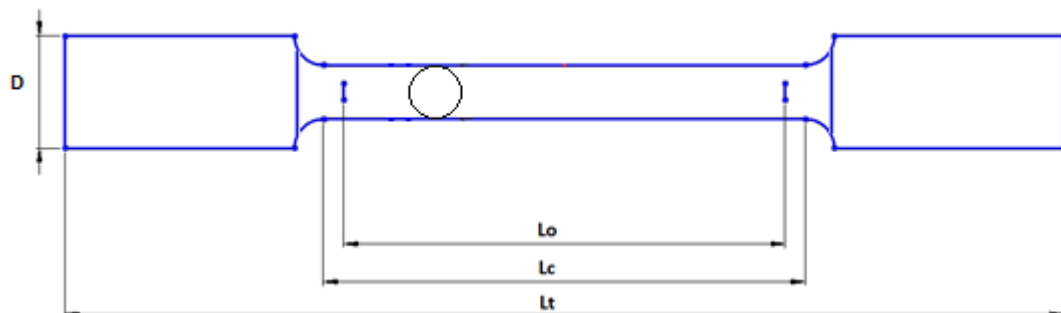
Fig II.3 – diameter > 4 mm circular tensile test samples sizes of products

Diameter do mm	Cross Sectional Area So mm^2	Initial Length Lo = 55do	Body Length Lc mm	Total Length Lt>Lc+2do
5	19,6	25	>28	>38
10	78,5	50	>55	>75
20	314	100	>110	>150

Table II.3 – diameter > 4 mm circular cross-section tensile test specimens

The head portions of the samples, tensile machine grips width and length desired can be produced according to conditions. The transition region between the head body and circular samples of at least 2mm in thickness and at least 12 mm radius of rectangular cross-section of the specimen is required. Proportionality between the thickness of the samples "a" with rectangular cross-section width "b" may be the most 8:1. 4-5 mm diameter sample is taken from the thin material headless. Is not recommended because the body is less than 4mm in diameter in the neck.
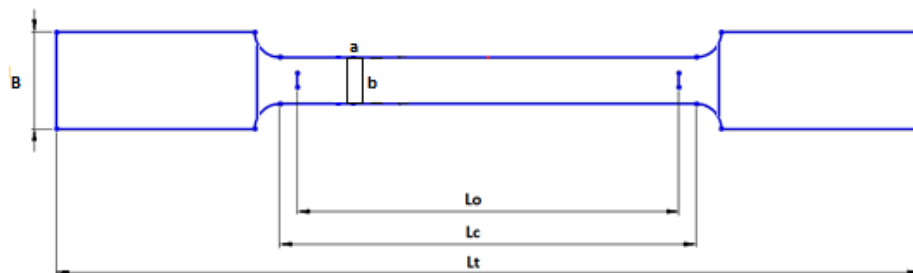
Thickness a	Width b	Initial Length Lo = 5,65$\sqrt{So}$	Body Length Lc mm	Total Length Lt > Lc + 2b
a	b	5,65(ab)^1/2	>Lo+1,5$\sqrt{So}$	>Lc + 2b

Fig II.4 - Greater than 3 mm from the tensile test specimens with dimensions of flat materials

II.2. GRIPPING TECHNIQUES

The use of proper grips and faces for testing materials in tension is critical in obtaining meaningful results. Trial and error often will solve a particular gripping problem. Tensile testing of most flat or round specimens can be accommodated with wedge-type grips. Wire and other forms may require different grips, such as capstan or snubber types. The load capacities of grips range from under 4.5 kgf (10 lbf) to 45,000 kgf (100,000 lbf) or more.

Screw-action grips, or mechanical grips, are low in cost and are available with load capacities of up to 450 kgf (1000 lbf). This type of grip, which is normally used for testing flat specimens, can be equipped with interchangeable grip faces that have a variety of surfaces. Faces are adjustable to compensate for different specimen thicknesses.

Wedge-type grips are self-tightening and are built with capacities of up to 45,000 kgf (100,000 lbf) or more. Some units can be tightened without altering the vertical position of the faces, making it possible to preselect the exact point at which the specimen will be held. The wedge-action design works well on hard-to-hold specimens and prevents the introduction of large compressive forces that cause specimen buckling.

Pneumatic-action grips are available in various designs with capacities of up to 90 kgf (200 lbf). This type of grip clamps the specimen by lever arms that are actuated by compressed air cylinders built into the grip bodies. A constant force maintained on the specimen compensates for decrease of force due to creep of the specimen in the grip. Another advantage of this design is the ability to optimize gripping force by adjusting the air pressure, which makes it possible to minimize specimen breaks at the grip faces.

Hydraulic Grips are generally designed for testing of metallic or non-metallic materials in both flat or round specimen shapes. Hydraulic grips have a compact body with large working space, and integrated connections for other connection or gripping elements. The eccentric piston shape with long piston travel creates a deep positioning for the gripping areas, and also a long gripping path. The required oil pressure on the hydraulic unit is adjusted according to the specimen grip's closing pressure. The control unit will control the opening and closing sequences separately for both the upper and lower specimen grips. Also the closing process has two phases of clamping and gripping.
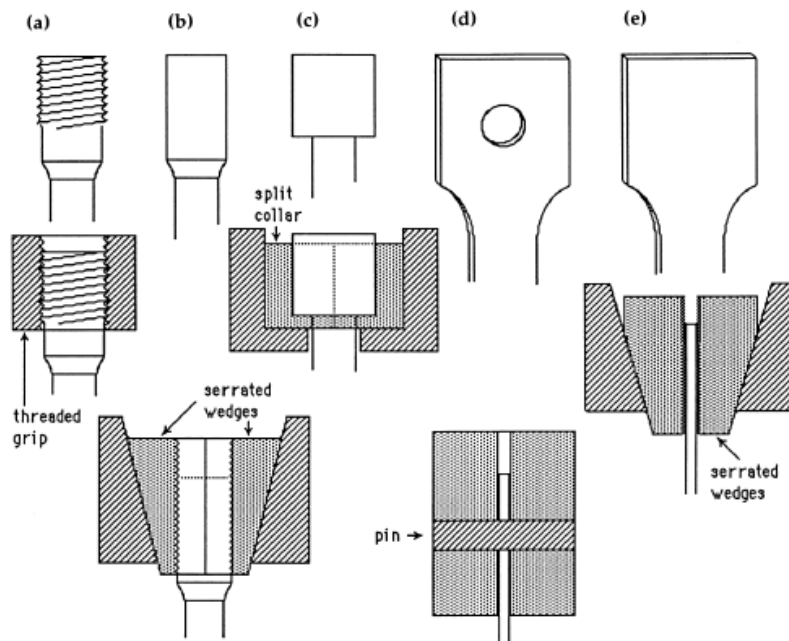

Fig II.5 - Systems for gripping tensile specimens. For round specimens, these include threaded grips (a), serrated wedges (b), and, for butt end specimens, split collars constrained by a solid collar (c). Sheet specimens may be gripped with pins (d) or serrated wedges (e).

II.3. ALIGNMENT

The force application axis of the gripping device must coincide with the longitudinal axis of symmetry of the test piece. If these axes do not coincide, the test piece will be subjected to a combination of axial loading and bending. The stress acting on the different locations in the cross section of the test piece then varies, from the sum of the axial and bending stresses on one side of the test piece, to the difference between the two stresses on the other side. Obviously, yielding will begin on the side where the stresses are additive and at a lower apparent stress than would be the case if only the axial stress were present. For this reason, the yield stress may be lowered, and the upper yield stress would appear suppressed in test pieces that normally exhibit an upper yield point. For ductile materials, the effect of bending is minimal, other than the suppression of the upper yield stress. However, if the material has little ductility, the increased strain due to bending may cause fracture to occur at a lower stress than if there were no bending.

II.3.1. Sample Preparation

Test samples must be prepared properly to achieve accurate results. The following rules are suggested for general guidance. First, as each sample is obtained, it should be identified as to material description, source, location and orientation with respect to the body of material, processing status at the time of sampling, and the data and time of day that the sample was obtained. Second, test specimens must be made carefully, with attention to several details. The specimen axis must be properly aligned with the material rolling direction, forging grain pattern, or composite layup. Cold working of the test section must be minimized. The dimensions of the specimen must be held within the allowable tolerances established by the test procedure. The attachment areas at each end of the specimen must be aligned with the axis of the bar (see Fig II.6). Each specimen must be identified as belonging to the original sample. If total elongation is to be measured after the specimen breaks, the gage length must be marked on the reduced section of the bar prior to testing.
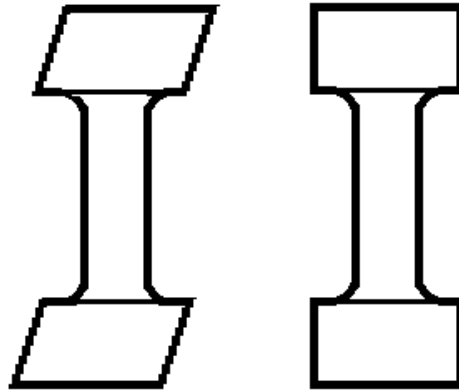
Fig II.6 - Improper (left) and proper (right) alignment of specimen attachment areas with axis of specimen

II.3.2. The test set-up

Requires that equipment be properly matched to the test at grips. There are three requirements of the testing machine: force capacity sufficient to break the specimens to be tested; control of test speed (or strain rate or load rate), as required by the test specification; and precision and accuracy sufficient to obtain and record properly the load and extension information generated by the test. This precision and accuracy should be ensured by current calibration certification. For grips, of which many types are in common use in tensile testing, only two rules apply: the grips must properly fit the specimens (or vice versa), and they must have sufficient force capacity so that they are not damaged during testing. There are several techniques for installing the specimen in the grips. With wedge grips, placement of the specimen in the grips is critical to proper alignment(Fig II.7).

Ideally, the grip faces should be of the same width as the tab ends of the test bar; otherwise, lateral alignment is dependent only on the skill of the technician. The wedge grip inserts should be contained within the grip body or crosshead, and the specimen tabs should be fully engaged by the grips (see Fig II.8).
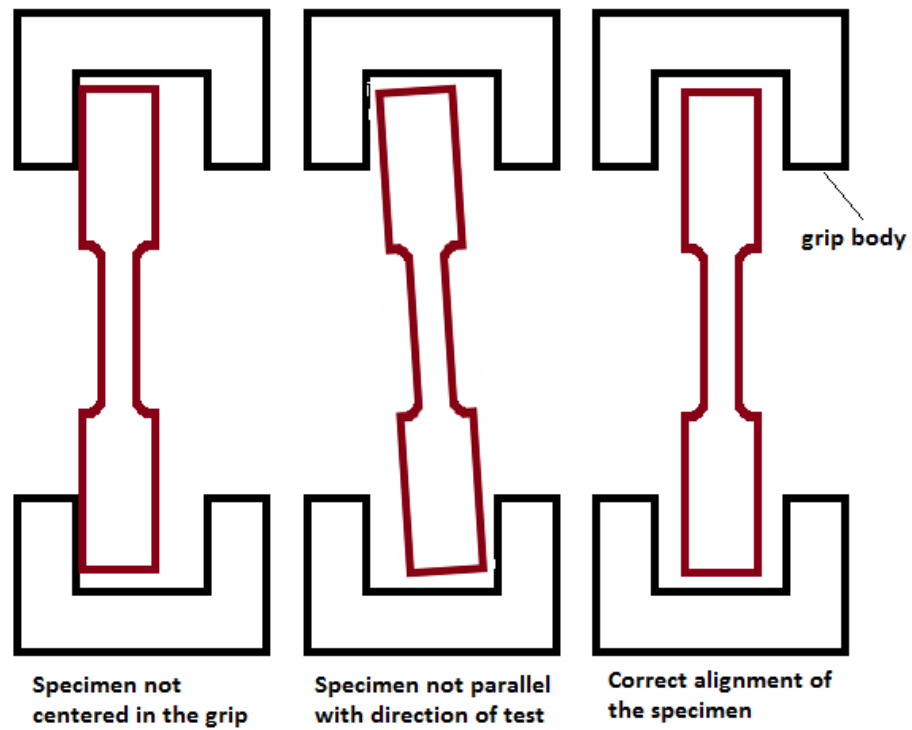
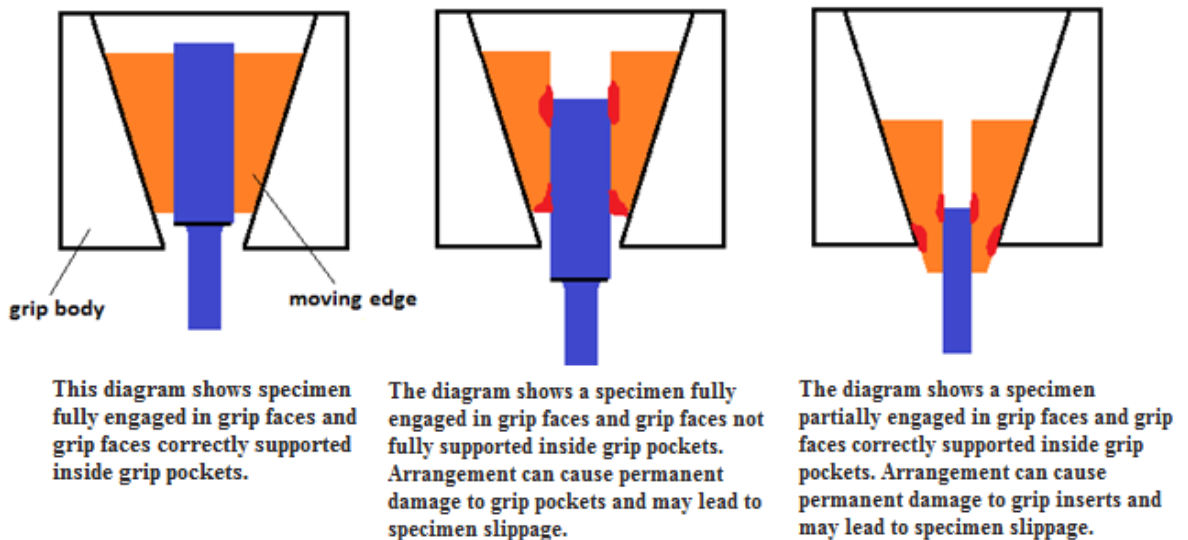**Fig II.7 -** Improper (left, center) and proper (right) alignment of specimen in wedge grips

Fig II.8 - Proper and improper engagement of a specimen in wedge grips

There are several potential problems that must be watched for during the test set-up, including specimen misalignment and worng grips. The physical alignment of the two points of attachment of the specimen is important, because any off-center loading will exert bending loads on the specimen. This is critical in testing of brittle materials, and may cause problems even for ductile materials. Alignment will be affected by the testing-machine loadframe, any grips and fixtures used, and the specimen itself. Misalignment may also induce load-measurement errors due to the passage of bending forces through the load-measuring apparatus. Such errors may be reduced by the use of spherical seats or "Ujoints" in the set-up. Worn grips may contribute to off-center loading. Uneven tooth marks across the width of the specimen tab are an indication of trouble in wedge grips. Split-collar grips may also cause off-center loading. Uneven wear of grips and mismatching of split-shell insert pairs are potential problem areas.

The technician must be responsible for doing the test according to specifications. He should be aware of the potential errors introduced by the machine, extensometer, grips and specimen irregularities, and also should alert the Lab supervisor when problems arise. In short, the technician should be trained in correctly generating the stress vs. strain curve for a given test method.

Correct alignment of the grips and the specimen, when clamped in the grips, is important. Offsets in alignment will create bending stresses and lower tensile stress readings. It may even cause the specimen to fracture outside the gage length.

II.4. TENSILE TEST MACHINES

The most common testing machines are universal testers, which test materials in tension, compression, or bending. Their primary function is to create the stress-strain. Testing machines are either electromechanical or hydraulic. The principal difference is the method by which the load is applied. We will make a study of hydraulic tensil test machines.

Electromechanical machines are based on a variable-speed electric motor; a gear reduction system; and one, two, or four screws that move the crosshead up or down. This motion loads the specimen in tension or compression. Crosshead speeds can be changed by changing the speed of the motor. A microprocessor-based closed-loop servo system can be implemented to accurately control the speed of the crosshead.

Hydraulic testing machines are based on either a single or dual-acting piston that moves the rosshead up or down. However, most static hydraulic testing machines have a single acting piston or ram. In a anually operated machine, the operator adjusts the orifice of a pressure-compensated needle valve to control the rate of loading. In a closed-loop hydraulic servo system, the needle valve is replaced by an electrically perated servo valve for precise control.

In some light-capacity machines (only a few hundred pounds maximum), the force is applied by an air piston and cylinder. Gear-driven systems obtain load capacities up to approximately 600 kN (1.35×10^5 lbf), while hydraulic systems can obtain forces up to approximately 4500 kN (1×10^6 lbf). Whether the machine is a gear-driven system or hydraulic system, at some point the test machine reaches a maximum speed for loading the specimen. Gear driven test machines have a maximum crosshead speed limited by the speed of the electric motor in combination with the design of the gear box transmission. Crosshead speed of hydraulic machines is limited to the capacity of the hydraulic pump to deliver a steady pressure on the piston of the actuator or crosshead. Servohydraulic test machines offer a wider range of crosshead speeds; however, there are continuing advances

in the speed control of screw-driven machines, which can be just as versatile as, or perhaps more versatile than, servohydraulic machines.

Conventional gear-driven systems are generally designed for speeds of about 0.001 to 500 mm/min (4x10^-6 to 20 in/min), which is suitable for quasi-static testing. Servohydraulic systems are generally designed over a wider range of test speeds, such as:

● 1 μm/h test speeds for creep-fatigue, stresscorrosion, and stress-rupture testing
● 1 μm/min test speeds for fracture testing of brittle materials
● 10 m/s (400 in/s) test speeds for dynamic testing of components like bumpers or seat belts

II.4.1. Electromechanical Machines

Gear-driven (or screw-driven) machines are electromechanical devices that use a large actuator screw threaded through a moving crosshead (Fig. II.9). The screw is turned in either direction by an electric motor through a gear reduction system. The screws are rotated by a variable-control motor and drive the moveable crosshead up or down. This motion can load the specimen in either tension or compression, depending on how the specimen is to be held and tested. Screw-driven testing machines currently used are of either a one-, two-, or four-screw design. To eliminate twist in the specimen from the rotation of the screws in multiple-screw systems, one screw has a right-hand thread, and the other has a left-hand thread. For alignment and lateral stability, the screws are supported in bearings on each end. In some machines, loading crossheads are guided by columns or guideways to achieve alignment. A range of crosshead speeds can be achieved by varying the speed of the electric motor and by changing the gear ratio. A closed-loop servodrive system ensures that the crosshead moves at a constant speed. The desired or userselected speed and direction information is compared with a known reference signal, and the servomechanism provides positional control of the moving crosshead to reduce any error or difference. State-of-the-art systems use precision optical encoders mounted directly on

preloaded twin ball screws. These types of systems are capable of measuring crosshead displacement to an accuracy of 0.125% or better with a resolution of 0.6 μm.

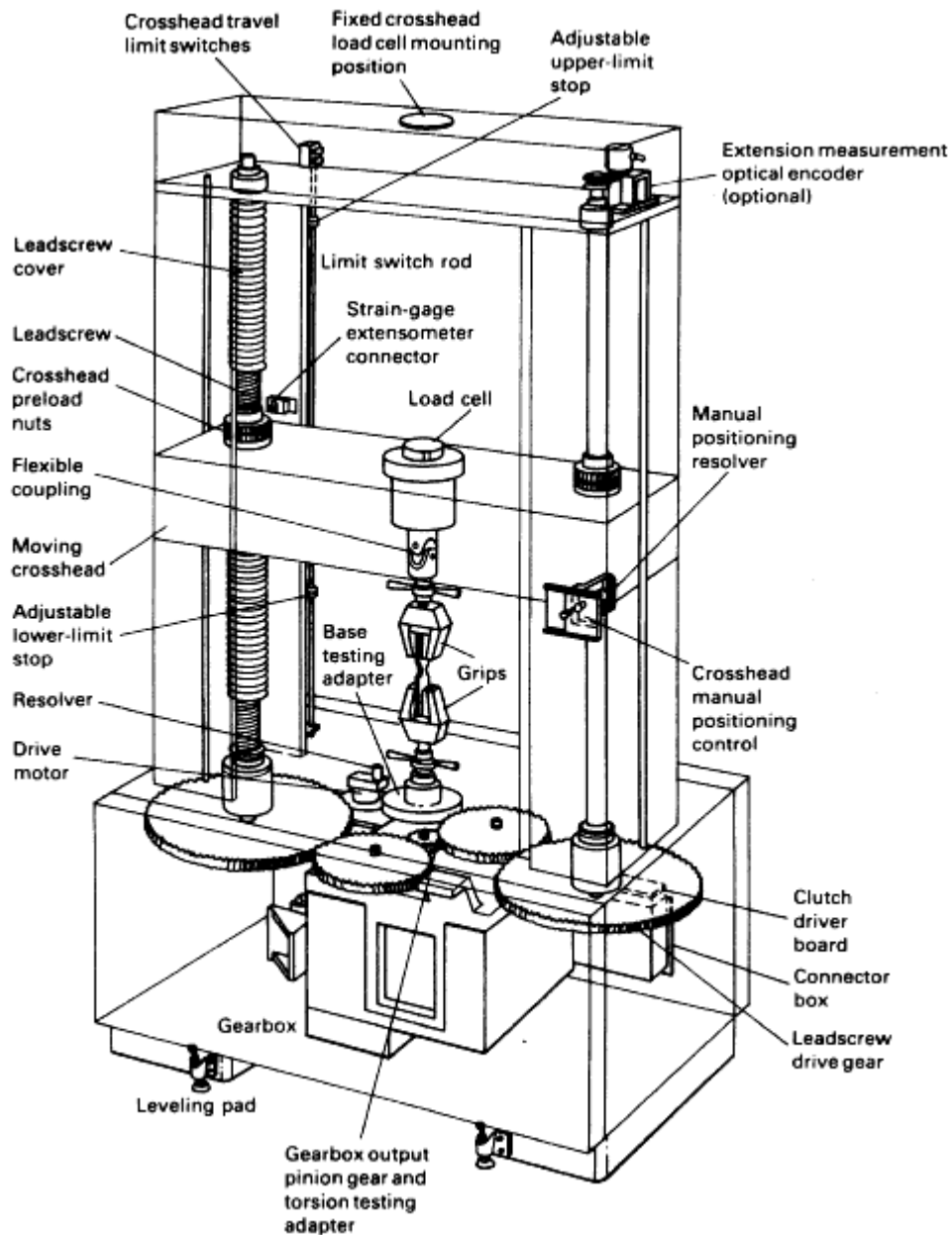

Fig II.9 - Components of an electromechanical (screw-driven) testing machine. For the configuration shown, moving the lower (intermediate) head upward produces tension in the lower space between the crosshead and the base

II.4.2. Servo Hudraulic Machines

Servohydraulic machines use a hydraulic pump and servohydraulic valves that move an actuator piston (Fig. II.10). The actuator piston is attached to one end of the specimen. The motion of the actuator piston can be controlled in both directions to conduct tension, compression, or cyclic loading tests. Servohydraulic test systems have the capability of testing at rates from as low as 45x10^-11 m/s (1.8 x 10^-9 in/s) to 30 m/s (1200 in/s) or more. The actual useful rate for any particular system depends on the size of the actuator, the flow rating of the servovalve, and the noise level present in the system electronics. Hydraulic actuators are available in a wide variety of force ranges. They are unique in their ability to economically provide forces of 4450 kN (1,000,000 lbf) or more. Screw-driven machines are limited in their ability to provide high forces due to problems associated with low machine stiffness and large and expensive loading screws, which are increasingly more difficult to produce as the force rating goes up.
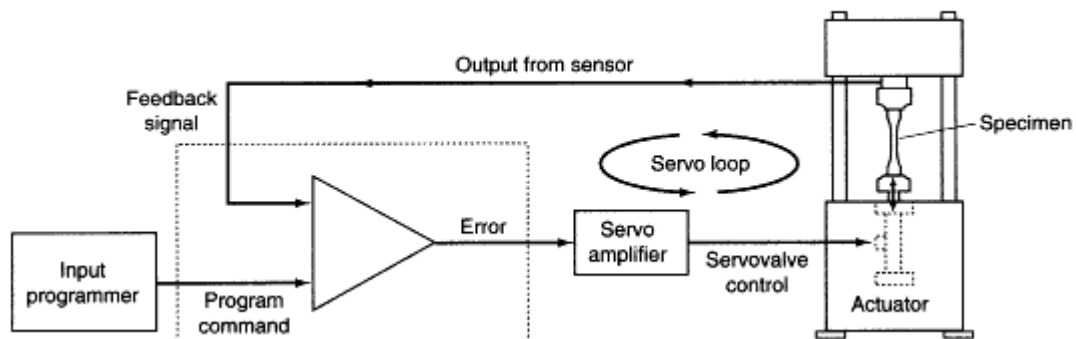
Fig II.10 - Schematic of a basic servohydraulic, closed-loop testing machine

II.5. CONTROL OF MACHINE

Machine is controlled by computer or manually. The machine generally has a hydraulic cylinder and a cylinder pressure changed during operation then mechanical valfes cannot used. This is more suitable for the use of servo-hydraulic valve.

Servo valves, hydraulic systems, control technology, although little used to provide many advantages. In general, prices have to be expensive, complex electronic circuits feeding, very limited repair facilities, to be more sensitive to reasons such as pollution fields that restricts the use of valves. However, emerging technologies become more and more high-quality, make the need for faster and more reliable materials. In this case, the design of the hydraulic systems with high sensitivity and high dynamic properties is becoming a need for the use of proportional and servo valves.

Servo valves for controlling the setting to primarily to process the is required. So the result is the desired result, if the expectation instead of the comparative it does not come embodiment, the necessary corrections should be made. For this reason, the results obtained must be known. Any feedback is called to read the results.

As seen in Fig II.10 of a valve according to the desired value by the computer with the drive connected to the computer and load cell sensor or feedback extensometers made according to the data from the machine control can be achieved.

II.6. SPEED OF TESTING

The speed of testing is extremely important because mechanical properties are a function of strain rate. It is, therefore, imperative that the speed of testing be specified in either the tension-test method or the product specification. In general, a slow speed results in lower strength values and larger ductility values than a fast speed; this tendency is more pronounced for lower-strength materials than for higherstrength materials and is the reason that a tensiontest must be conducted within a narrow testspeed range. In order to quantify the effect of deformation rate on strength and other properties, a specific definition of testing speed is required. A conventional (quasi-static) tensile test, for example, ASTM E 8, prescribes upper and lower limits on the deformation rate, as determined by one of the following methods during the test:

● Strain rate

● Stress rate (when loading is below the proportional limit)

● Cross-head separation rate (or free-running cross-head speed) during the test

● Elapsed time

These methods are listed in order of decreasing precision, except during the occurrence of upper-yield-strength behavior and yield point elongation (YPE) (where the strain rate may not necessarily be the most precise method). For some materials, elapsed time may be adequate, while for other materials, one of the remaining methods with higher precision may be necessary in order to obtain test values within acceptable limits. ASTM E 8 specifies that the test speed must be slow enough to permit accurate determination of forces and strains. Although the speeds specified by various test methods may differ somewhat, the test speeds for these methods are roughly equivalent in commercial testing.

II.6.1. Strain Rate

Strain rate is expressed as the change in strain per unit time, typically expressed in units of min^{-1} or s^{-1} because strain is a dimensionless value expressed as a ratio of change in length per unit length. The strain rate can usually be dialed, or programmed, into the control settings of a computer-controlled system or paced or timed for other systems.

Strain rate, or the rate at which a specimen is deformed, is a key test variable that is controlled within prescribed limits, depending on the type of test being performed. Table II.4 summarizes the general strain-rate ranges that are required for various types of property tests. Conventional (quasi-static) tensile tests require strain rates between 10^{-5} and 10^{-1} s^{-1}. A typical mechanical test on metallic materials is performed at a strain rate of approximately 10^{-3} s^{-1}, which yields a strain of 0.5 in 500 s. Conventional equipment and techniques generally can be extended to strain rates as high as 0.1 s^{-1} without difficulty. Tests at higher strain rates necessitate additional considerations of machine stiffness and strain measurement techniques. In terms of machine capability, servohydraulic load frames equipped with high-capacity valves can be used to generate strain rates as high

as 200 s^-1. These tests are complicated by load and strain measurement and data acquisition. If the crosshead speed is too high, inertia effects can become important in the analysis of the specimen stress state. Under conditions of high crosshead speed, errors in the load cell output and crosshead position data may become unacceptably large. A potential exists to damage load cells and extensometers under rapid loading. The damage occurs when the specimen fractures and the load is instantaneously removed from the specimen and the load frame.

Type of test	Strain rate range, s^{-1}
Creep tests	10^{-8} to 10^{-5}
Pseudostatic tensile or compression tests	10^{-5} to 10^{-1}
Dynamic tensile or compression tests	10^{-1} to 10^{2}
Impact bar tests involving wave propagation effects	10^{2} to 10^{4}

Table II.4 - Strain rate ranges for different tests

II.6.2. Stress Rate

Stress rate is expressed as the change in stress per unit of time. When the stress rate is stipulated, ASTM E8 requires that it not exceed 100 ksi/min. This number corresponds to an elastic strain rate of about 5x10^-5 s^-1 for steel or 15x10^-5 s^-1 for aluminum. As with strain rate, stress rate usually can be dialed or programmed into the control settings of computer-controlled test systems. However, because most older systems indicate force being applied, and not stress, the operator must convert stress to force and control this quantity. Many machines are equipped with pacing or indicating devices for the measurement and control of the stress rate, but in the absence of such a device, the average stress rate can be determined with a timing device by observing the time required to apply a known increment of stress. For example, for a test piece with a cross section of 0.500 in by 0.250 in and a specified stress rate of 100,000 psi/min, the maximum force application rate would be 12,500 lbf/min (force = stress rate x area = 100,000 psi/min x (0.500 in x 0.250 in.)). A minimum rate of 1/10 of the maximum rate is usually specified.

Figure II.12 compares strain-rate control with stress-rate control for describing the speed of testing. Below the elastic limit, the two methods are identical. However, as shown in Fig. II.12, once the elastic limit is exceeded, the strain rate increases when a constant stress rate is applied. Alternatively, the stress rate decreases when a constant strain rate is specified. For a material with discontinuous yielding and a pronounced upper yield spike (Fig II.11), it is a physical impossibility for the stress rate to be maintained in that region because, by definition, there is not a sustained increase in stress in this region. For these reasons, the test methods usually specify that the rate (whether stress rate or strain rate) is set prior to the elastic limit (EL), and the crosshead speed is not adjusted thereafter. Stress rate is not applicable beyond the elastic limit of the material. Test methods that specify rate of straining expect the rate to be controlled during yield; this minimizes effects on the test due to testing machine stiffness.
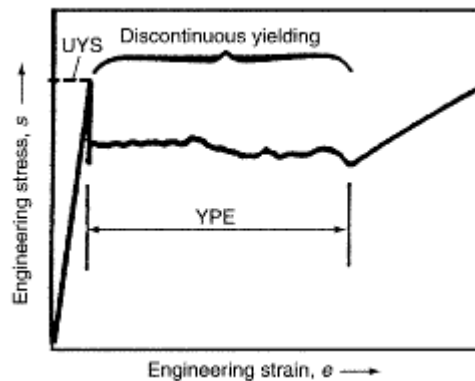

Fig II.11 - Examples of stress-strain curves exhibiting pronounced yield-point behavior. Pronounced yielding, of the type shown, is usually called yield-point elongation (YPE). Classic example of upper-yield-strength (UYS) behavior typically observed in low-carbon steels with a very pronounced upper yield strength.
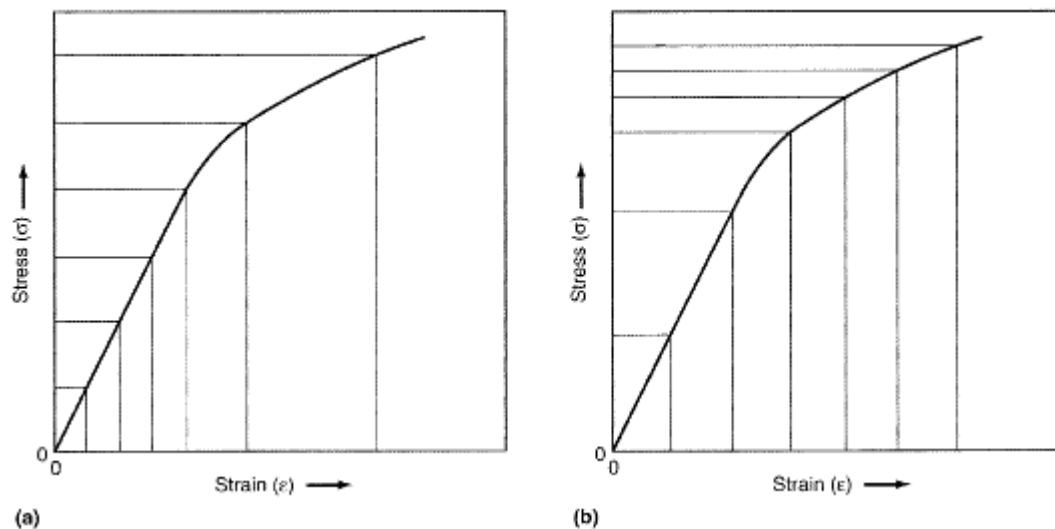
Fig II.12 - Illustration of the differences between constant stress increments and constant strain increments. (a) Equal stress increments (increasing strain increments). (b) Equal strain increments (decreasing stress increments)

II.6.3. Cross-head separation rate

The rate of separation of the grips (or rate of separation of the cross heads or the cross-head speed) is a commonly used method of specifying the speed of testing. In ASTM A 370, for example, the specification of test speed is that "through the yield, the maximum speed shall not exceed 1⁄16 in per inch of reduced section per minute; beyond yield or when determining tensile strength alone, the maximum speed shall not exceed 1⁄2 in per inch of reduced section per minute. For both cases, the minimum speed shall be greater than 1⁄10 of this amount." This means that for a machined round test piece with a 2 1⁄4 in reduced section, the rate prior to yielding can range from a maximum of 9⁄64 in/min (i.e., 2 1⁄4 in reduced-section length x 1⁄16 in/min) down to 9⁄640 in/min (i.e., 2 1⁄4 in reduced-section length x 1⁄160 in/min).

II.6.4. Elapsed time

The elapsed time to reach some event, such as the onset of yielding or the tensile strength, or the elapsed time to complete the test, is sometimes specified. In this case, multiple test pieces are usually required so that the correct test speed can be determined by trial and error. Many test methods permit any speed of testing below some percentage of the specified yield or tensile strength to allow time to adjust the force application mechanism, ensure that the extensometer is working, and so on. Values of 50 and 25%, respectively, are often used.

II.7. MACHINE STIFNESS

The most common misconception relating to strain rate effects is that the testing machine is much stiffer than the specimen. Such an assumption leads to the concept of deformation of the specimen by an essentially rigid machine. However, for most tests the opposite is true: the conventional tensile specimen is much stiffer than most testing machines. As shown in Fig. II.13, for example, if crosshead displacement is defined as the relative displacement, D, that would occur under conditions of zero load, then with a specimen gripped in a testing machine and the driving mechanism engaged, the crosshead displacement equals the deformation in the gage length of the specimen plus elastic deflections in components such as the machine frame, load cell, grips, and specimen ends. Before yielding, the gage length deformation is a small fraction of the crosshead displacement. After the onset of gross plastic yielding of the specimen, conditions change. During this phase of deformation, the load varies slowly as the material strain hardens. Thus, the elastic deflections in the machine change slowly, and most of the relative crosshead displacement produces plastic deformation in the specimen. Qualitatively, in a test at approximately constant crosshead speed, the initial elastic strain rate in the specimen will be small, but the specimen strain rate will increase when plastic flow occurs. Quantitatively, this effect can be estimated as follows. Consider a specimen having an initial cross-sectional area A_o and modulus of elasticity E gripped in a testing machine so that its axially stressed gage length initially is

L_0 (This discussion is limited to the range of testing speeds where wave propagation effects are negligible. This restriction implies that the load is uniform throughout the gage length of the specimen.) Denote the stiffness of the machine, grips, and so on, by K and the crosshead displacement rate (nominal crosshead speed) by S. The ratio S/L_0 is sometimes called the nominal rate of strain, but because it is often substantially different from the rate of strain in the specimen, the term specific crosshead rate is preferred. Let loading begin at time t equal to zero. At any moment thereafter, the displacement of the crosshead must equal the elastic deflection of the machine plus the elastic and plastic deflections of the specimen. Letting s denote the engineering stress in the specimen, the machine deflection is then sA_0/K. It is reasonable to assume that Hooke's law adequately describes the elastic deformation of the specimen at ordinary stress levels. Thus, the elastic strain e_e is s/E. Denoting the average plastic strain in the specimen by e_p, the above displacement balance can be expressed as:

$$\int_0^t S\, dt = s\left(\frac{A_0}{K} + \frac{L_0}{E}\right) + e_p L_0 \qquad\qquad \text{(Eq. 1)}$$
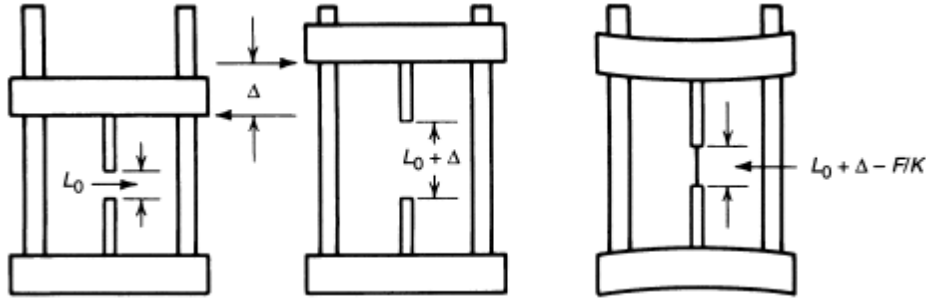
Fig II.13 Schematic illustrating crosshead displacement and elastic deflection in a tensile testing machine. Δ is the displacement of the crosshead relative to the zero load displacement; L_0 is the initial gage length of the specimen; K is the composite stiffness of the grips, loading frame, load cell, specimen ends, etc.; F is the force acting on the specimen. The development of Eq 1 through 5 describes the effects of testing machine stiffness on tensile properties.

Differentiating Eq 1 with respect to time and dividing by L_0 gives:

$$\frac{\dot{S}}{L} = \left(\frac{\dot{s}}{E}\right)\left(\frac{A_0 E}{KL_0} + 1\right) + e_p \qquad \text{(Eq. 2)}$$

The strain rate in the specimen is the sum of the elastic and plastic strain rates:

$$\dot{e} = \dot{e}_c + \dot{e}_p = \left(\frac{\dot{s}}{E}\right) + \dot{e}_p \qquad \text{(Eq. 3)}$$

Using Eq 2 to eliminate the stress rate from Eq 3 yields:

$$\dot{e} = \frac{\left(\frac{\dot{S}K}{A_0 E} + \dot{e}_p\right)}{\left(\frac{KL_0}{A_0 E} + 1\right)} \qquad \text{(Eq. 4)}$$

Thus, it is seen that the specimen strain rate usually will differ from the specific crosshead rate by an amount dependent on the rate of plastic deformation and the relative stiffnesses of the specimen ($A_0 E / L_0$) and the machine, K.

II.7.1. Determination of Testing Machine Stiffness

Machine stiffness is the amount of deflection in the load frame and the grips for each unit of load applied to the specimen. This deflection not only encompasses elastic deflection of the load frame, but includes any motion in the grip mechanism, or at any interface (threads, etc.) in the system. These deflections are substantial during the initial loading of the specimen, that is, through the elastic regime. This means that the initial crosshead speed (specified by the operator) is not an accurate measure of specimen displacement (strain). If the strain in the elastic regime is not accurately known, then extremely large errors may result in the calculation of Young's modulus (E, the ratio of stress versus strain in the elastic regime). In the analysis by Hockett and Gillis, the machine stiffness K is accounted for in the following equation:

$$K = \left(\frac{S}{P_0} - \frac{L_0}{A_0 E} \right)^{-1} \qquad\qquad\qquad (\text{Eq. } 5)$$

where L_0 is initial specimen gage length, S is crosshead speed of the testing machine, A_0 is initial cross-sectional area of the specimen, P_0 is specimen load rate ($dF/dt = A_0\, s\,\dot{}$), and E is Young's modulus of the specimen material.

II.8. TENSILE TESTING EQUIPMENTS

II.8.1. Load Cells

Current testing machines use strain-gage load cells and pressure transducers. In a load cell, strain gages are mounted on precision-machined alloy-steel elements, hermetically sealed in a case with the necessary electrical outlets, and arranged for tensile and/or compressive loading. The load cell can be mounted so that the specimen is in direct contact, or the cell can be indirectly loaded through the machine crosshead, table, or columns of the load frame. The load cell and the load cell circuit are calibrated to provide a specific voltage as an output signal when a certain force is detected. In pressure transducers, which are variations of strain-gage load cells, the strain-gaged member is activated by the hydraulic pressure of the system. Load cells are rated by the maximum force in their operating range, and the deflection of the load cell must be maintained within the elastic regime of the material from which the load cell was constructed. Because the load cell operates within its elastic range, both tensile and compressive forces can be monitored. Electronics provide a wide range of signal processing capability to optimize the resolution of the output signal from the load cell. A prior knowledge of the mechanical properties of the material being studied is also useful to obtain full optimization of these signals.
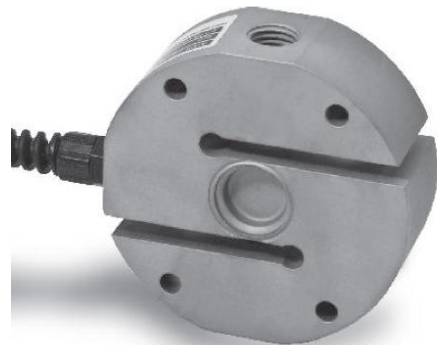
Fig II.14 S-beam Load Cell 5tonf

II.8.2. Extensometry

The elongation of a specimen during load application can be measured directly with various types of devices, such as clip-on extensometers (Fig II.15), directly-mounted strain gages (Fig II.16), and various optical devices. These devices are used extensively and can provide a high degree of deformation- (strain-) measurement accuracy. Other more advanced instrumentations, such as laser interferometry and video extensometers, are also available.

Various types of extensometers and strain gages are described below. Selection of a device for strain measurement depends on various factors:

● The useable range and accuracy of the gage
● Techniques for mounting the gage
● Specimen size
● Environmental test conditions
● Electronic circuit configuration and analysisfor signal processing
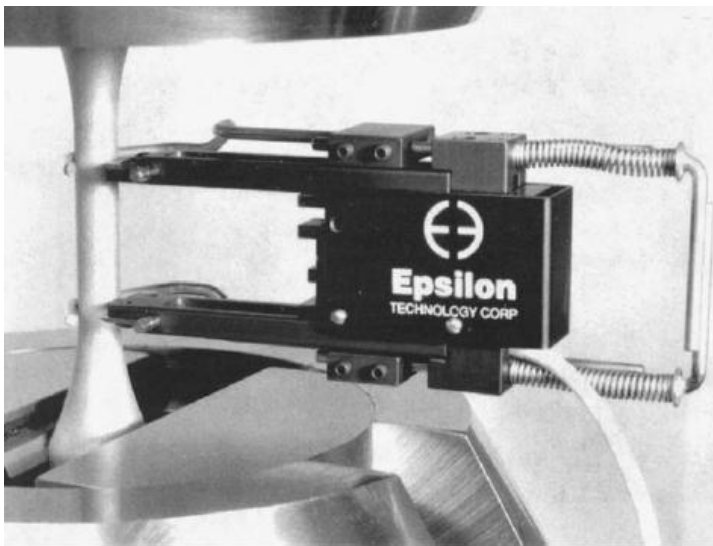
Fig II.15 Test specimen with an extensometer attached to measure specimen deformation. Courtesy of Epsilon Technology Corporation
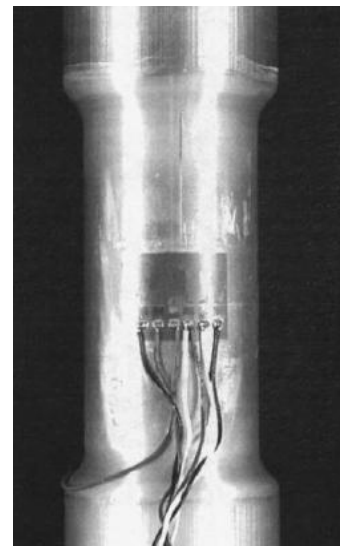
Fig II.16 Strain gages mounted directly to a specimen

Clip-on extensometers can be attached to a test specimen to measure elongation or strain as the load is applied. This is particularly important for metals and similar materials that exhibit high stiffness. As shown in Fig II.15, typical extensometers have fixed gage lengths such as 25 or 50 mm (1 or 2 in.). They are also classified by maximum percent elongation so that a typical 25mm (1 in.) gage length unit would have different models for 10, 50, or 100% maximum strain. Extensometers are used to measure axial strain in specimens. There also are transverse strainmeasuring devices that indicate the reduction in width or diameter as the specimen is tested.

Optical Systems Lasers and other systems can also be used to obtain linear strain measurements. Optical extensometers are particularly useful with materials such as rubber, thin films, plastics, and other materials where the weight of a conventional extensometer would distort the workpiece and affect the readings obtained. In the past, such strain-measuring systems were expensive, and their principal use has been primarily in research and development work. However, these optical techniques are becoming more accessible for commercial testing machines. For example, bench-top UTM systems with a laser extensometer are available. This laser extensometer allows accurate measurement of strain in thin films, which would not otherwise be practical by mechanical attachment of extensometer devices. Optical systems also allow noncontact measurement from environmental test chambers.

Table II.5 Classification of extensometer systems

Classification	Error of strain not to exceed the greater of(a):		Error of gage length not to exceed the greater of:	
	Fixed error, in./in.	Variable error, % of strain	Fixed error, in.	Variable error, % of gage length
Class A	0.00002	±0.1	±0.001	±0.1
Class B-1	0.0001	±0.5	±0.0025	±0.25
Class B-2	0.0002	±0.5	±0.005	±0.5
Class C	0.001	±1	±0.01	±1
Class D	0.01	±1	±0.01	±1
Class E	0.1	±1	±0.01	±1

(a) Strain of extensometer system—ratio of applied extension to the gage length. Source: ASTM E 83

CHAPTER III

After literature review, in this chapter we will discuss how to machine designed and passed manufacturing processes. At first we decided how wiII be the machine drive system and mechanisim. As a result of research which concluded the decision to elect the two systems which are gear system and hydraulic system. Hydraulic drive system is choosen system. The biggest reason that support of the sponsor company in hydraulic systems . The company produces its own cylinders, hydraulic cylinder production greatly facilitated on the job. Other raw materials were supplied part of the factory junkyard and the final products are obtained through production processes in the same factory. The steel material used is a type of AISI 1045 steel. Sensors are provided in the other companies. Whether the electrical panel design installation by an electrician at the factory. Daqcard for purchase from the sensor data have been used. Daqcard is used to send the data read from the sensors to the computer was obtained from the university.

First, the capacity of the machine has been decided how many kN or tonf. This capacity universal testing machine capacity up to an average five tonf. This value will be considering the design. Second, grips system design. I examined the mechanisms available for the grips, and wedge construction of the grip has been decided. Do you wiII be at the bottom of the hydraulic cylinder on the machine or on a small exchange of ideas were made. Hydraulic cylinder is decided to be at the bottom of the machine. Then, the fixed grip and the other one movable thought to connect the structure to be decided. Considered a system of guide shafts bed.

Electrical and electronic part of the works in two ways. Utility to perform the control of the hydraulic cylinder back and forth to the computer and data transmission. As well as the manual control of the hydraulic cylinder can be controlled by buttons.

A computer program written for the processing of data is received. Office programs, such as Excel could be use for this work. In addition, data have to be used in the daqcard has its own special software.

3D designs, technical drawings and analyzes were made of solid works program. Besides this, catia program to create videos on the mechanism used. Proteus for the design of printed circuit board electronic circuit diagrams, and electronic drawing program. Automation Studio software has been used for the hydraulic circuit diagram. matlab or excel program was used for the data coming from the sensors.
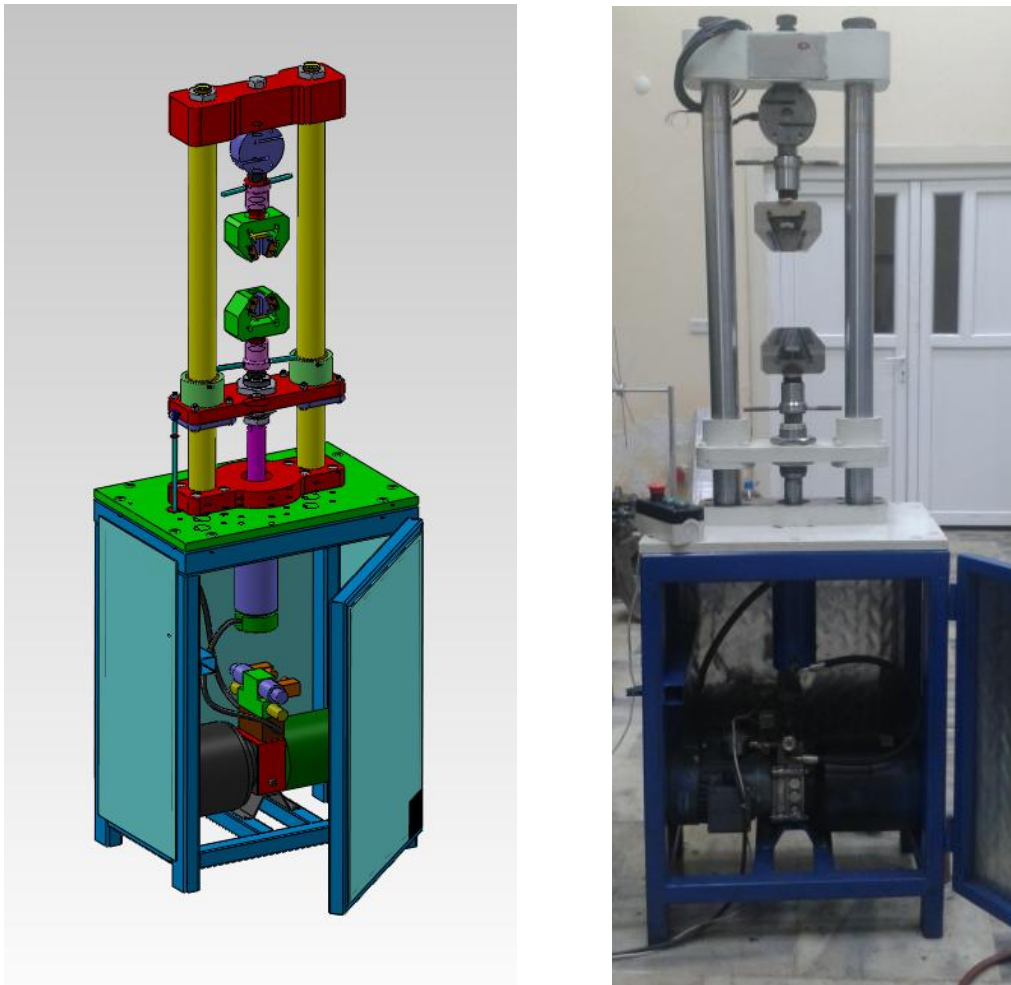
Fig III.1 3D view the tensile test machine(left) and the real image(right)

III.1. WEDGE GRIP SYSTEM

The Grips system was designed as a wedge type. This type of connection of the grip features an easy connection of parts and components of various geometries and self-locking to specimen with wedge parts. This are very common in this type of area. We have designed the system design places the mechanical wedge. Mechanical wedge grips compression of the parts are provided turned the tightening ears. The systems are available with electro-wedge. The systems are available with electro-wedge. This style has an actuator systems, and you can move the opening and closing wedges with a computer or buttons.

The mechanical structure of this design is completely unique and based on the up to 10 tonf but due to the safety factor 2 must be used up to the maximum 5tonf. The wedge inner surfaces hardened because of that the inner surfaces damaged the most places. The distance between wedges to connect the flat shape of samples 0 - 11mm, cylindrical samples, this value is designed to be 14.2mm max min 4mm. Reason for wedges min value is not 0 for the positioning of the cylindrical part must be alignment which mentinod on chapter 2. This hollow allows to aligned cylindrical parts connected to the grip.

The working principle is briefly as follows. The connection screw fixed the grips to machine. With the tightening ears turning, the block to move up and down by the block screw fixed the block. The block moves up the connection screw is fixed and the wedge head in the screw conneciton to because they have a fixed wedge is forced to move down. so that the wedges closing each other by the inner surfaces due to the geometry of the part compresses the specimen.

Force loaded is fitted on where the part is determined to be analyzed on SolidWorks Simulation. Then, the force applied the place, the direction and magnitude which is 50kN are determined. After, the part is meshed with high precision and run the simulation in order to take result. According to the results we obtain three different representative picture.

they stress, displacement and strain distribution. Figure III.3, III4 show that mesh of the block, distribution of stress and dicplacment.
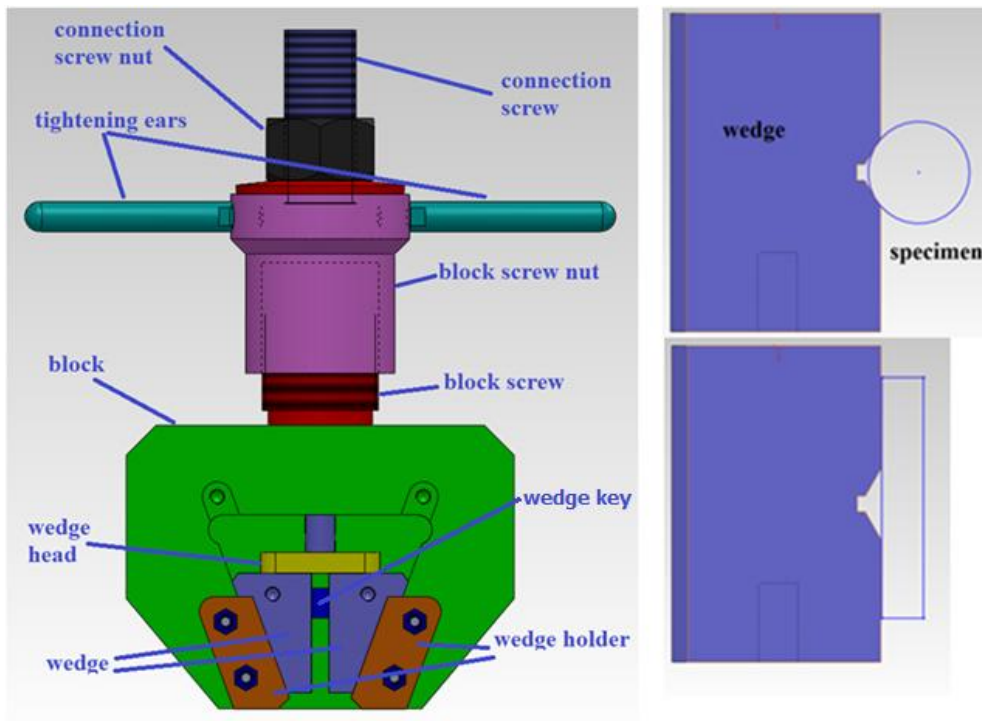
Fig III.2 Wedge type tensile test machine grip(left) and specimen position(right)
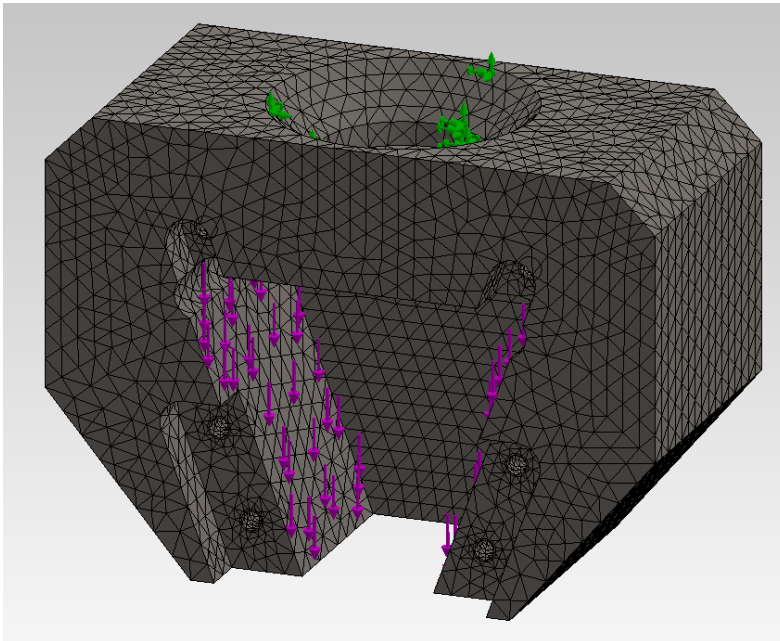
Fig III.3 Mesh diagram block part on solid works
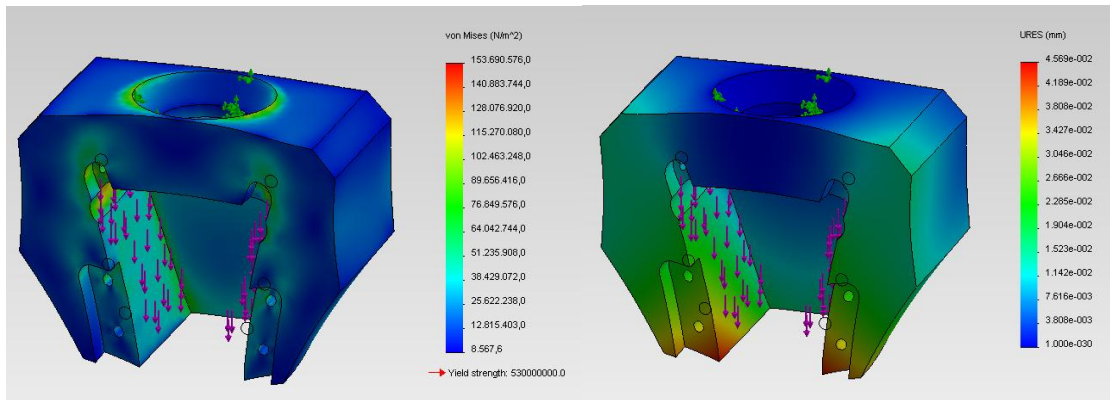
Fig III.4 The block stress and displacement distrubution

According to the above figures the block under 50kN (5tonf) force of the minimum stress of 8.57 MPa, the maximum stress is 154 MPa. The yield strength is 530 MPa for the safety factor of 50kN n = 530/145 from 3.45. This value is suitable for design. The deformation value of 4.57 for the maximum 5-002 mm seems to be 50kN on scale. This is a rather small value for 50kN. Round corners on the inner side of the block in order to reduce stresses designed geometry. Fig III.2 shows the round corners. The wedges slip angle was möeasured is 70 degrees by examining a number of different grips design. This angle is much less than in the case of stress, and increasing the friction increases the self-locking feature makes it ineffective.
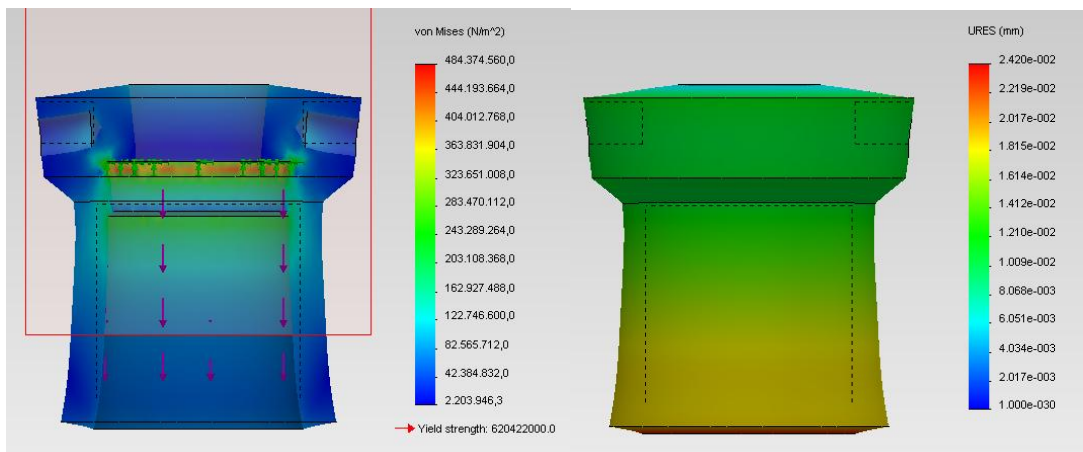
Fig III.5 The block screw nut stress and displacement distrubution
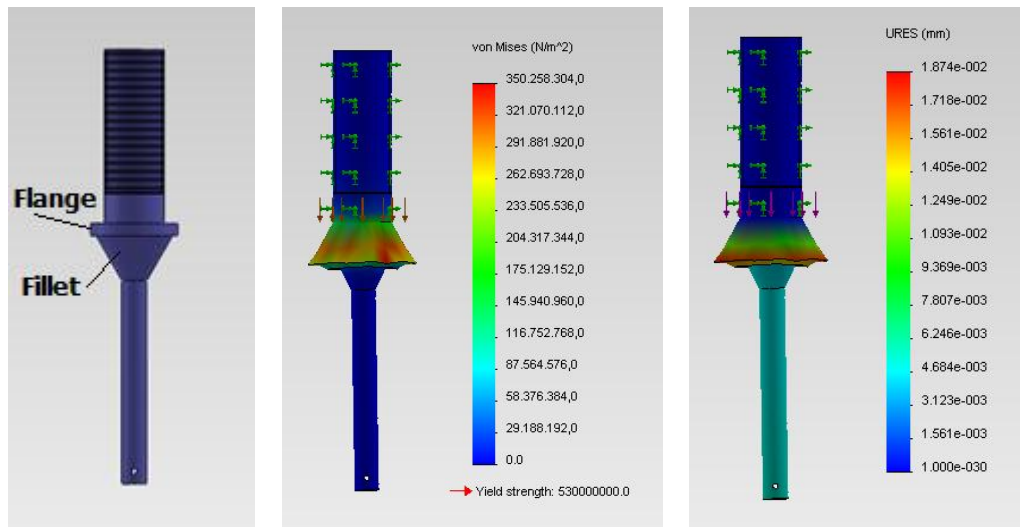
Fig III.6 The connection screw stress and displacement distrubution, normal view(left), stress view(midlle), deformation view(right)

The part in Fig III.5 is called the block screw nut. The Connection screw (Figure III.6) loaceted into the block screw nut. The flange of the connection screw keeps a constant height in the screw nut block and allows rotation of concentric manner at the same time. In this way, when we rotate the block screw nut connected to the tigtenning ears, the block moves upward, but the load value flowing through the connection screw creates high stress levels on the flange. Using an angle of 45 degrees from the bottom of the flange fillet should be made larger or smaller. Because the angle is 45 degrees max shear stress. If we want to reduce this stress, the value of this angle should be smaller than 45 degrees from the vertical axis. To be considered here, make sure that the properly located into the the connection screw to the blockscrew nut. This angle was 30 degrees in Fig III.7.

Factor of safety for Figure III.5 n = 530/484 = 1.1 maximun deformation value is 2.42e-002 mm. Factor of safety for Figure III.6 n = 530/350 = 1.5, maximum deformation value is 1.67e-002 mm.
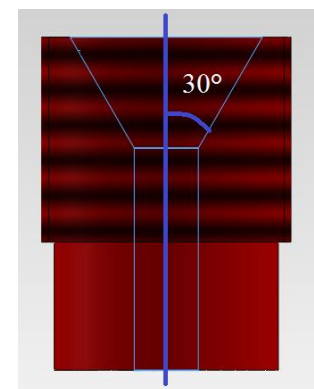
Fig III.7 The block screw nut
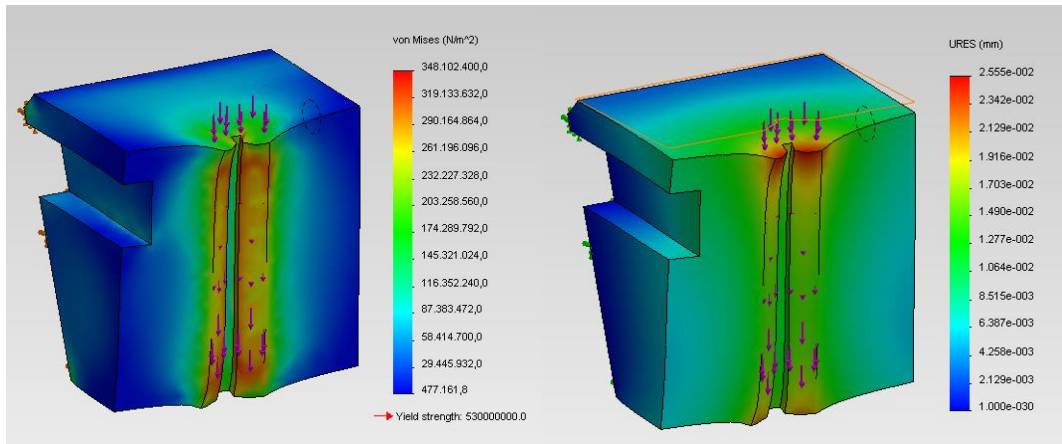
Fig III.8 The wedge stress and displacement distrubution

The force applied on simulation 5tonf on two wedges. They are divided into two, so you performed to analysis 2.5tonf as the value of the force. Safety factor according to this value 530/348 = 1.52, max deformation is 2.55-002 mm.

Cuttued surface behind of the wedges is slot of the wedge key in seen fig III.8. The wedge key placed there ensures that the horizontal axis aligned with each other. This is guaranteed to be aligned on the vertical axis of specimens. After analysis, technical drawing are created on SolidWorks to manufactur parts. Used for this purpose lathe machines, cnc milling machines, oxygen cutting, band saw and welding machine. During the manufacturing process of parts benefited from the experience of the masters in factoty.

CNC work is done at the university lab, I-Deas program is used to obtain the cnc code. There are three cnc code which are belongs to the four of wedge, two of the block and four of the wedge holders. The full CNC code added at appendix.

After manufacturing, in order to assembly of the grips must be follow exploded view on technical drawings on appendix. Also created a video about how to assembly the grip and other parts.
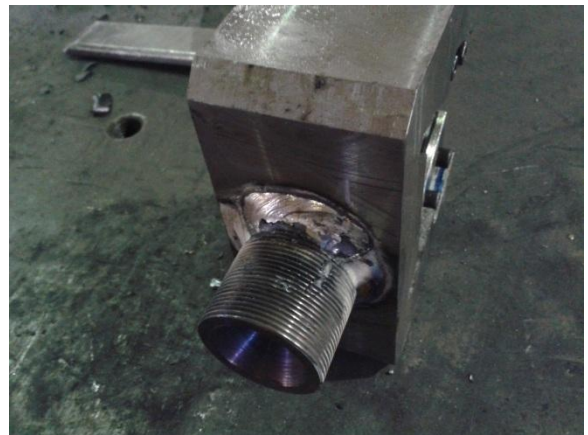
Fig III.9 Some images of manufacturing of the wege grips.

III.2. THE MAIN CONSTRUCTION

We mentioned design and manufacture of the grip mechanism. Now we will begin how to move the grip and talk about set them on the chassis. One of the two grips shape allows us to design the most suitable to be fixed and the other movable. Drive power of the hydraulic cylinder, which is below the moving means the grip will be attached to it. In this case, the bridge must be connected to the upper part of the fixed grip. For loadcell the most suitable palce is the connection between the grip and the top bridge. The grip can move up and down without misalignment must be designed and beared the guide shafts. The brass material is used for this bearing the guide shafts into the honned pipe which are used hydraulic cylinder. Other material could be used for this operation is teflon but, teflon is more expensive than brass material. These materials are not damage during sliding on the bearing materials.

The outer diameter of the brass pipe is a little big than inner diameter of honned pipe. This reason that the brass pipe must not be move in honned pipe easily and it pressed to locate into honned pipe as hard fit. Inner diameter of brass pipe is not important how precision because of changing diameter when pressing. We want to use lathe machine desired diameter which is 60 mm. Setskur must use to fix two part most strenghtly.

Diameter of the guide shaft is important about loading force acting them buckling and compression stress during tensile force on specimen. We must calculate critical dimater of this sutition and then design the bearings.
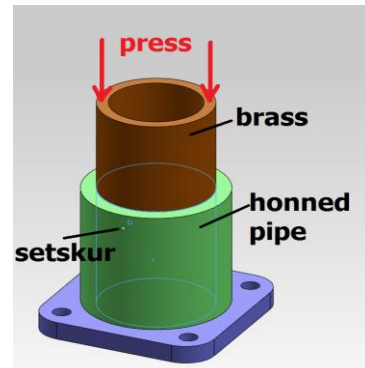
Fig III.10 The Guide shaft bearing(top), real image of bottom view (bottom)

Critical diameter for buckling:

$$P_{cr} = \frac{\pi^2 EI}{Le^2} \qquad \text{(Eq. 6)}$$

P_{cr} = 50 kN, Le = 2 m (effective length for fix-free connection, 2L), E = 207e09 Pa,

I = $\frac{1}{4}\pi r^4$ m^4, from Eq.6 gives us radius r = 18.7 mm, diameter D = 37.5 mm. We used

diameter is 60 mm. Then Safety factor is n = 60/37.5 = 1.6

For compresion:

$$\sigma_y = \frac{F}{A} \qquad \text{(Eq. 7)}$$

$\sigma_y = 530\ MPa$, $F = 50\ kN$, A = πr^2, fron Eq.7 gives us radius r = 11 mm, diameter D = 22 mm calculated. This value gives us safety factor as n = 60/22=2.7.

Figure in below simulation runned on SolidWork shows us stress and deformation distrubution values on scale diagram. Max stress 81 Mpa, max deformation 8.15e-002 mm. Based on these values, safety factor is n = 530 / 81 = 6.54.
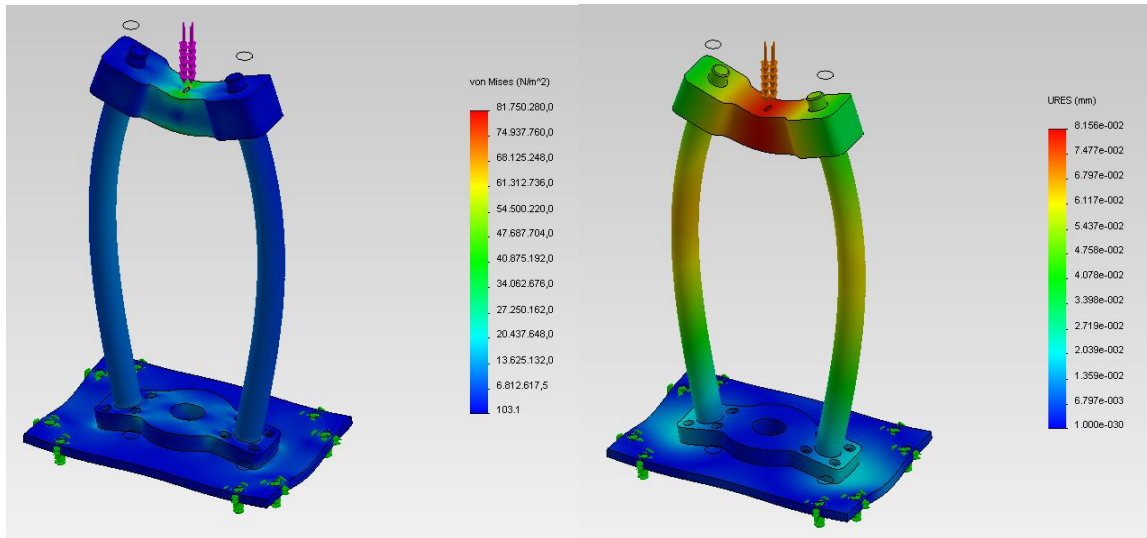
Fig III.11 The guide shaft stress and displacement distrubution

Steel profiles are used to creating the chassis which carry the guide shaft mechanisim and all upper parts grips, sensors. Tensile force during testing does not affect on these profiles. They just carry weight of upper mechanisim and parts. Hence, The general framework are made from 40x60 mm pipe-square profile and traverse are made from 40x40 mm pipe-square profile. Connection between chassis and the table are connect with 8 pieces counter-sunk head screw M10x1.25. There is the technical drawings in detail on the size at appendix.

Fig III.12 The Chassis designed on solidworks(left) and real image(right)

III.3 HYDRAULIC CYLINDER AND UNITE

Double-acting hydraulic cylinder is used for the tensile test machines in general. Double-acting cylinder means hydraulic cylinder can move both side with high pressure. How will be producing hydraulic cylinder pipe and shaft diameter should be determined by your application as well as the direction of the force applied. Differences in size, consisting of, or otherwise insufficient thrust cause more weight and cost disadvantage. That influence it seals which sealing will be damaged. and hydraulic cylinders does not work properly most probably leaks. Hydraulic unit is supplied as ready. It has hyfraulic pump, hydraulic tank, valves and variable non return throttle valves each way. Its pressure adjust to 180 bar. Pressure can adjustable allen key. On 4/3 NC spring return solenoid valve is used with this valve can send two-way hydraulic cylinder produced a high-pressure oil by hydraulic unit.

Hydraulic cylinder tube inner diameter 80 mm, the shaft diameter 40 mm was chosen. Stroke is 150 mm. We obtain the following results if arrange max pressure 180 bar of hydraulic units:

$$P = \frac{F}{A}$$ (Eq. 8)

Pressure: P = 180 bar = 180e05 Pa max, Area: $A = \pi r^2$
radius for forward force r = 0.04 m (high pressure), Area = 5.027 x10^{-3} m^2
radius for back force r = (0.04^2-0.02^2) / 2 = 0.02 mm (low pressure), Area = 3.77 x10^{-3} m^2

High pressure force F = 90.5 kN (~9 tonf). we do not use this force because of our hydraulic cylinder assemblied upward position. So, tensile force occurs when hydraulic cylinder moves down. If we want a compression test, we use this hydraulic cylinder for 5-7 tonf, but important point that loadcell capacity is 5tonf and bucling of hydraulic cylinder shaft.

Low pressure force F = 67.9 kN (~7 tonf). we need 5 tonf max. In addition, hydraulc cylinder shaft exposed 50kN compression force. It must not be yield.

calculation of yiled point of radius on equation 7:
$\sigma_y = 530\ MPa, F = 50\ kN, A = \pi r^2 = 9.43\ m^2$
r = 5.5 mm, diameter d = 11 mm. used diameter is 40 mm.

buckling calculations on equaiton 6 (compression test):
P$_{cr}$ = 50 kN, Le = 0.17 m (effective length for fix-fix connection, 0.5L), E = 207e09 Pa,
$I = \frac{1}{4}\pi r^4\ m^4$, r = 5.47 mm, diameter d = 10.9 mm.

Both radius are very close each other. Factor of safety is n = 40 / 11 = 3.6. This value is quite adequate.

Fig III.13 3D view(left), real image of hydraulic clinder(middle) and hydraulic unite(right)
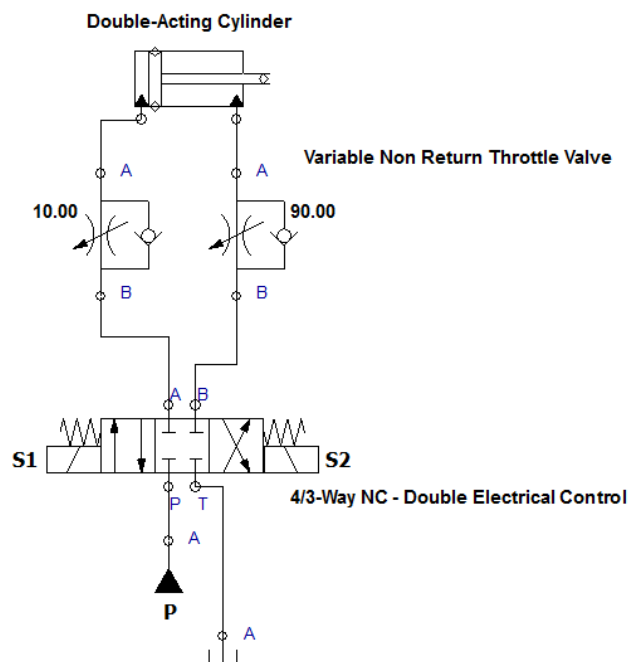
Fig III.14 Hydraulic Circuit Diagram

S1 and S2 in diagram are contacts of solenoid valves. This contacts are connected the electronic card. Contacts change the position of the valve where provided +24VDC. Thus, the hydraulic cylinder could move.

III.4 ELECTRIC PANEL

Electrical panel can control the machine by both computer manually. It has a set of buttons to control it manually. Hydraulic cylinder can be controled up and down and the system energy can be cutted with emergency button in case of emergency. There are power switch on the cover of the panel and led shows power on. This switch provides energy to the system as well as the engines directly. All inputs and outputs are part of the panel terminal connections.

The signal from the computer to electronic card and with buttons to control the hydraulic cylinders positive 24 VDC provides the energy required for the valves. There are 4 relays on the electronic board. Two of which are used to control valves. The other two are made because studies to be controlled by the grips added to the electro-mechanical in future. Electronic circuit has a anti-locking cicuit after inputs itself. It will be usefull when the two signals at the same time on, all of output could be zero to prevent unstable position of the valve. To do this, 7404 NON-GATE and 7408 AND-GATE were used. As can be seen in the Fig III.16 the anti-locking circuit left and the case diagram on right. Groups of inputs are connected to computer or the buttons. The Outputs are coonnected the relay to control them. In the case diagram stepo 2 and 3 so that there is only one step in the output indicates that the signal from a single source. Step 4 for the circuit output signal comes from two sources, so the outputs exit are zero. In this way, the two coils of valve are prevented unsatable position at the same time the signals occuring on.

Electronic circuit built on Pertenax board. After the component sequenced pins connected with thin copper wire. This method is very simple and inexpensive method by flat copper plaque. The printed circuit and electronic circuit are drawn to the Proteus and can be found full version circuits in the appendix.
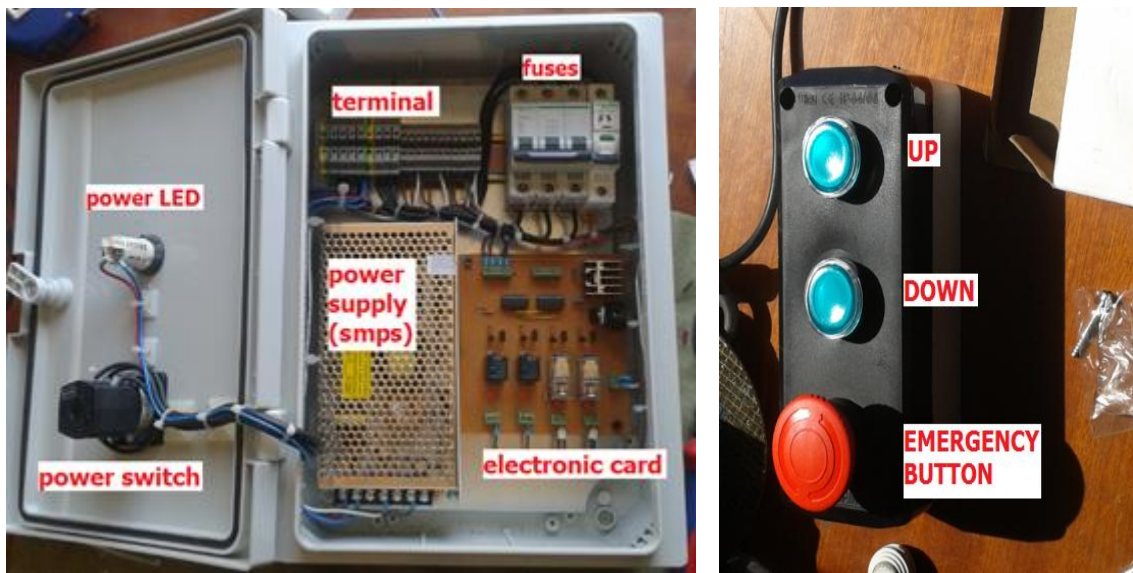
Fig III.15 Electric Panel(left), Control buttons(right)
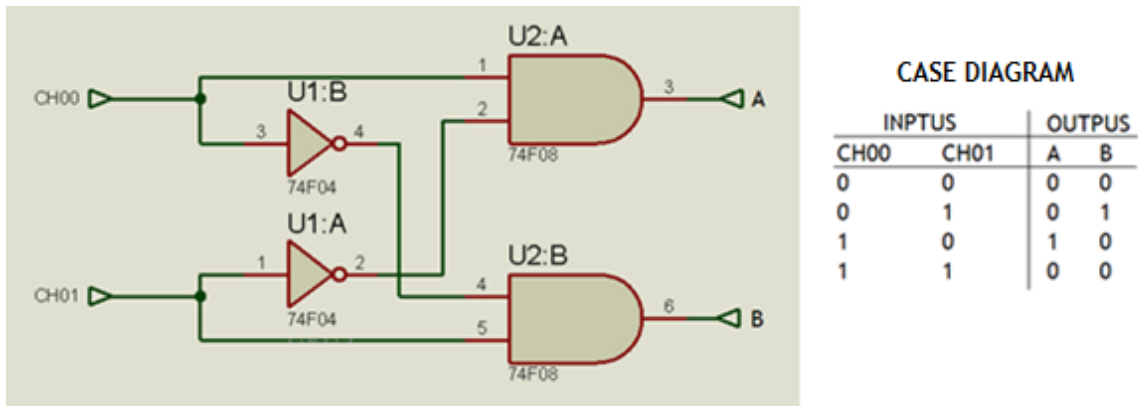
Fig III.16 Logic diagram to lock down for same two signal if on, and case diagram

III.5 SENSORS CONNECTIONS

As mentioned before, two types sensor are used of tensile testing machines. These are loadcell which to measure force and other extensometry to measure deformartion or the linear rules alternatively be used. We have chosen s-type load cells of different types are the ones because they can be measure both tensile and compressive forces. It consist of one piece steel material and it has a straingauges. When this straingauge become deformaed, the resistance changes and relatively voltage differ. Hence, voltage differences can be read as a load cell force. Connection to the machine of load cells is simple added in appendix and the electronic circuit at the terminals of the cables and the load cell of the datasheet, technical drawings can be found appendix.

Linear displacement transducer (linear ruler) was used to measure the deformation. The working principle of the linear rulers, reader head slides on the strip-shaped of resistance located inside and resistance changes when it moves relatively change voltage as loadcell. the voltage information gives us dicplacement data. The linear ruler consist of two parts which are chassis and slider. The connection can be done between a movable part and a fixed part of the machine. Disadvantage of this linear rules is that measuring the total value deformation of specimen and deformation of machine parts because of connection to machine directly. Extensometer is installed on the specimen directly, it should not be affected the machine deformaiton.

The sensors power are supplied by electric panel and outputs are connected the daqcard. The daqcard is attached to computer to read the data. There is an important point the connection about is that the ground of electric panel and ground of computer are connected each other to equalize reference points. Otherwise, same signal seems to be different from each other and reading wrong data.

III.6. DATA OF TESTING

Data generally may be grouped into "raw data," meaning the observed readings of the measuring instruments, and "calculated data,"meaning the test results obtained after the first step of analysis. In the most simple tensile test, the raw data comprise a single measurement of peak force and the dimensional measurements taken to determine the cross-sectional area of the test specimen. The first analysis step is to calculate the "tensile strength," defined as the force per unit area required to fracture the specimen. More complicated tests will require more information, which typically takes the form of a graph of force versus extension. Computer-based testing machines can display the graph without paper, and can save the measurements associated with the graph by electronic means. A permanent record of the raw test data is important, because it allows additional analyses to be performed later, if desired, and because it allows errors in analysis to be found and corrected by reference to the original data. A stress-strain diagram will help you determine: Modulus of Elasticity, Elastic Deformation, Yield Strength, Proportional Limit, Proof Stress, Uniform Elongation, Total Elongation, Yield Point Elongation and n-Value.

Determining Yield Strengths
There are two common methods of determining Yield Strength from a curve. Let's look briefly at both of them.

1. **The Offset Method:** The **offset** is the horizontal distance between the modulus line and any line running parallel to it. For example, the line C-D in Fig III.17is "offset" from the modulus line by 0.2% (0.002 in./in.). The value of the offset for a given material is usually expressed this way: **Yield Strength, 0.1% or 0.2% Offset.** What this means is that a certain percentage of the set equals a certain percentage of the fundamental extension units. For example, "0.2% Offset" means 0.2% of the fundamental extension units of inches per inch, or 0.002 in./in. Starting at the origin of the curve, measure off a distance equal to 0.002 in./in. along the **X-axis.** Now using that as the origin, draw a line (C-D) parallel to the modulus line. Notice that the line C-D intersects the stress-strain curve at a certain point

(Y in Fig III.17). The ordinate of this point (the amount of stress in psi) is the **Yield Strength at 0.2% Offset.** You can use the same method to determine the yield strength at a 0.1% offset by noting the intersection of the curve and a line drawn parallel to the modulus line with an offset of 0.001 in./in.

2. **The Extension Under Load Method:** This method involves drawing an ordinate line (that is, a completely vertical line) from the point on the **X-axis** where the elongation equals the specified extension, e.g. Yield Strength = 0.5% Extension. To make this determination, locate the point on the abscissa, which is equal to 0.5% (0.005 in./in.) of extension from the origin of the curve (E in Figure 2). Draw an ordinate line (E-F) from this point up through the curve. Convert the load value of this point into psi. The stress value is the **Yield Strength at 0.5% (0.005 in./in.) Extension Under Load.** In some cases, the yield strength may be given in other than strain fundamental units, e.g. Yield Strength = 0.1 in. / 2 in. Extension. In such cases, the limiting extension must first be converted into fundamental strain units (in./in.) A limiting extension of 0.01 in with a 2 in gauge length is equal to 0.005 in./in. extension.

Young's Modulus of Elasticity

The modulus of elasticity (Young's Modulus) is the ratio of stress in pounds per square inch (psi) to strain in inches per inch (in./in.) as computed from the modulus line (A-B).

$$Modulus\ (psi) = \frac{\Delta Stress(psi)}{\Delta Strain(in./in.)}$$

To find the modulus, take any two points (K & L) on the modulus line (A-B), and divide the differential between their stress values in psi from the strain differential in in./in. The result of this division is the modulus of the material tested. For Example:

	Load lbs.	Strain in./in.
Point K	17,400	0.003
Point L	5,800	0.001
Difference (Δ)	11,600	0.002

This load (11,600 lbs.) must be converted into psi by dividing the load in pounds by the crosssectional area of the specimen. For example, a standard .505 in. dia. test bar has an area of 0.200 sq. in. Therefore, a load of 11,600 lbs. would be equal 58,000 psi (11,600 divided by 0.200). Computing the Modulus of Elasticity from the above example:

$$Modulus = \frac{58000\ psi}{0.002\ in./in.} = 29\ Mpsi$$

To obtain better readability and greater convenience, it is recommended that you use points near the end of the modulus line that are the intersection of easily interpreted load and extension lines. Further, the final modulus of elasticity of a material should never be based on the stress-strain curve from a single test. It should be the average of values calculated for several tests with comparable specimens.

Proportional Limit and Proof Strength

As previously discussed, the proportional limit is the greatest stress that a material is capable of sustaining without any deviation from proportionality of stress to strain (Hooke's Law). This should not be confused with the elastic limit, which is the maximum stress that can be applied without any permanent strain remaining when the stress is released. Both of these values are extremely difficult to accurately determine because of the problem of finding the exact point where the curve ceases to be linear. For this reason, it's generally recommended that you use a yield strength measurement instead with a small offset (0.01%) for tests on critical materials. To do this, follow the offset method previously described, but use a small arbitrary number for the offset. The resulting yield strength is called the **Proof Strength** or **Proof Stress** of a specimen. Using this method gives you a straight line that intersects the curve at a load point (Point W in Fig III.17), which unlike the proportional or elastic limit can be easily located.
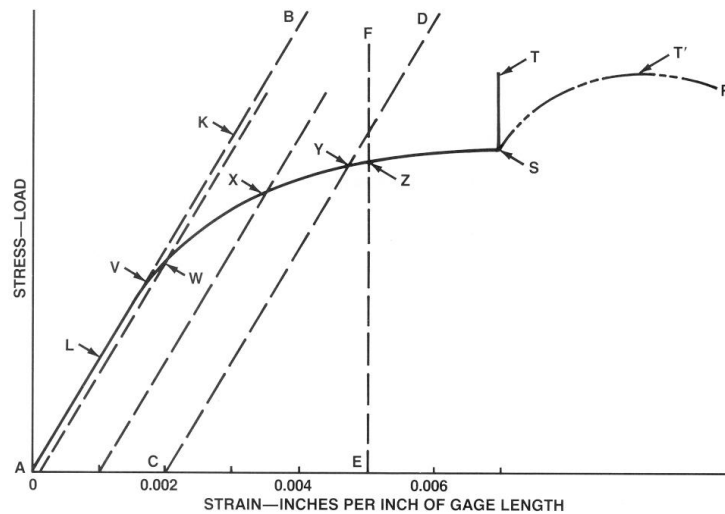
Fig III.17 Typical Tension Stress-Strain Diagram

Calculation of Tensile Properties of Materials:

Line A-B is Modulus Line; Young's Modulus of Elasticity = slope of initial straight portion of curve expressed as ratio of stress (psi) divided by strain (in./in.).

Line C-D is the 0.2% (0.002 in./in.) Offset Line.
Line E-F is the 0.5% (0.005 in./in.) Extension Line.
Curve A-R is a complete Stress-Strain Curve to specimen failure.
Segment S-R can be obtained with an instrument with the appropriate measuring capacity.

Point V = Proportional Limit.
Point W = Proof Stress, 0.01% Offset.
Point X = Yield Strength, 0.1% Offset.
Point Y = Yield Strength, 0.2% Offset.
Point Z = Yield Strength, 0.5% Extension Under
Load (conventional Yield Point). At Point S, the extensometer was removed.
Point T or T'=Ultimate Tensile Strength.
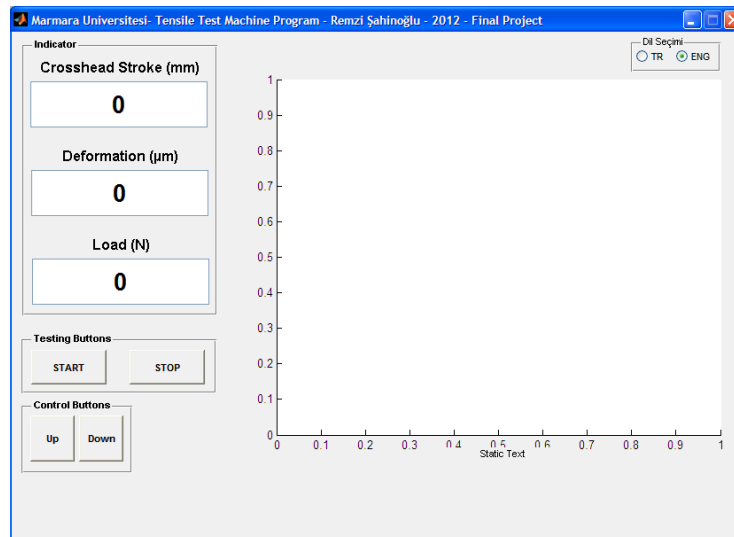
Fig III.18 Simple Matlab Program about recieving,calculation and showing datas

TROUBLESHOOTING

Troubleshooting is a form of problem solving, often applied to repair failed products or processes. It is a logical, systematic search for the source of a problem so that it can be solved, and so the product or process can be made operational again. We build it under three headings which are mechanic, elektronik and sofware.

- When you close switch the green LED should light up front of the electrical panel. If it does not:
    1. Check the fuse in the electrical panel. If it is open close.
    2. There is no power in the socket. Check the control with the stylus.
    3. Check CLIPS in the electric panel.
- If LED is on then motor of hidrolik unite must be run. If not.
    1. Check CLIPS of motor in the electric panel.
- Hydraulic cylinder movement provided by using the manual buttons provided. If it does not:
    1. The emergency button can be pushed. Pacify it.
    2. +24VDC may be not going to valves. Check with an avometer. Hydraulic cylinder with an external source of energy if it is running it is not a mechanical problem.Check the electronic circuit relays red led should light up after pressing the button. Circuit power supply is off. Check it out.
    3. Hydraulic cylinder seals may be able to leaked oil. Check it out.
    4. The motor connections can be made as reverse. There is no pressure. Check it out.
- When the button is pressed, the barometer on the hidrolik unite value rising suddenly:
    1. Throttle valve may be very bored. Check it out.
    2. Disassembly hoses from the hydraulic unit to hydraulic cylinder. If flow is exist then problem is on hydraulic unite. Repair it.
- Load cell and linear ruler are absolute sensors. If the signal can not be received from the computer:
    1. Sensors and supply voltages should be checked with an avometer at idle.
    2. Whether or not the output should be checked.
    3. If still the computer has no signal then problem is software.

RESULTS AND ARGUMENTS

As a result of our studies, we found a test control machine, two different drive system as well as advantages and disadvantages of these systems are different from each other.

For example electromechanical test machine could be more effort and cost although they are more controllable than hydraulics test machines. This test machine can be controlled as a strain rate. According to volume of machine, electromechanical test machine are less occupied than hydraulic test machine. Hydraulic machines are manufactured using less material than electromechanics, therefore, are produced with less cost. Concerned that the pressure of hydraulic cylinders are controlled as a stress rate. They take more space because the hydraulic cylinder is long, and needs hydraulic unit for power. There is a limit of a hydraulic test machine stroke due to hydraulic cylinder's size. Despite this, electromechanical machines are usually based on length of screw shaft and screw shaft lenght is almost machine lenght, its stroke is more than hydrauli machines. Some designs hydraulic cylinder was put at the top of the machine because of this problem of hydraulic units. This is also another problem. Hydraulic hoses. It goes down from the top of the machine to hydraulic unite. It is an unwanted situation.

When we talk about the design of mechanical grips, mechanical wedge system is the most widely used system. The most important feature of this grips, different parts of the sample geometry easily installed in. In addition, the threaded grips are prefered most stuations. Some specimens are out of the standart then grips desing must be specific to the specimen.

CONCLUDING

As a result, we learned of a tensile testing machine is used for what purposes. Knowledge of the mechanical properties of materials for design issues vital it realized. For this purpose the development of materials technology improve machines capable of measuring to describe them is obvious. We read the devolopment of tensile test machines since 16th Century. Today, there are high tech automatic machines provided sofware and included robot control in order to installitiaiton a specimen. In this way, more than one test machine run at the same time.

We examined would be looking for a tensile test machine when design. Alignment, and sample load is causing the unwanted part and we saw that we pay attention to avoid them. We touched on the design of the grips and found that the designs are different grips for different specimens. Machine stiffness touched on the topic. Deformation of the specimen during testing machine parts while the machine is also seen on the deformations. We saw the value of stiffness is important in the knowledge of the results of this machines. We have considered the other affecting the speed of tensile tests. Stress and strain rate issues examined values by the standards. How many types of sensors types and these sensor what purpose used and studied. There are sensor as alternatively of avoid sensors have touched on that. Obtained datas by the sensors read by the computer automatically calculated by special software.

Finally, we desing a tensile testing machine capacity of 5tonf (50kN), and thanks to a company that sponsors have produced this machine. We desinged and produced the grips. Eletronik card is put into making the electrical panel. This card is provided to control his computer to the machine.

ACKNOWLEDGEMENT

I owe a great many thanks to a great many people who helped me and supported me during this project.

My deepest thanks to Supervisor Doç.Dr. Bülent Ekici the Guide of the project for guiding and correcting various documents of mine with attention and care.

My deep sense of gratitude to Halidun Mumcu and Abdulmuttalib Tezcan, Merkon Makina support and guidance. Thanks and appreciation to helpful people at Merkon Makina, for their support.

I would also thank my faculty members without whom this project would have been a distant reality. I also extend my heartfelt thanks to my family and wall wishers.

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APPENDIX

APP.1: TECHNICAL DRAWINGS OF THE MACHINE

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		17.05.2012	
CHK'D				Assem1_tensile_test_machine
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

SCALE: 1:20

SHEET 1 OF 1

A4

R100
400
120
448
400
120
90
Ø60
112
311
573
990
103
100
30
Ø95
Ø10
302
1820
Ø40
40
105
20
830
50

ITEM NO	PART NUMBER	QTY.
1	şase	1
2	tabla	1
3	alt_köprü	1
4	orta_köprü	1
5	üst_köprü	1
6	klavuz_mili	2
7	HS_boru	1
8	HS_arka_kapak	1
9	HS_ön_kapak	1
10	HS_piston	1
11	HS_rod	1
12	HS_flans	1
13	HS_somun	1
14	bağlantı_somunu	1
15	orta_köprü_somunu	2
16	hidrolik_ünite	1
17	linear_rule_inner	1
18	linear_rule_outer	1
19	Stonf_loadcell	1
20	Assem1_çene_v3	2
21	şase_yan_kapak	2
22	şase_arka_kapak	1
23	şase_ön_kapak	1
24	klavuz_mili_somun	4
25	Assem2_klavuz_mili_yatağı	2
26	loadcell_civata_M24x2.0	1
27	klavuz_mili_yatak_civata_M10x1.25	8
28	klavuz_mili_yatak_somun_M10x1.25	8
29	alt_köprü_civata_M14x1.5	8
30	alt_köprü_somun_M14x1.5	14
31	HS_flans_civata_M14x1.5	6
32	linear_cetvel_civata_M8x1.0	2
33	plaket	1
34	tabla_civata_M10x1.25	8
35	çeyrek_parmak_hortum	1
36	çeyrek_parmak_hortum_2	1

Assem1_tensile_test_machine_exploded

A4

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	
CHK'D				hidrolik_ünite
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

SCALE: 1:5   SHEET 1 OF 1   A4

40

Ø115

32

112

80

50

M24x2.0

1 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	5tonf_loadcell
CHK'D				
APP'VD				
MATERIAL				SCALE: 1:2
WEIGHT				
NOTE				

SHEET 1 OF 1

A4

0-175mm stroke length

15 281 53

Ø38 Ø8 Ø10 Ø10

1 adet

APP.2: TECHNICAL DRAWINGS OF THE CHASSIS

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	şase
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:10
WEIGHT				
NOTE				

SHEET 1 OF 1   A4

4

560

710

1 adet

	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	şase_arka_kapak		
CHK'D						
APPV'D						
MATERIAL				SCALE: 1:10	SHEET 1 OF 1	A4
WEIGHT						
NOTE						

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	şase_ön_kapak
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:10
WEIGHT				
NOTE				

SHEET 1 OF 1 A4

4

340

710

2 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	şase_yan_kapak
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:10
WEIGHT				
NOTE				

SHEET 1 OF 1   A4
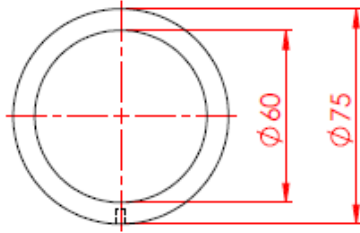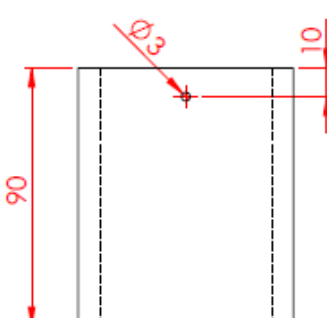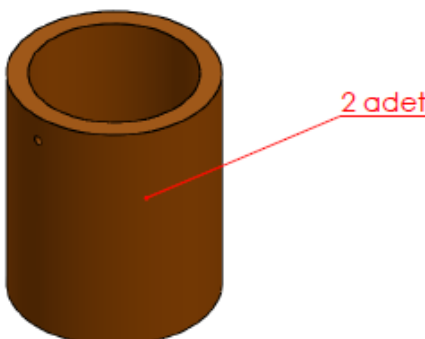
APP.3: TECHNICAL DRAWINGS OF THE GUIDE SHAFT

600

300

280

140

200

400

8x Ø15

71

6xHavşa M Ø15

Ø38

90

71

20

Ø 40,2

80

Ø 100

Ø 135

Ø 100

8xHavşa M Ø 10

80

20

20

1 adet

	NAME	SIGNATURE	DATE	TITLE:			
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	tabla			
CHK'D							
APPV'D							
MATERIAL				SCALE: 1:10		SHEET 1 OF 1	A4
WEIGHT							
NOTE							

400

60

120

20

80

Ø45,2

Ø24

Ø45,2

12xR20

140

280

90

1 adet

400

8xØ25

Ø200

8xØ15

Ø70

Ø50

Ø50

120

60

71

140

71

280

11

40

1 adet

M39x2.0

30

Ø45

115

Ø60

1050

835

100

60

45

M39x2.0

2 adet

Ø65

Ø75

Ø95

Ø3

10

90

100

2 adet

Ø60
Ø75

Ø3
10

90

2 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	klavuz_mili_yatak_princi
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:2
WEIGHT				
NOTE				

SHEET 1 OF 1   A4

120

Ø125

120

88

Ø95

88

4xØ12

13

2 adet

120

120

4xØ12

Ø95
Ø75
Ø60

100

13

2 adet

	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012			
CHK'D				Assem2_klavuz_mili_yatağı		
APPV'D						
MATERIAL						
WEIGHT				SCALE: 1:2	SHEET 1 OF 1	A4
NOTE						

400

88

8×⌀12

⌀60

⌀96

⌀125

⌀96

120

60

88

140

280

10

20

M8×1.0

30

1 adet

80

M24x2.0

26

90

55

M60x1.5

M39x1.5

1 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	bağlantı_somunu
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:2
WEIGHT				
NOTE				

SHEET 1 OF 1   A4

98,150

85

M60x1.5

15

2 adet

82

APP.4: TECHNICAL DRAWINGS OF THE WEDGE GRIP

2 adet

Ø24
Ø36
Ø57
Ø60
Ø50
Ø39
Ø35

40
Ø10
7
21

30
21
4
60
5
95
228,8

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		17.05.2012	
CHK'D				Assem1_çene_v3
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

SCALE: 1:2   SHEET 1 OF 1   A4

ITEM NO.	PART NUMBER	QTY.
1	çene_sase_v3	1
2	çene_yuvarlak_papuc_sag_v3	1
3	çene_yuvarlak_papuc_sol_v3	1
4	çene_kama_v3	1
5	çene_üst_somun_v3	1
6	çene_iç_mil_v3	1
7	çene_papuc_başı_v3	1
8	çene_tırnak_v3	2
9	çene_sase_üstü_vida	1
10	çene_tutucuları_v3	2
11	çene_yaylı_pul	1
12	çene_bağlantı_somunu	1
13	çene_vida_M5x0.8	4

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		17.05.2012	
CHK'D				
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

TITLE: Assem1_çene_v3_exploded

SCALE: 1:10   SHEET 1 OF 1   A4

DETAIL D
SCALE 1 : 1

DETAIL E
SCALE 1 : 1

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		17.05.2012	çene_sase_v3
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:2
WEIGHT				
NOTE				

2 adet

SHEET 1 OF 1   A4

86

Ø39
Ø30
Ø10

M39x2.0

52

20

35

Ø35

2 adet

	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	çene_sase_üstü_vida		
CHK'D						
APPV'D						
MATERIAL				SCALE: 1:1	SHEET 1 OF 1	A4
WEIGHT						
NOTE						

Ø24
Ø35

M24x2.0

70
58
5
60°
175
Ø10
82
Ø2
5

2 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	çene_iç_mil_v3
CHK'D				
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

SCALE: 1:1   SHEET 1 OF 1   A4

Ø60
Ø24
10

2 adet

M8x1.0
Ø24
7.500
15
8
Ø35
60
40
37
M39x2.0
Ø50

15

8

Ø10

M8x1.0

10

75

4 adet

$\emptyset\,57$

$\emptyset\,29$

4,483

3

2 adet

26,533

1

4

2

30°

27,559

55°

M5x0.8

42,567

13

5

5

10

10

40

40

2 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	çene_yuvarlak_papuc_sag_v3
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:1
WEIGHT				
NOTE				

SHEET 1 OF 1

A4

	NAME	SIGNATURE	DATE	TITLE:			
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	çene_yuvarlak_papuc_sol_v3			
CHK'D							
APPV'D							
MATERIAL				SCALE: 1:1		SHEET 1 OF 1	A4
WEIGHT							
NOTE							

70°

50

10

5

2 adet

94

40

Ø7

20

40

20

2xR5

Ø2

5

10

7

2 adet

95

19

2x Ø5

R5

37,588

7,048

70°

7,500

15

20

40

46,840

10

45°

5

4 adet

36

M24x2.0

41,569

21

2 adet

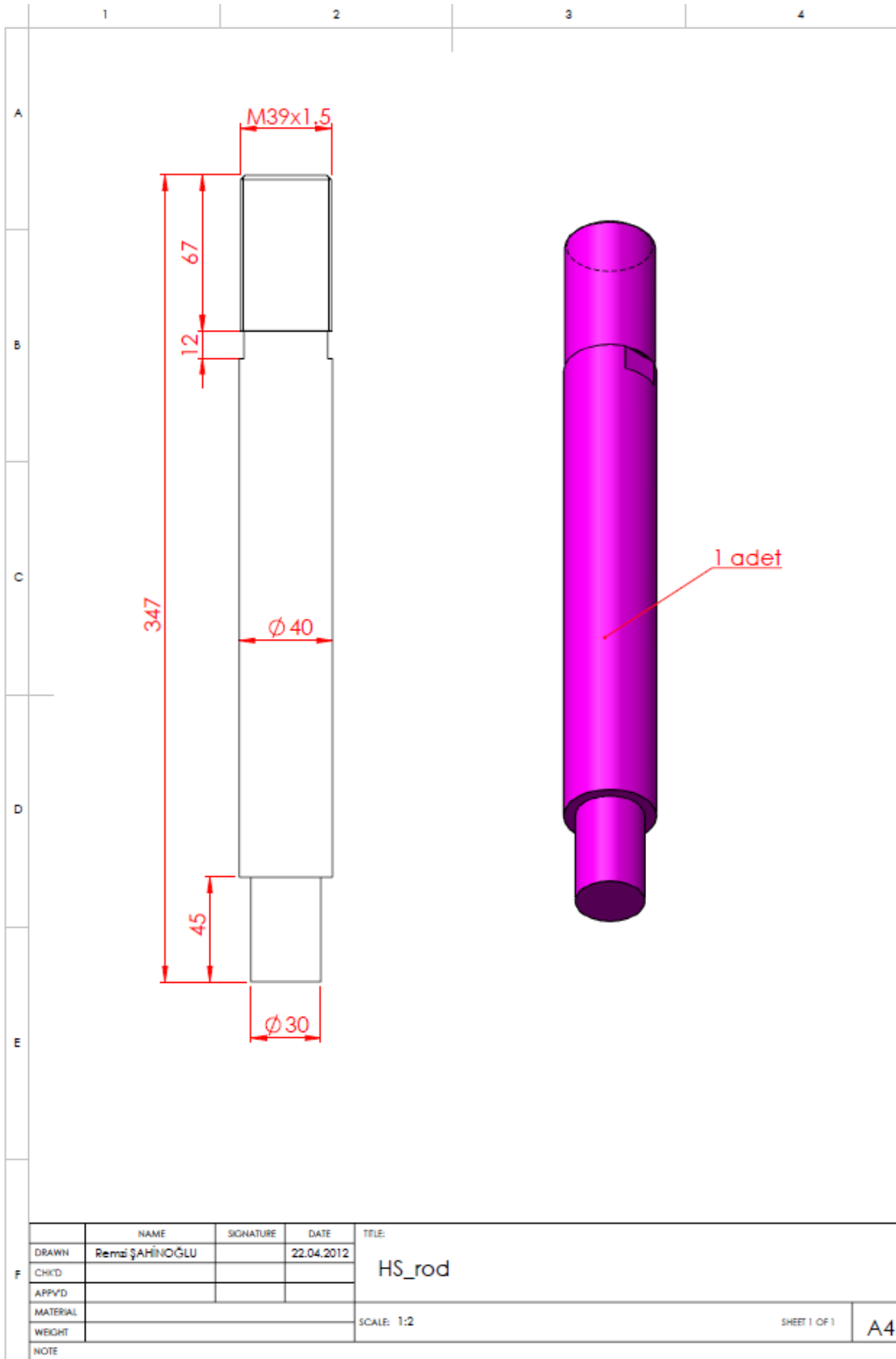|	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	çene_bağlantı_somunu
CHK'D				
APPV'D				
MATERIAL				
WEIGHT			SCALE: 1:1	SHEET 1 OF 1
NOTE				A4

97

APP.5: TECHNICAL DRAWINGS OF THE HYDRAULIC CYLINDER

Ø165

296,600

195

82,557

0-150mm stroke

Ø95

1 adet

	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	HS_150mm_Strok		
CHK'D						
APPV'D						
MATERIAL				SCALE: 1:2	SHEET 1 OF 1	A4
WEIGHT						
NOTE						

ITEM NO.	PART NUMBER	QTY.
1	HS_boru	1
2	HS_rod	1
3	HS_flans	1
4	HS_piston	1
5	HS_ön_kapak	1
6	HS_arka_kapak	1

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		24.04.2012	
CHK'D				
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

TITLE: HS_150mm_Strok_exploded

SCALE: 1:5   SHEET 1 OF 1   A4

100

Ø95
Ø93
Ø80
15
52
256,600
45°
4

1 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	HS_boru
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:2
WEIGHT				
NOTE				

SHEET 1 OF 1   A4

6x Ø15

Ø135

Ø93
Ø165

15

1 adet

	NAME	SIGNATURE	DATE	TITLE:			
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012				
CHK'D				HS_flans			
APPV'D							
MATERIAL				SCALE: 1:2		SHEET 1 OF 1	A4
WEIGHT							
NOTE							

40

5,800

4,200

20

⌀79,400

⌀76

⌀65

1 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	HS_piston
CHK'D				
APPV'D				
MATERIAL				SCALE: 1:2
WEIGHT				
NOTE				

SHEET 1 OF 1   A4

103

M39x1.5

67

12

347

Ø40

1 adet

45

Ø30

	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012			
CHK'D				HS_rod		
APPV'D						
MATERIAL				SCALE: 1:2	SHEET 1 OF 1	A4
WEIGHT						
NOTE						

Ø95

Ø40

11

63

47

5

Ø80

1 adet

Ø12

4

45

60

Ø80

9,600

40

Ø95

45°

3

Ø12

55

1 adet

	NAME	SIGNATURE	DATE	TITLE:
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012	
CHK'D				
APPV'D				
MATERIAL				
WEIGHT				
NOTE				

HS_arka_kapak

SCALE: 1:2

SHEET 1 OF 1

A4

55

M39x1.5

15

1 adet

	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	Remzi ŞAHİNOĞLU		22.04.2012			
CHK'D				HS_somun		
APPV'D						
MATERIAL				SCALE: 1:2	SHEET 1 OF 1	A4
WEIGHT						
NOTE						

107

APP.6: G-CODES OF THE GRIP PARTS

G-CODES OF THE BLOCK of TWO:

This code is very long about 6658 line. It is added just as cycle codes. It have three cycle. First layer is down from 0 to -10mm. Second layer is -50mm and Third layer is -62mm. Block width is 60mm. Margin is 2mm for revers operation of the block. If you use this code, you will first determine your cutting height which is I used 0.25mm, then copy past the current cycle untill reach next layer, then do it same thing for other layer. Ignore the number of N codes.

First cycle:

%12 G71	N25 X-100.517 Y65	N25 X-75.640 Y49
N10 G00 G17 G90 G40	N25 X-102.517	N25 X-64.360
N11 G99 T01 L00 R0	N25 X-37.483	N25 X-61.762 Y50.50
N12 S1000 M03	N25 X-39.483	N25 X-64.360 Y49
N13 M08 Z0.0	N25 X-35.455 Y76.067	N25 X-66.754 Y42.422
N14 X0.00 Y0.00	N25 X-49.460 Y37.588	N25 X-56.654 Y0
N14 X-33.668 F200	N25 X-51.487	N25 X-42.973 Y37.588
N16 X0 Y40.124	N25 X-65.168 Y0	N25 X-34.460
N17 Y92.071	N25 X-66.319	N25 X-48.141 Y0
N18 X-12.929 Y105	N25 X-82.912 Y45.588	N49 X0
N19 X-127.071	N25 X-84.938	N52 Z-0.25
N20 X-140 Y92.071	N25 X-89.092 Y57	... (copy the 1st cycle)
N21 Y40.124	N25 X-92.156 Y59.571	N52 Z-0.50
N22 X-106.332 Y0	N25 X-89.092 Y57	... (copy the 1st cycle)
N23 X-91.859	N25 X-50.908	...
N24 X-105.540 Y37.588	N25 X-47.844 Y59.571	...
N25 X-97.027	N25 X-50.908 Y57	...
N25 X-83.346 Y0	N25 X-55.062 Y45.588	N52 Z-10.0
N25 X-74.823	N25 X-57.088	... (copy the 1st cycle)
N25 X-88.513 Y37.588	N25 X-65.743 Y21.809	
N25 X-90.540	N25 X-75.640 Y49	
N25 X-104.545 Y76.067	N25 X-78.238 Y50.50	

Second cycle:	Third cycle:
... (copy the 1st cycle)	... (copy the 2nd cycle)
N52 Z-10.25	N52 Z-50.25
N14 X-33.668 F200	N14 X-33.668 F200
N16 X0 Y40.124	N16 X0 Y40.124
N17 Y92.071	N17 Y92.071
N18 X-12.929 Y105	N18 X-12.929 Y105
N19 X-127.071	N19 X-127.071
N20 X-140 Y92.071	N20 X-140 Y92.071
N21 Y40.124	N21 Y40.124
N22 X-106.332 Y0	N22 X-106.332 Y0
N22 X-76.859	N23 X0
N22 X-100.517 Y65	N52 Z-50.5
N22 X-102.517	... (copy the 3rd cycle)
N22 X-37.483	N52 Z-50.25
N22 X-39.483	... (copy the 3rd cycle)
N22 X-63.141 Y0	...
N22 X-71.654	...
N22 X-50.544 Y58	N52 Z-62.0
N22 X-89.456	N14 X-33.668 F200
N22 X-74.257 Y16.240	N16 X0 Y40.124
N22 X-61.605 Y51	N17 Y92.071
N22 X-78.395 Y51	N18 X-12.929 Y105
N22 X-75.486 Y43.009	N19 X-127.071
N22 X-71.654	N20 X-140 Y92.071
N22 X-74.236 Y35.915	N21 Y40.124
N22 Y0	N22 X-106.332 Y0
N22 X0	N23 X0
N52 Z-10.50	N45 Z10
... (copy the 2nd cycle)	N80 M30
N52 Z-10.75	N90 M02
...	%12 G71
...	
N52 Z-50.0	
... (copy the 2nd cycle)	

G-CODES OF THE WEDGE of FOUR:

This code also very long about 2136 line. It have 2 layer. Same operation should be do like previous code operation. First layer is down to -10mm. Seconde layer is down to -42mm. The wedge width is 40mm. Margin is 2mm for revers operation of the wedge.

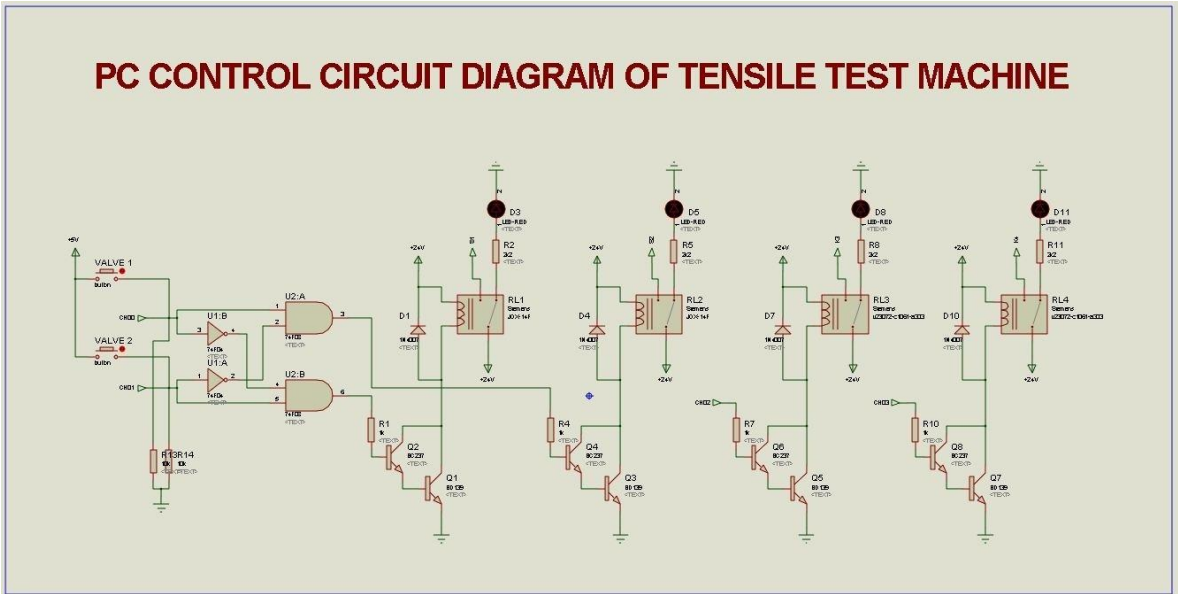| First cycle:	Second cycle:
%14 G71	... (copy the 1st cycle)
N10 G00 G17 G90 G40	N33 Z-10.5
N11 G99 T01 L00 R0	N14 Y50 F200
N12 S1000 M03	N15 X-122.401
N13 M08 Z0.0	N16 Y0
N14 X0 Y0	N17 X-61.201
N14 Y50 F200	N18 Y50
N15 X-39.700	N19 X-82.702
N16 X-21.501 Y0	N20 X-100.900 Y0
N17 X-61.201	N21 X-21.501
N18 Y50	N22 X-39.700 Y50
N19 X-82.702	N22 X-21.501 Y0
N20 X-100.900 Y0	N22 X0
N21 X-122.401	N33 Z-10.75
N22 Y50	... (copy the 2nd cycle)
N23 X0	N33 Z-11.00
N24 Y35	...
N25 X-34.24	...
N26 X-26.960 Y15	N33 Z-42.0
N27 X-95.441	N14 Y50 F200
N28 X-88.161 Y35	N15 X-122.401
N30 X-122.401	N16 Y0
N31 Y0	N17 X-61.201
N32 X0	N18 Y50
N33 Z-0.25	N19 X-82.702
... (copy the 1st cycle)	N20 X-100.900 Y0
N33 Z-0.50	N21 X-21.501
... (copy the 1st cycle)	N22 X-39.700 Y50
	N22 X-21.501 Y0
	N22 X0
	N23 Z10
	N80 M30
	N90 M02
	%14 G71

G-CODES OF THE WEDGE HOLDER of FOUR:

This code also very long about 567 line. It have 1 layer. The layer is down to -5mm.
Seconde layer is down to -42mm. The wedge width is 40mm. Margin is 2mm for revers
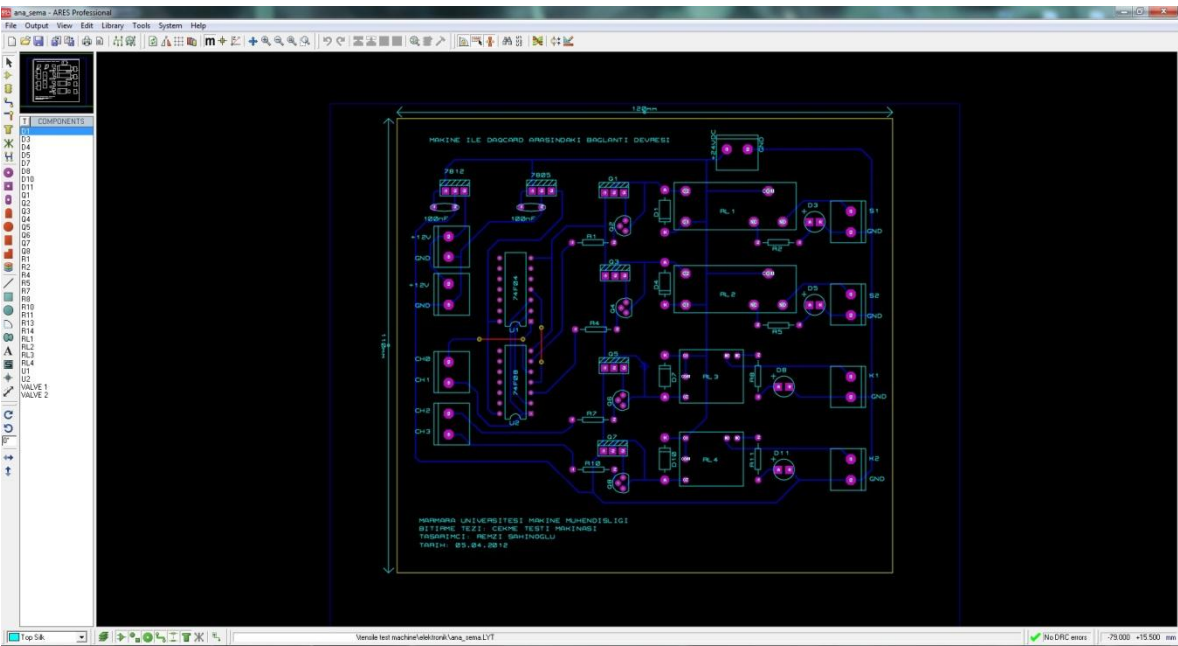operation of the wedge.

```
%14 G71
N10 G00 G17 G90 G40
N11 G99 T01 L00 R0
N12 S1000 M03
N13 M08 Z0.0
N14 X0 Y0
N14 X-2.397
N14 X3.878 Y8.963
N14 X-10.180 Y47.59
N14 X-58.203
N14 X-65.483 Y67.588
N14 X-1.201
N14 X-8.481 Y47.589
N14 X-59.785
N14 X-67.469 Y36.613
N14 X-54.143 Y0
N14 X-33.038
N14 X-26.763 Y8.963
N14 X-40.821 Y47.588
N14 X-29.143
N14 X-36.827 Y36.613
N14 X-23.501 Y0
N14 X0
N15 Z-0.25
... (copy the cycle)
N15 Z-0.5
...
N15 Z-5.0
...
N14 X0
N23 Z10
N80 M30
N90 M02
%14 G71
```

APP.7: ELECTRONIC CIRCUIT DIAGRAMS

ELECTRONIC CIRCUIT DIAGRAM

PRINTED CIRCUIT DIAGRAM

APP.8: ELECTRIC TERMINAL CONNECTION

Tensile Test Machine

Remzi ŞAHİNOĞLU

114

ANA GIRIS

HIDROLIK MOTORU

ACIL STOP GIRIS 24VDC
ACIL STOP CIKIS
BUTON GIRIS ORTAK UC
BUTON 1 ASAGI
BUTON 2 YUKARI
VALF ORTAK UC 0VDC
VALF 1 ASAGI
VALF 2 YUKARI
PC VALF 1
PC VALF 2
PC ORTAK UC 0VDC

Remzi ŞAHİNOĞLU

Scale FULL

A3

PRODUCT INDEX

Drawn by
Date
Checked
Date

TITLE

Tensile Test Machine

Project: micro1

Print Date

Drg No. 2

Sheet 2 of

Rev 00

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