Design and Development of Wire Electric Discharge Machine

Under The Valuable Guidance Of

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(SRPEC)

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Group No:-09

OUTLINE

- Introduction
- Principle of WEDM
- Literature Review
- Research Gap
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- Industrial Survey
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- Project Model & Market Machine Specification
- Machine setup
- Conclusion
- Project Planning and Scheduling

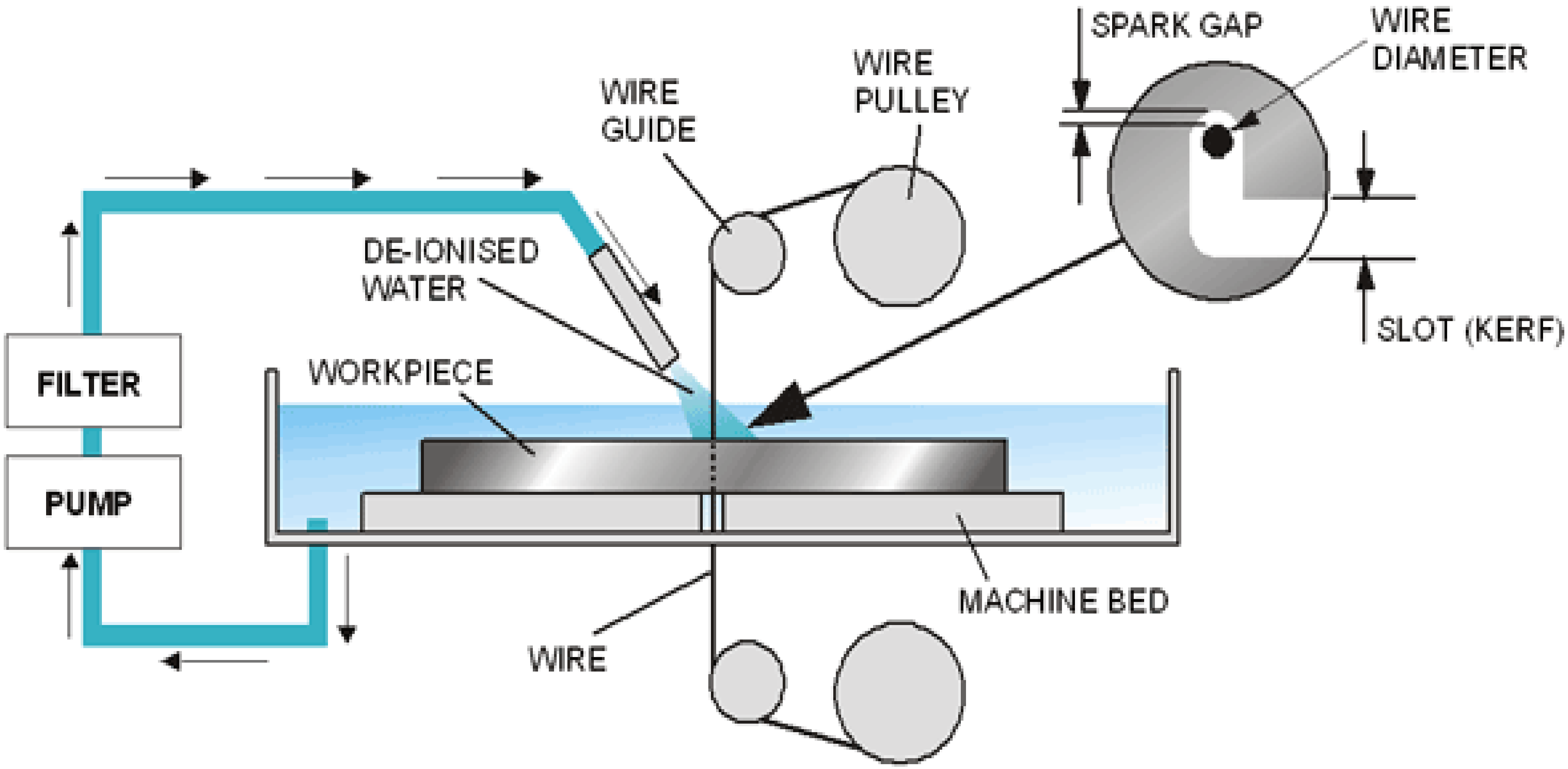
INTRODUCTION

- WEDM uses thermal erosion process for material removal from the work piece. The effect is produced when electric sparks are generated between the work piece and a wire.
- Wire-cut EDM is typically used to cut plates and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.
- Wire electrical discharge machining (WEDM) is widely used in machining of conductive materials when precision is considered as a prime importance.
- We can easily cut the complicated shapes with the help of wire cut electric discharge machine.
- The accuracy of this machine is very high.

PRINCIPLE OF WEDM

- In wire cut EDM, the conductive materials are machined with a series of electrical discharges(spark) that are produced between wire and work piece.
- High frequency pulses of alternating or direct current is discharged from wire to the work piece with a very small spark gap through an insulated dielectric fluid.

WEDM working process



Literature Review

➢Kumar et.al.(July-Aug 2014)

- Study about various features of WEDM and improvement from the past to recent improvements in manufacturing processes.
- Also about a better understanding and basic overview of fundamentals, features and pratical uses WEDM.

➢Marigoudar et.al.(2014)

- Study on work on behavior of zinc- aluminium alloy rain forced with silicon carbide particles with WEDM.
- It observed that applied current and pulse on time increases the MRR where as pulse off time has less effect on it.

➢R.Ramakrishnan et.al.(2014):

- Their study applied the Taguchi’s method which is one of the methods of robust design and to optimize multi responses of WEDM.
- Each experiment was conducted under different cutting condition of pulse on, pulse off time, wire tension, delay time, wire feed, speed etc.

➢H.V.Ravindrab et.al.(2014):

- The minimization of the machining performance measurement such as ace roughness (Ra) mustbeformulated in the standard mathematical model.
- While AI based models are developed using nonconventional approaches such as Artificial Neural Network.

➢Anand Sharmaa et.al.(2012):

- Experimental results have shown the feasibility and validity of the power supply and control system.

➢Y-S. Liaoa et.al.(2013):

- The result of the experiments proved that an accurate on-line estimation of workpiece height is attainable.
- The electrical discharges developed between the tool electrode and the workpiece, parts having various contours could be detached from a plate workpiece.

➢Zahid A. Khana et.al.(2012):

- WEDM process has been a key process for the tooling and manufacturing industry. WEDM was introduced in the late 1960s', In WEDM, material is removed by means of rapid and repetitive spark discharges across the gap between the tool and the workpiece

➢G. Domek et.al.(2011):

- Modern timing belts should not only be durable or effective but also safe for users and their environment. While designing timing belt much attention should be paid to selection of materials, which have significant influence on mechanical properties of belts. Design of composites and usage of new polymer materials allows for improvement of constructional properties of belts. Depending on application: transmission, conveying or controlling, is different meshing in gear. The work presents meshing model between timing belt and pulley and in it constructional features of transmission timing belts depending on materials used for their production.

Research Gap

- Different types of work is carried out on WEDM like analysis of different parameters.
- And also other work is carried out on the optimization of this process.
- The improvement in some fields in this process like reduction of cost, design of machine and wire feed mechanism.

SCOPE OF PROJECT

- Our main purpose is use in college laboratory for students practical knowledge.
- Use in Small Scale Industries.

PROJECT OBJECTIVE

- Design of wire cut electrical discharge machine
- Development of wire cut electrical discharge machine
- To reduce the size of machine.
- To significant reduction in the cost of machine.

WORK-FLOW OF THE PROJECT

Start

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Literature Review

↓

Industrial Survey

↓

Pre-experimental Work

↓

Manufacturing of Different Machine Part

↓

Design all Components of Machine in Design Software

↓

Assembly

↓

Apply Automation in EDM

↓

Experimental Work

↓

Result Analysis Discussion

↓

Conclusion

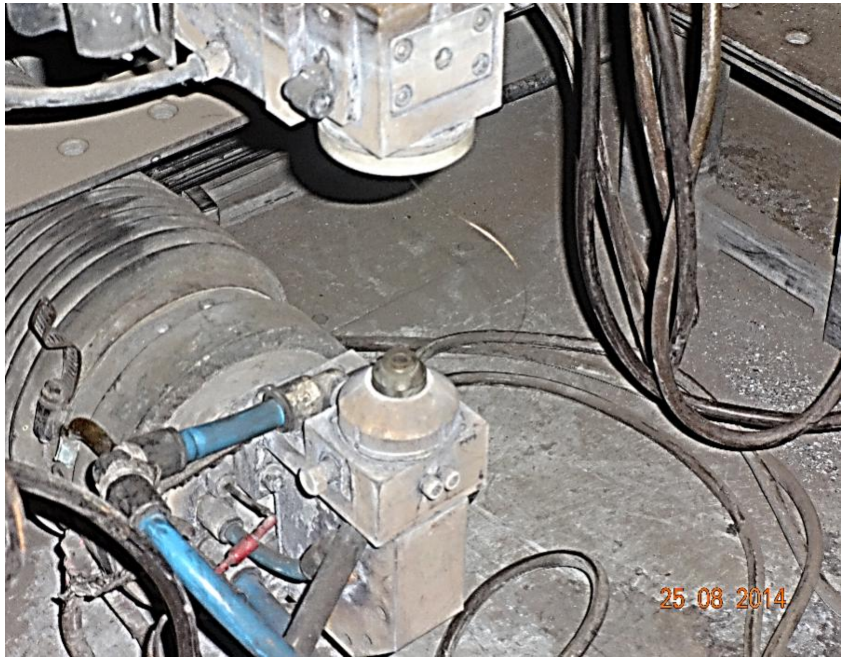
IMPORTANT PARAMETERS OF WEDM

Parameters	Range	Units
Pulse on time	16,32,48	µs
Pulse off time	4,8,12	µs
Wire Feed Rate	47,11.2	m/s
Peak Current	3,5,7	Amp
Voltage	20,30,40	volts
Wire Tension	2,3,4	kg-f
Wire Feed Rate	4,5,6	m/min
Wire Diameter	0.18,0.25	mm
Flushing Pressure Of Dielectric	2,3,4	Kg/cm^2

Industrial Survey

VISIT OF INDOGERMAN AND CIPET

- At CIPET and INDOGERMAN we show Electric Discharge Machine working model. We show different component of machine and discuss about it.
- We show different work piece which are already machined on EDM.



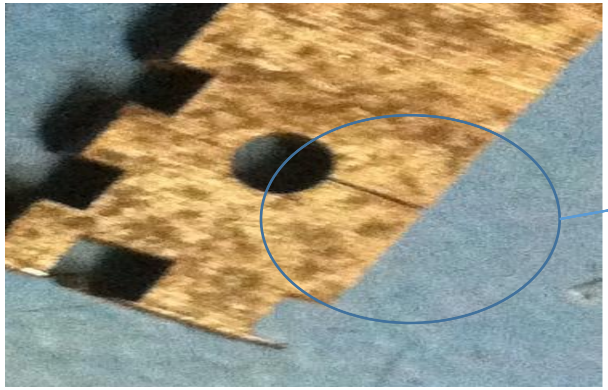
WIRE CUT ELECTRIC DISCHARGE MACHINE

Visit Of the GEC Patan

Electric circuit

Wire Roll

Lubrication Pump, Filter and Tank



Initial gap of 1 mm for insertion of the wire

Cross sectional view of the part

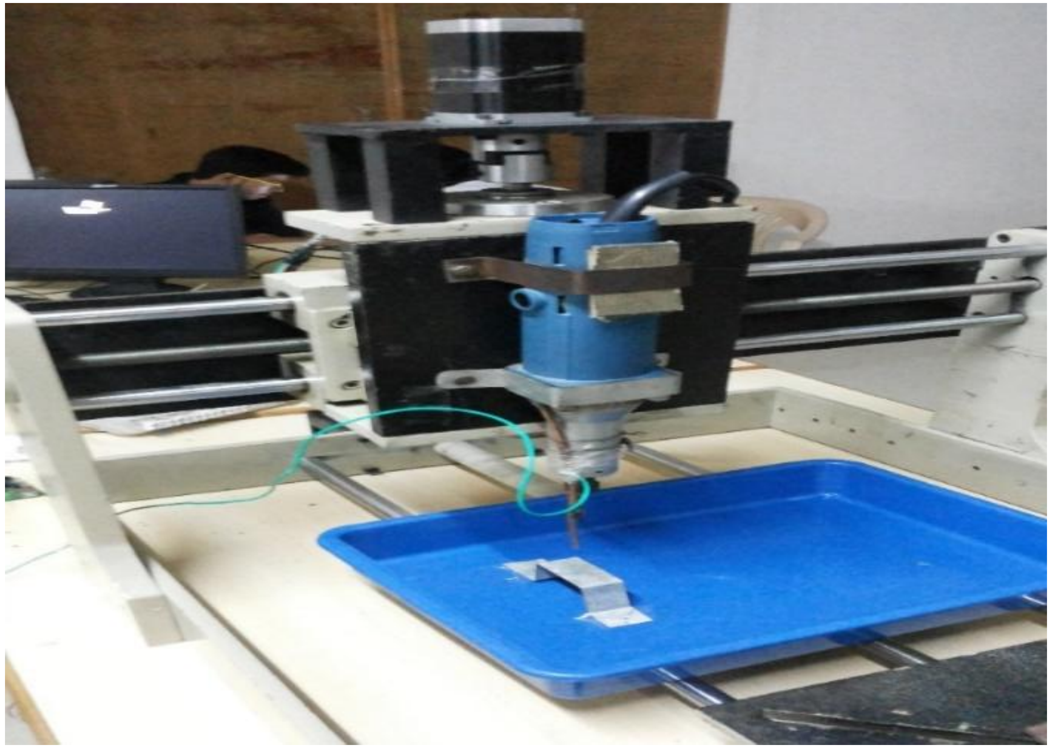
Different complicate shapes can be achieved

Reference of : Rakesh Patel(Work Shop In charge – GEC, Patan)

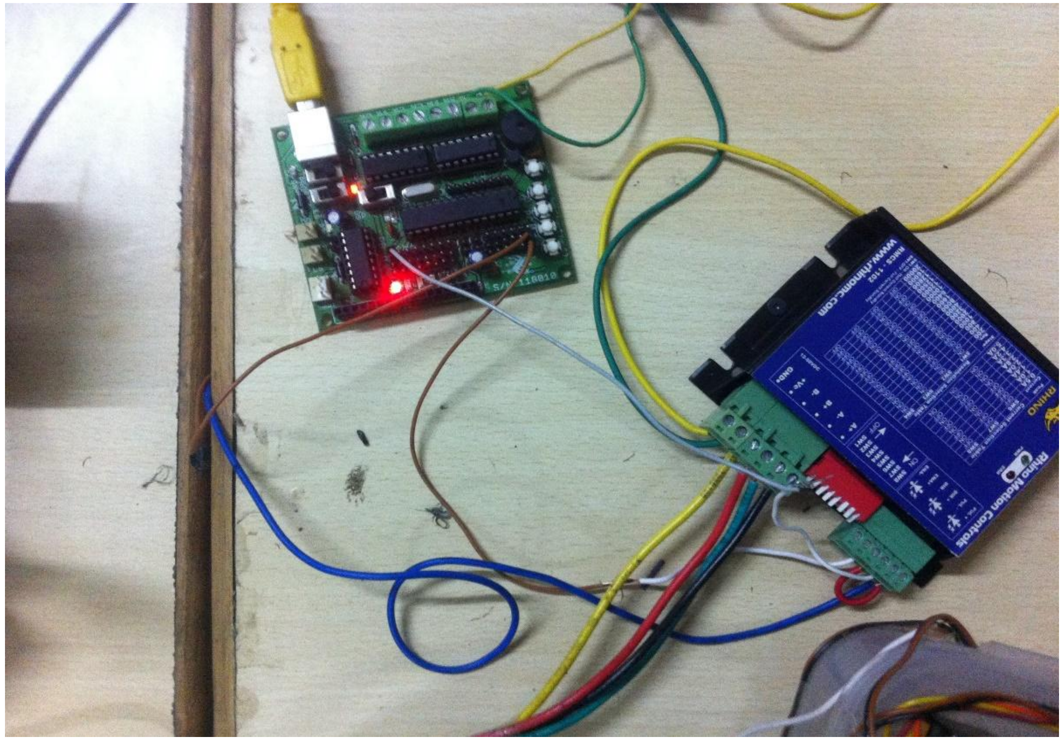
PRE-EXPERIMENT WORK ON METAL SHEET

In our college we experiment on 1mm galvanize iron sheet. We try to cut and make a hole by using 3 mm diameter copper rod. According to experimental set up we arranged all the equipment. By changing different input parameters like voltage, current, pulse on-off time and take an output parameters reading.

Operation or Work	Parameter
Material which cut	Galvanized Iron
Material for Rod	Copper
Diameter of the Rod	3mm
Applied Voltage	35 volt
Applied current	3 Amp



[Pre-Experimental Set-up]

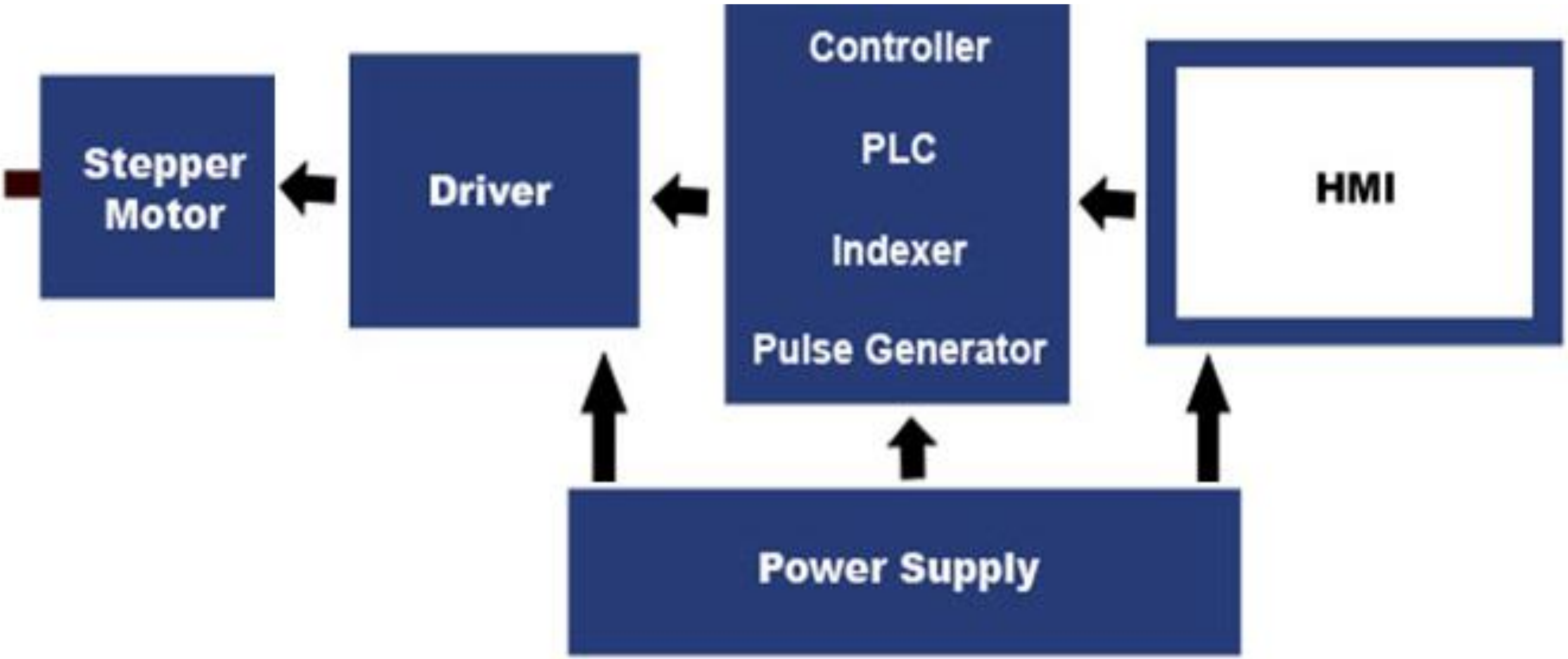


[Experimental set up of Drive and Controller]

PROJECT MODEL SPECIFICATION

Sr. No	Name	Dimensions
1	Machine Outside Dimensions:	6750mm * 1020mm * 450mm
2	Working Table Dimensions:	620mm*620mm*50mm
3	X Axis Travel	100mm Dia. 12mm Guide
4	Y Axis Travel	200mm Dia. 8mm Guide
5	Wire diameter:	0.25 mm
6	Special water bath	180 mm
6	Coupling	Love –Joy Coupling
7	Main Materials of Machine	Mild Steel
8	X axis accuracy	0.005
9	Y axis accuracy	0.005
10	Machine weight:	126 kg

Machine Setup



WEDM EQUIPMENTS

SR NO.	There are different parts are used in WEDM are as under:		
1.	Basic Structure (Frame, Body)	9.	V-pulley
2.	X direction-table	10.	Bearings
3.	Y direction-table		
4.	Stepper Motor		
5.	Wire		
6.	Wire Drum		
7.	Lead Screw		
8.	Guide Way		

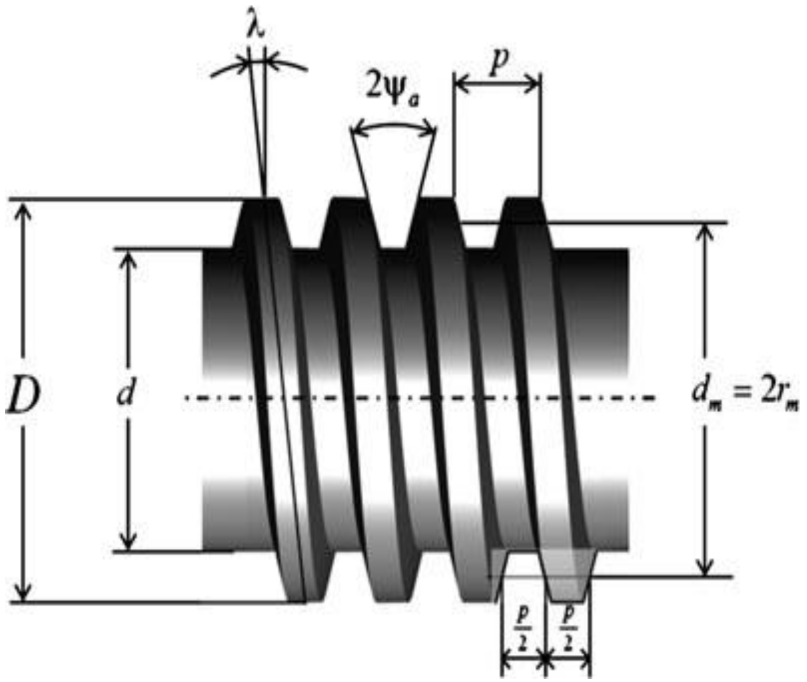
MAJOR COMPONENTS

Work-piece	All the conductive material can be worked by WEDM.
Tool Wire	The WEDM wire is the tool that determines the shape of the cavity to be produce.
Dielectric fluid	The WEDM setup consists of tank in which the dielectric fluid is filled. Electrode & work piece submersed into the dielectric fluid.
Servo system	The servo system is commanded by signals from gap voltage sensor system in the power supply and control the feed of electrode & work piece to precisely match the rate of material removal.
Power supply	The power supply is an important part of any EDM system. It transform the alternating current from the main utility supply into the pulse direct current (DC) required to produce the spark discharge at the machining gap.

- The **DC pulse generator** is responsible for supplying pulses at a certain voltage and current for specific amount of time.

Vertical or Horizontal Application:

ST – Screw type, ball or acme
e – Efficiency of screw %
μ_s – Friction coefficient
L – Length of screw inches
D – Diameter of screw inches
P—Pitch threads/inch
W – Weight of load lbs.
F—Breakaway force ounces
Directly coupled to the motor? Yes
CT –Love-joy Coupling



Lead Screw Dimension

Model	Lead Screw	
Axis Name	X	Y
Diameter(mm)	8	20
Pitch(mm)	1	1.5

LEAD SCREW DESIGNS

A stepper motor is a small brushless synchronous electric motor that can divide a full rotation into a large number of steps. If it is electronically connected to the MCU, the motor's position can be controlled with precision without any feedback mechanism.

[Stepper Motor]

DRIVE ACCURACY

Step Available on Drive (Rev.)	Increment per One Step (mm) for 1mm pitch
200	0.005
400	0.0025
800	0.00125
1000	0.001
2000	0.0005
3200	0.0003125
4000	0.00025
8000	0.000125
1600	0.000625
6400	0.00015625
10000	0.0001
12000	0.000083333
12500	0.00008
12800	0.000078125
16000	0.0000625
20000	0.00005

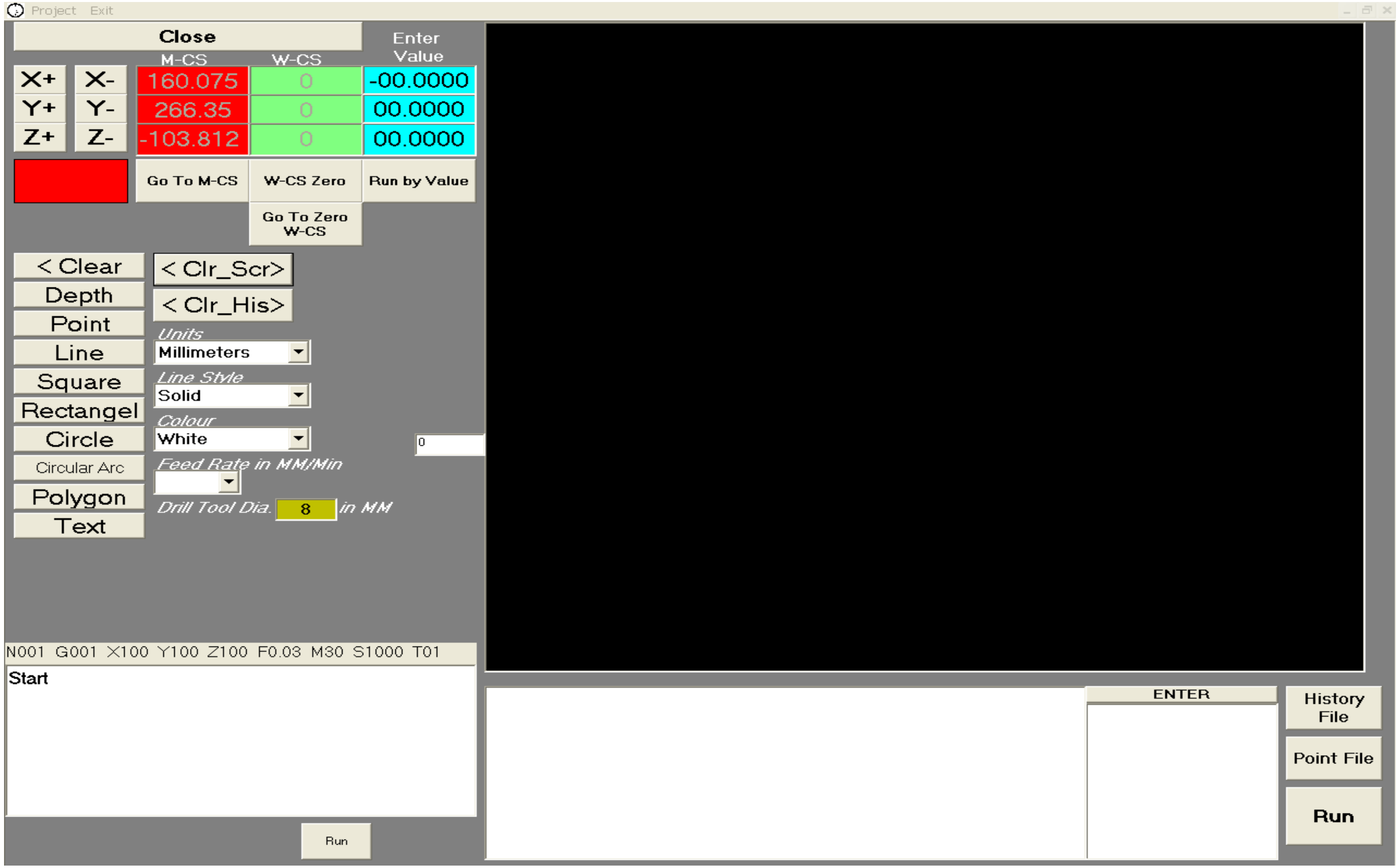
Step Available on Drive (Rev.)	Increment per One Step (mm) for 1.5mm pitch
200	0.0075
400	0.00375
800	0.00187
1000	0.0015
2000	0.00075
3200	0.00046
4000	0.00037
8000	0.00018
1600	0.00093
6400	0.00023
10000	0.00015
12000	0.00012
12500	0.00012
12800	0.00011
16000	0.00009
20000	0.00007

SOFTWARE

- Low cost, home and small business CNCs require at least one software package to operate. This is the basic package which allows the user to open a graphics file and command the system to machine the part.
- The hand-made software is developed in the visual basic 6.0.

VISUAL BASIC 6.0

It is a very easy programming language to learn. The code looks a lot like English Language. Different software companies produced different versions of BASIC, such as Microsoft QBASIC, QUICKBASIC, GWBASIC, and IBM BASICA and so on. However, people prefer to use Microsoft Visual Basic today, as it is a well-developed programming language and supporting resources are available everywhere. Now, there are many versions of VB exist in the market, the most popular one and still widely used by many VB programmers is none other than Visual Basic 6.



Hand-made software

C. Design Considerations for feed drive mechanism

(1) Design of Lead Screw

The lead screw selected for our purpose is of following characteristics according to IS: 4218 (Part III) 1976 [11].

a) Screw Starts: This is the number of independent threads on the screw shaft. The lead screw selected here is a single start. For a single start screw, lead & pitch are the same.

b) Pitch: It is the distance along the screw axis from a point on one thread to a corresponding point on the
adjacent thread. Here pitch =1mm

c) Lead: It is the distance the nut advances along the screw in one revolution.

Lead= pitch x number of starts

$=1 \times 1$

=1mm

d) Major Diameter =d= 8 mm
e) Minor (core) Diameter = dc=6 mm
f) Direct compressive stress due to axial load:
The body of a screw is subjected to an axial force Wand torsional moment (T).
The direct compressive stress σc is given by,
$\sigma c = W/[(\pi/4)\times dc2]$
Maximum axial load induced by the stepper motor (W)
= 245.25N
$= (245.25\times4) / (\pi\times6^2)$
σc= 8.67 MPa

g)Shear Stress Due to motor torque:

The torsional shear stress is given by,

$\tau=16T/ (\pi\times dc^3)$

Here T= motor torque= 25 kg.cm =0.43164 Nm

$= (16\times25) / (\pi\times6^3)$

= 0.589 MPa

h) To find the principal stresses

Maximum principal stress (tensile or compressive)

$\sigma c(max)=1/2[\sigma c+\sqrt{(\sigma c2+4\tau 2)}]$

$=0.5[8.67+\sqrt{(8.67^2 +4\times0.589^2)}]$

= 8.70 MPa.

i) Maximum shear stress

$\tau(max)=1/2[\sqrt{(\sigma c2+4\tau 2)}]$

$=0.5[\sqrt{(8.67^2 +4\times0.589^2)}]$

= 4.37 MPa

j) Check for Safety

Assume Factor of safety, S_f =2, for steel material and subjected to external static forces (1.5 to 2 based on yield strength
of material

$(\sigma_c)_{all} = S_{yc}/S_f$

Where, S_{yc}= yield strength =250 MPa (for steel lead screw)

= 250/2

$(\sigma_c)_{all}$ =125 Mpa

As $(\sigma_c)_{all} >> \sigma_c$ (max)

Lead screw is safe

Allowable Shear stress is given by,

$\tau_{all}=S_{sy}/S_f$

Where, S_{sy} =Yield strength in shear =0.5 S_{yc}

= 125/2

τ_{all} =62.5 MPa

As $\tau_{all} >> \tau_{max}$,

Lead screw is safe in Shear.

2) Design of Nut

Major Diameter =d= 8 mm

Core Diameter = dc=6.6472 mm

a) Height of Nut (H)

The bearing pressure between the contacting surfaces of the screw and the nut is an important consideration in design.

Therefore,

Pb=W/ [(π/4) × (d2 - dc2) ×n]Where, Pb = unit bearing pressure (N/mm^2)

n = Number threads in contact

0.085=10×4 /[π × (82-6.6472) ×n] (Assume Pb= 0.085 MPa for nut)

n= 7.56 = 8

Height of nut, h = n × p

Where p = Pitch of threads

h = 8×1.25

h=10 mm

b) Check for the stress in the nut

The threads of the screw which are engaged with the nut are subjected to transverse shear stresses. The screw will

tend to shear off the threads at the core diameter under the action of load W. The shear area of one thread is $\pi d_c t$. The

transverse shear stress in the screw is given by,

$\tau(nut) = W / \pi n d t$

Where, t = Thickness of screw = p / 2=1.25/2=0.625mm

$= 10 / (\pi \times 8 \times 8 \times 0.625)$

$\tau_{nut} = 0.0796$ MPa

As $\tau_{all} >> \tau_{nut}$ Nut is safe.

Tension Formula

W = Weight of the body,
m = mass of the body,
a = acceleration of the moving body
If the body is moving upward the tension would be T = W + ma
If the body is moving downward the tension would be T = W - ma
If the tension is equal to weight of body T = W.

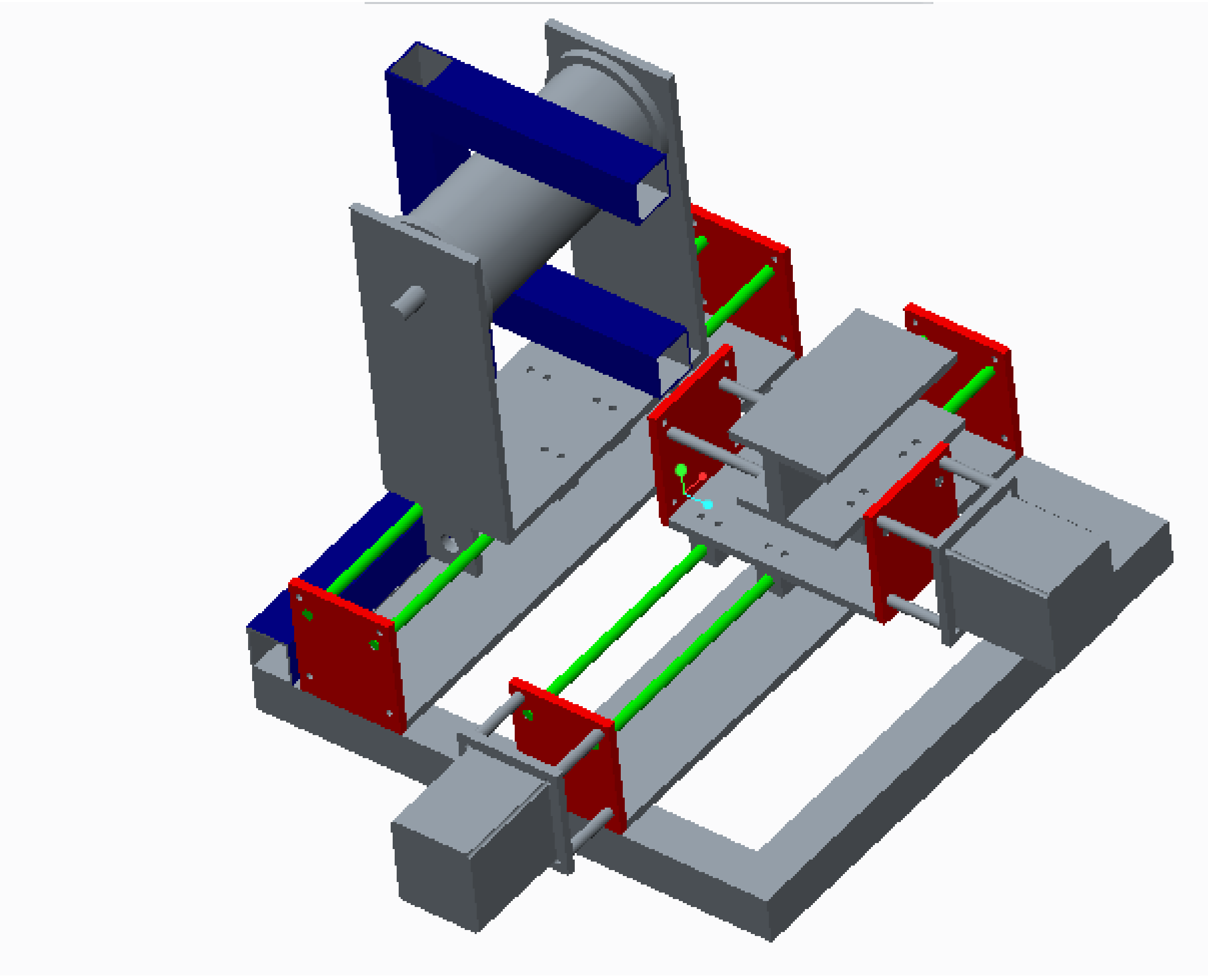
$$T = W \pm ma$$

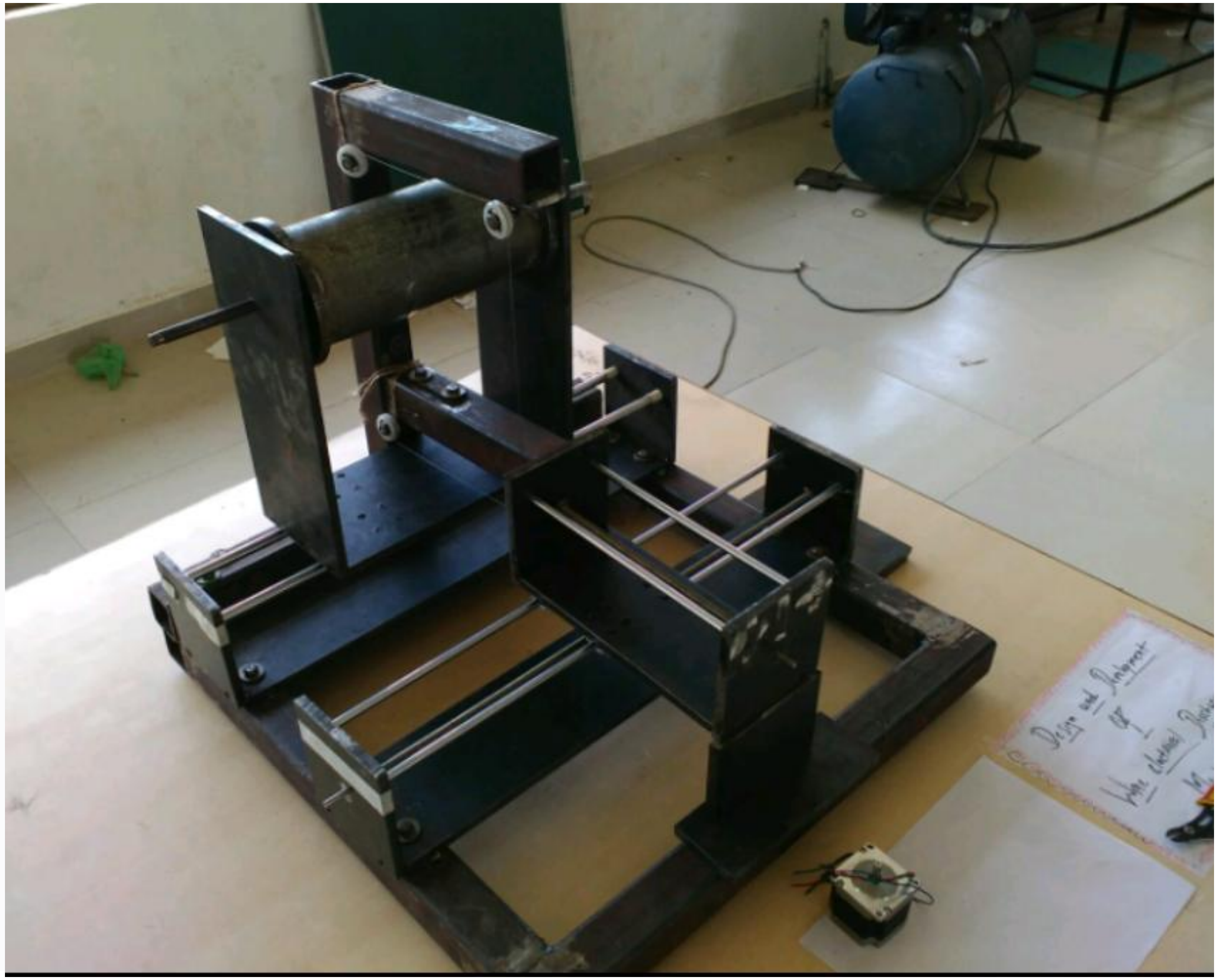
- **Tension Formula** is used to find the tension force acting on any body. It is helpful in problems. Tension is a force so it is expressed in **Newton's (N)**

- The density of mild steel is **approximately 7.85 g/cm^3** (**7850 kg/m^3** or 0.284 lb/in^3) and the Young's modulus is 210 GPa (30,000,000 psi). Low-carbon steels suffer from yield-point run out where the material has two yield points.

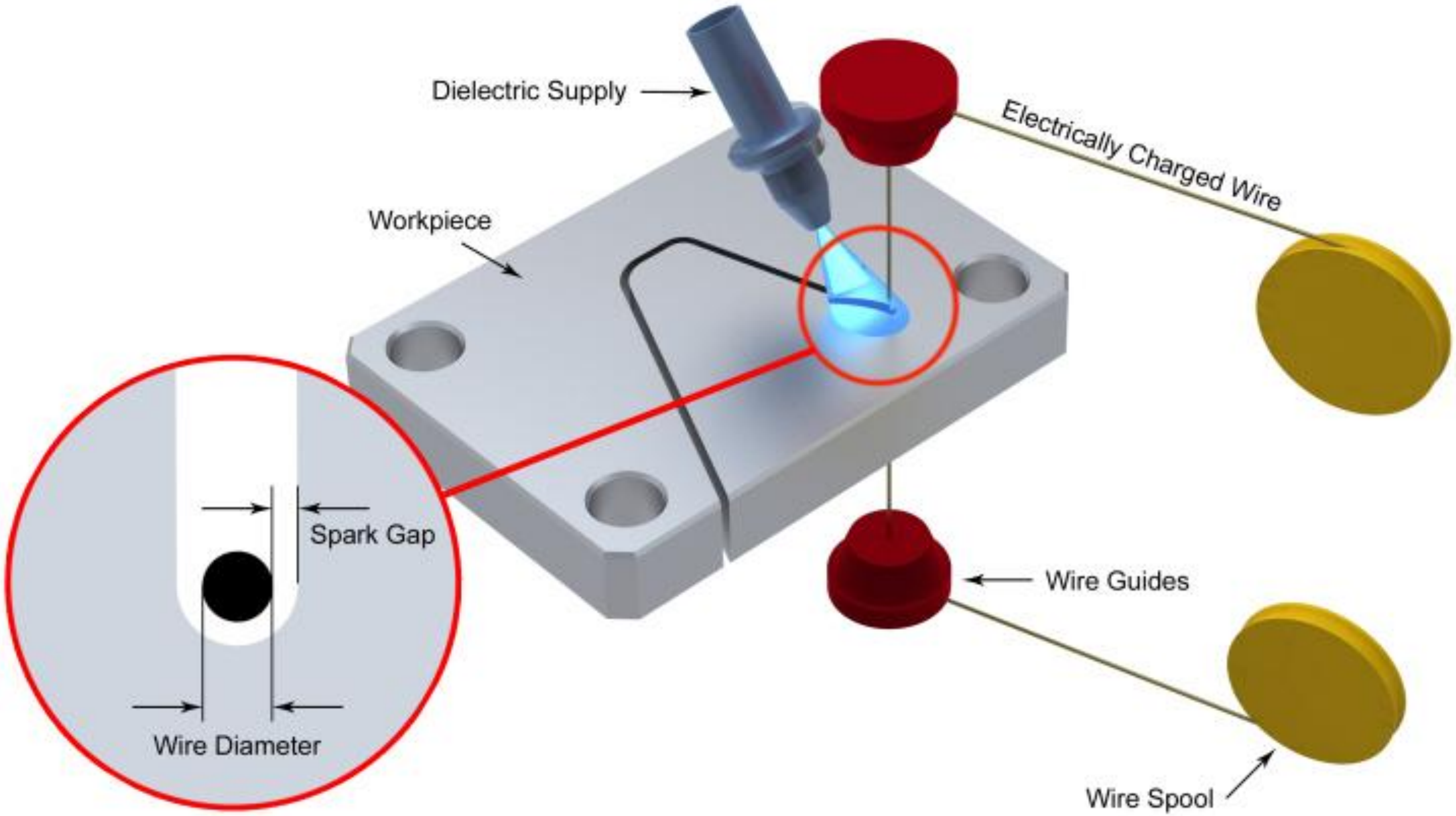
MATERIAL	DENSITY (lb/in³)	DENSITY (Kg/m³)
Stainless Steel 301	0.285	7888.77284
Stainless Steel 302	0.284	7861.092935
Stainless Steel 304	0.289	7999.492458
Stainless Steel 316	0.284	7861.092935

MACHINE SETUP

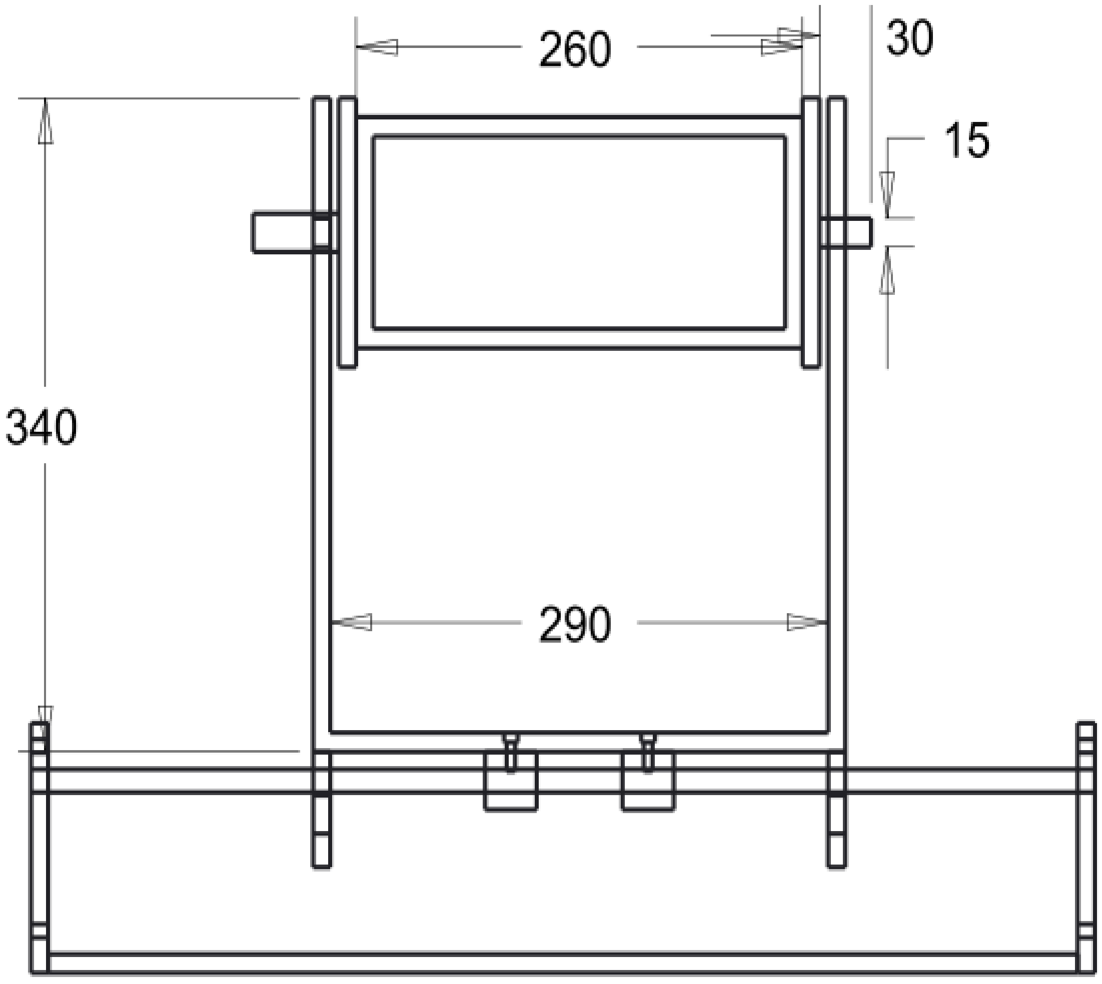


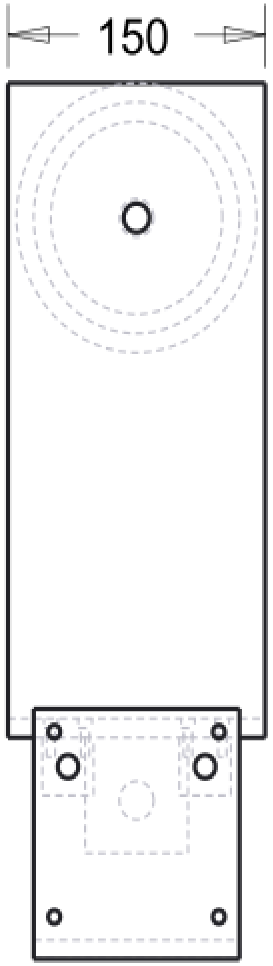


Machine Assembly

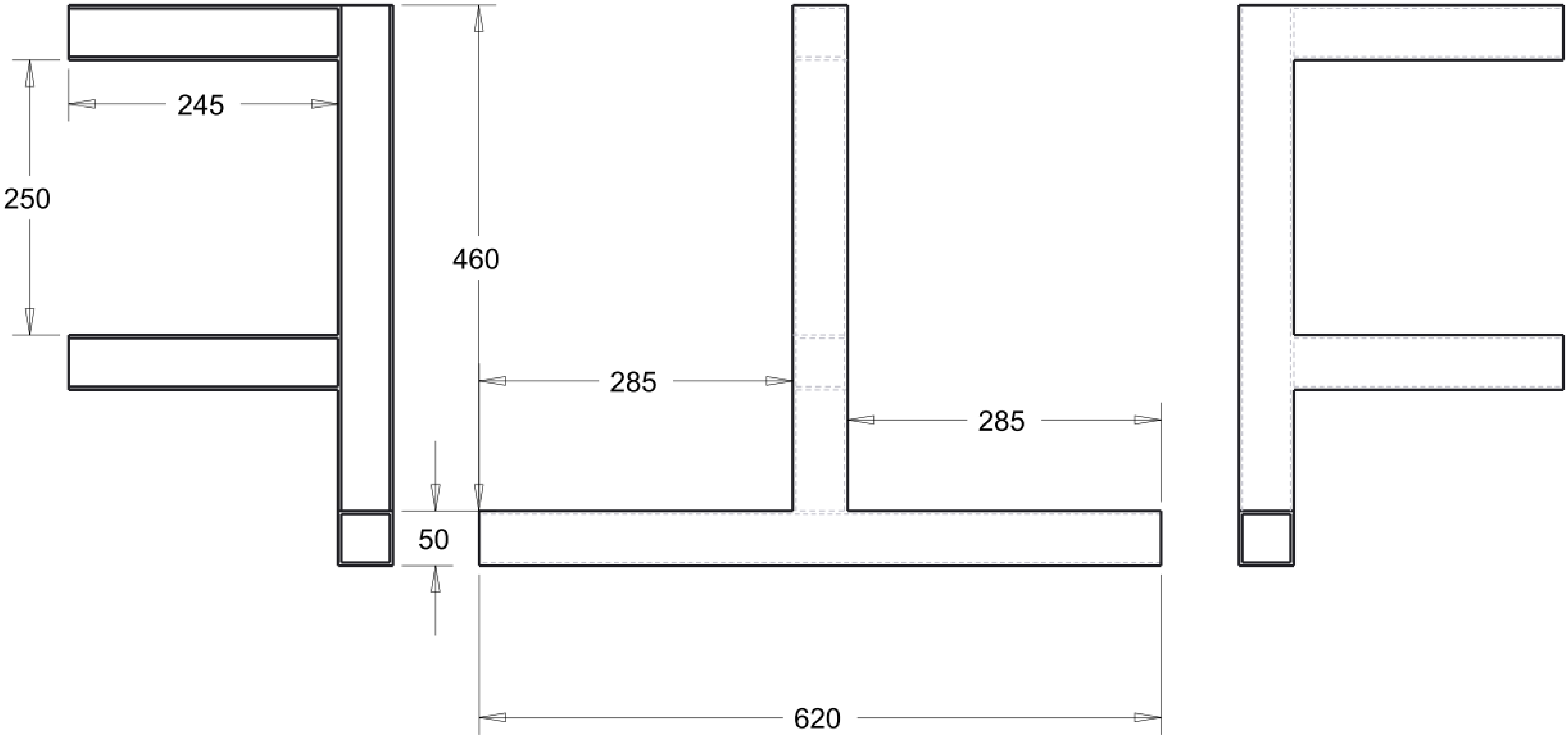

Dielectric Supply
Electrically Charged Wire
Workpiece
Spark Gap
Wire Diameter
Wire Guides
Wire Spool

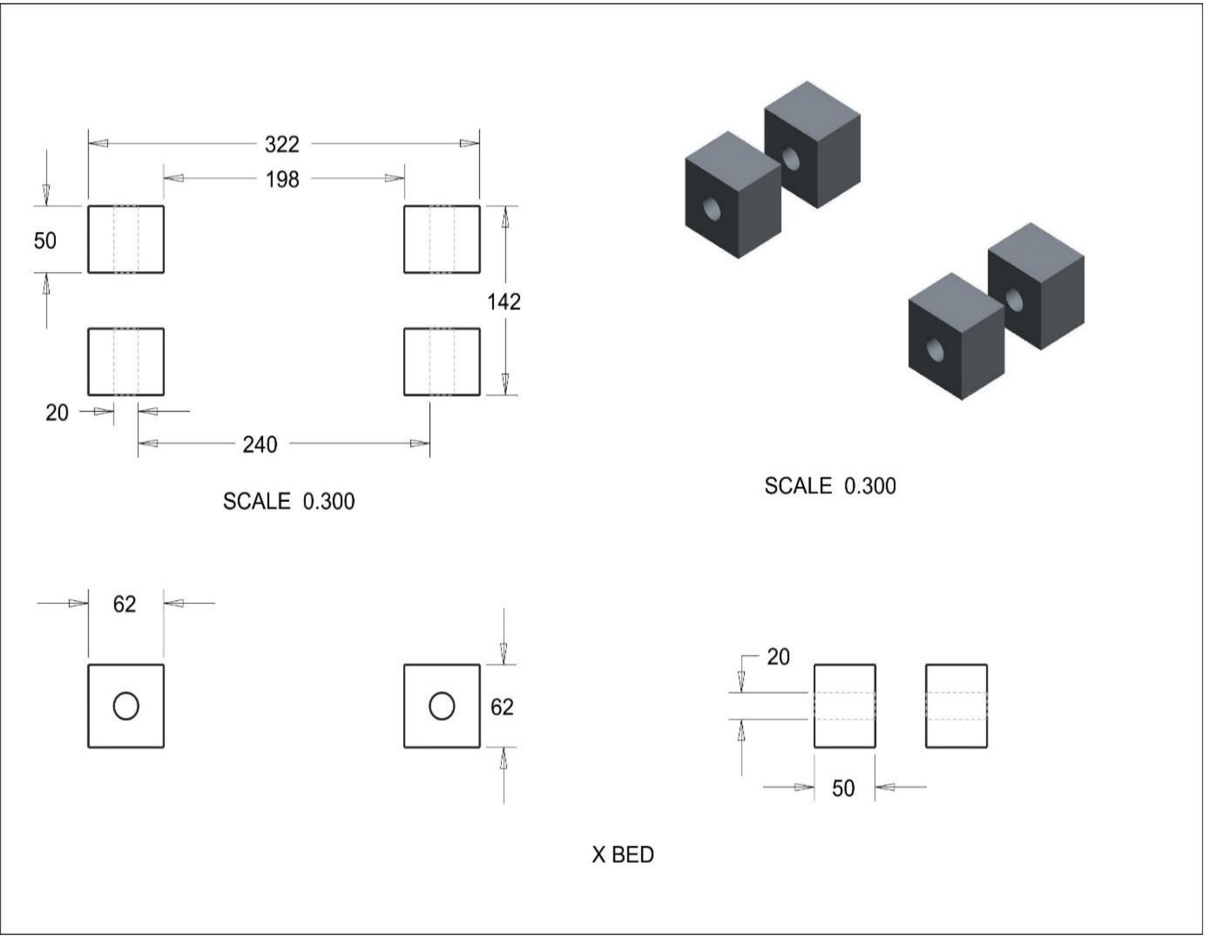
Wire Feed Mechanism





Wire Feed Support

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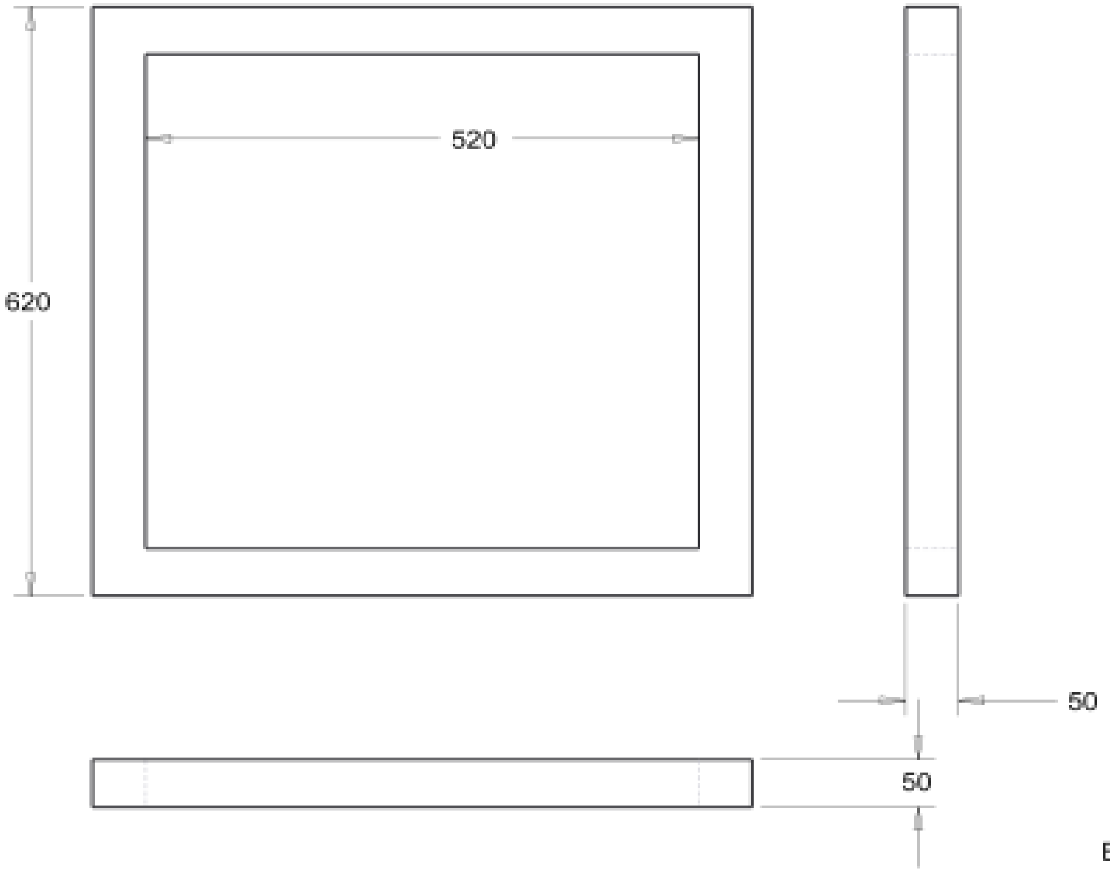
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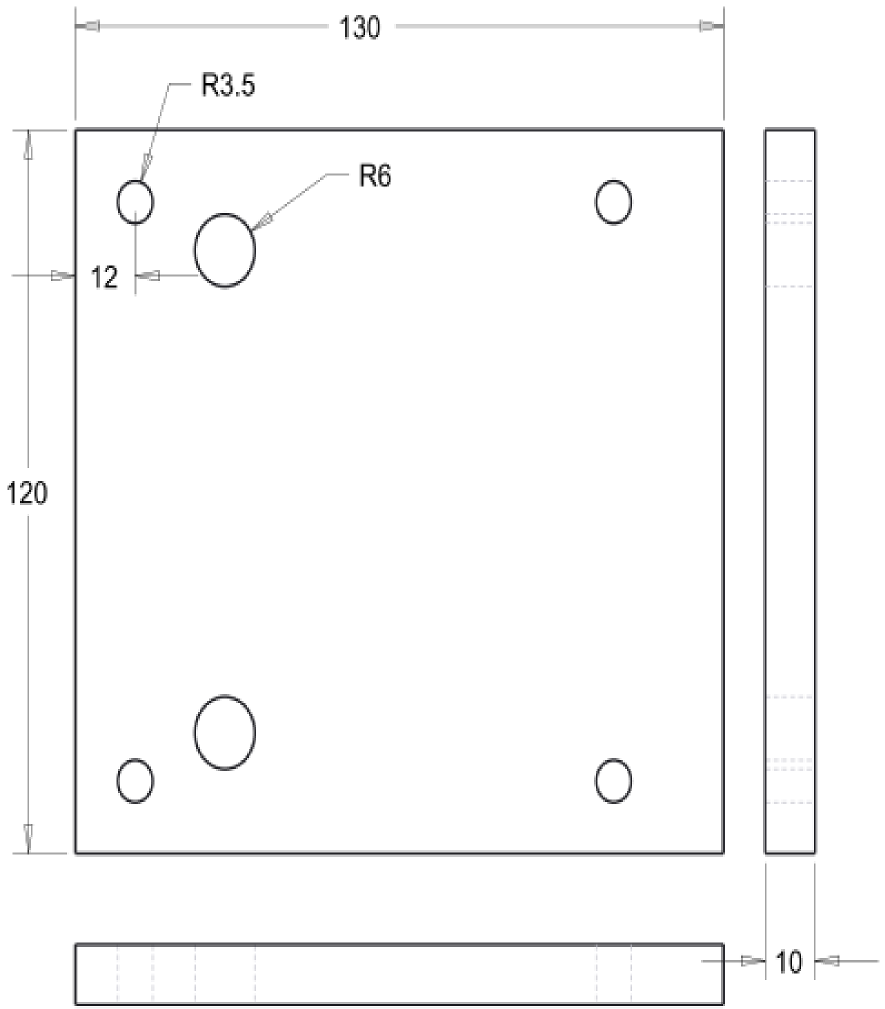
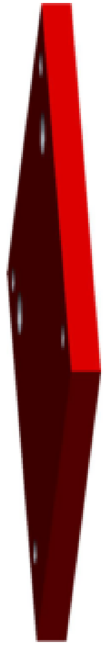
Base





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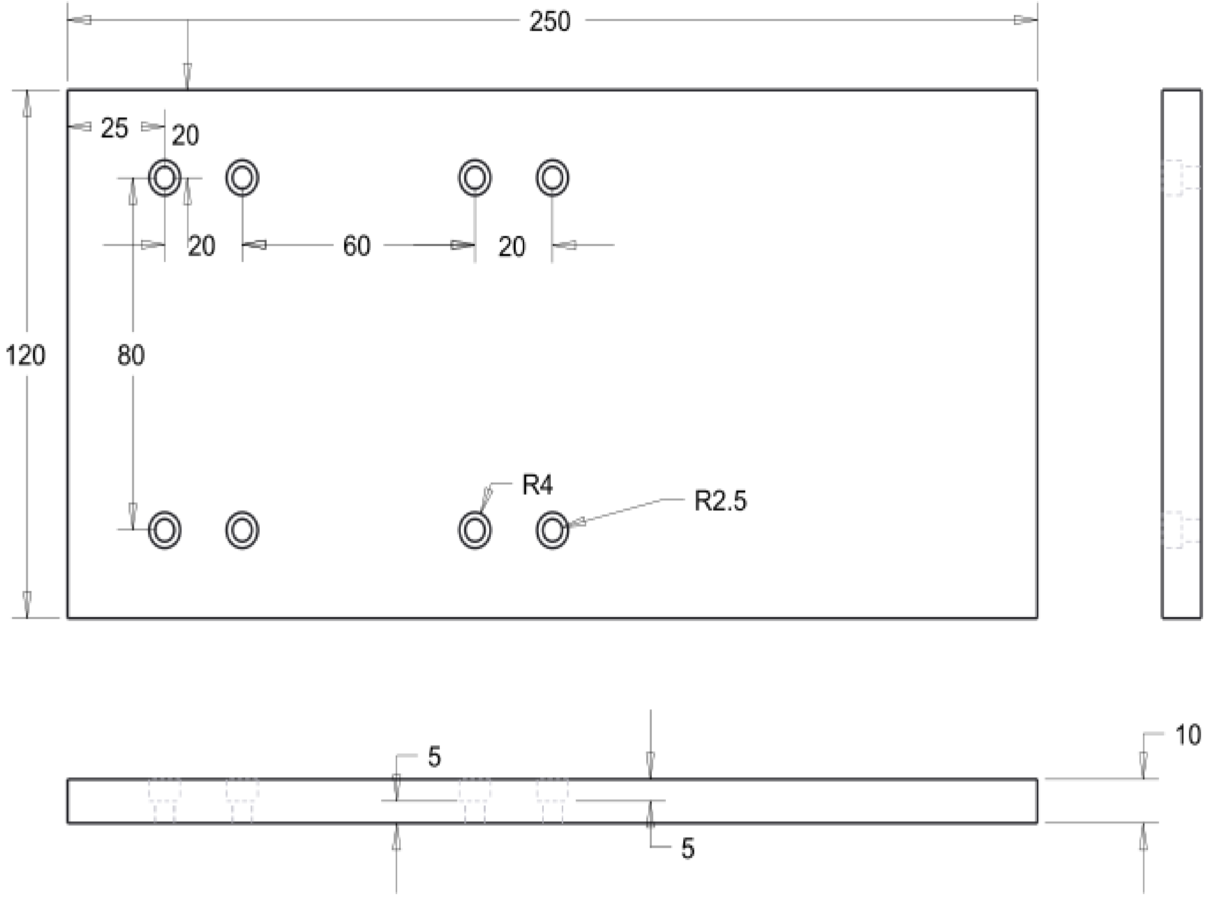

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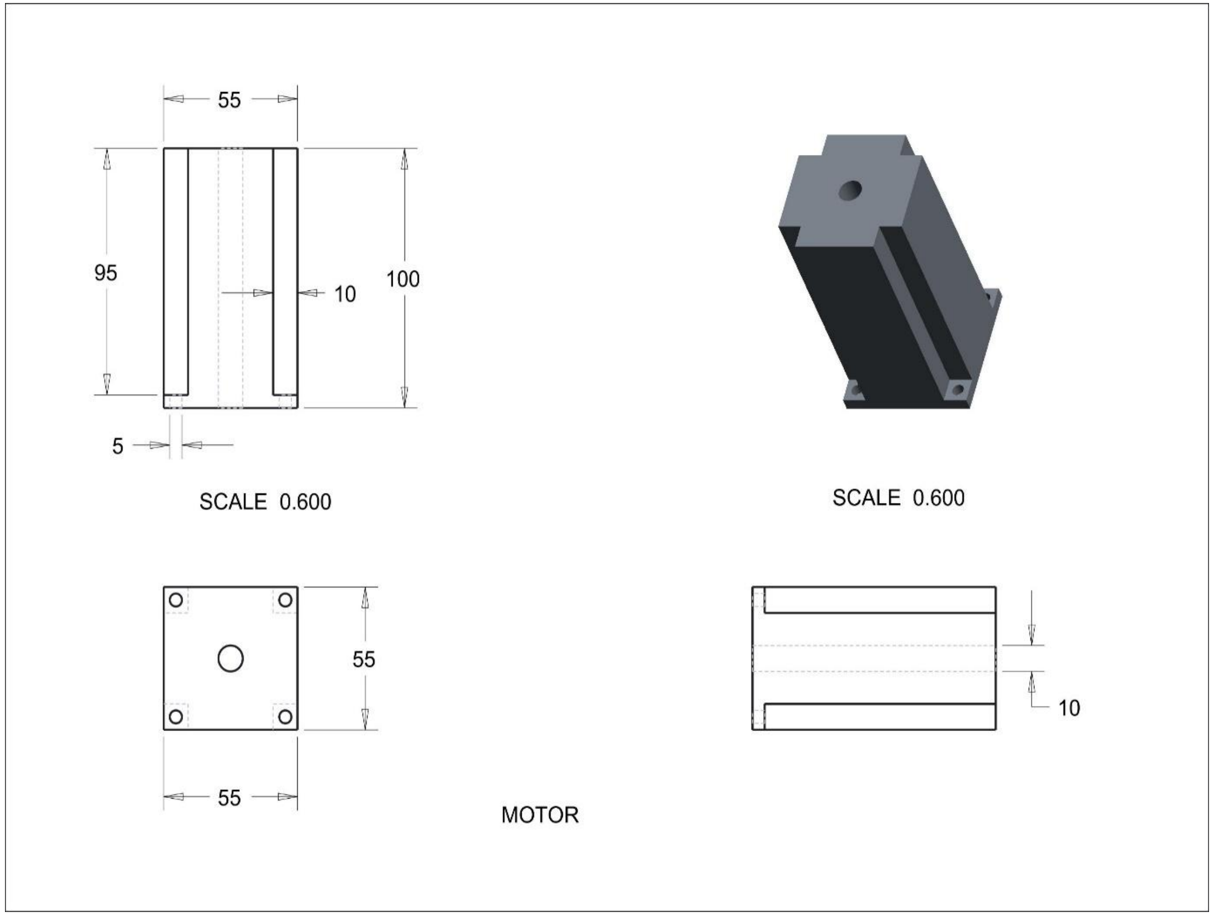
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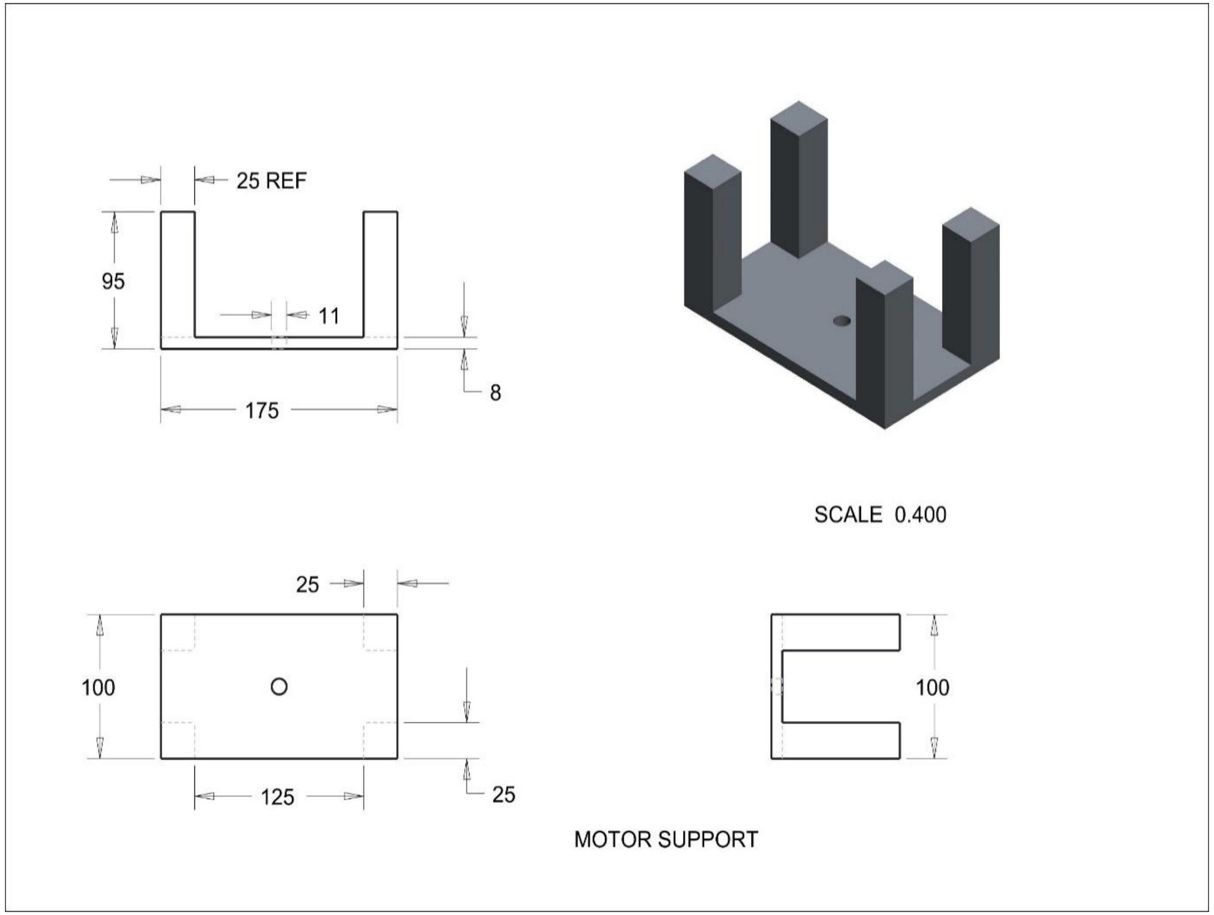
MOTOR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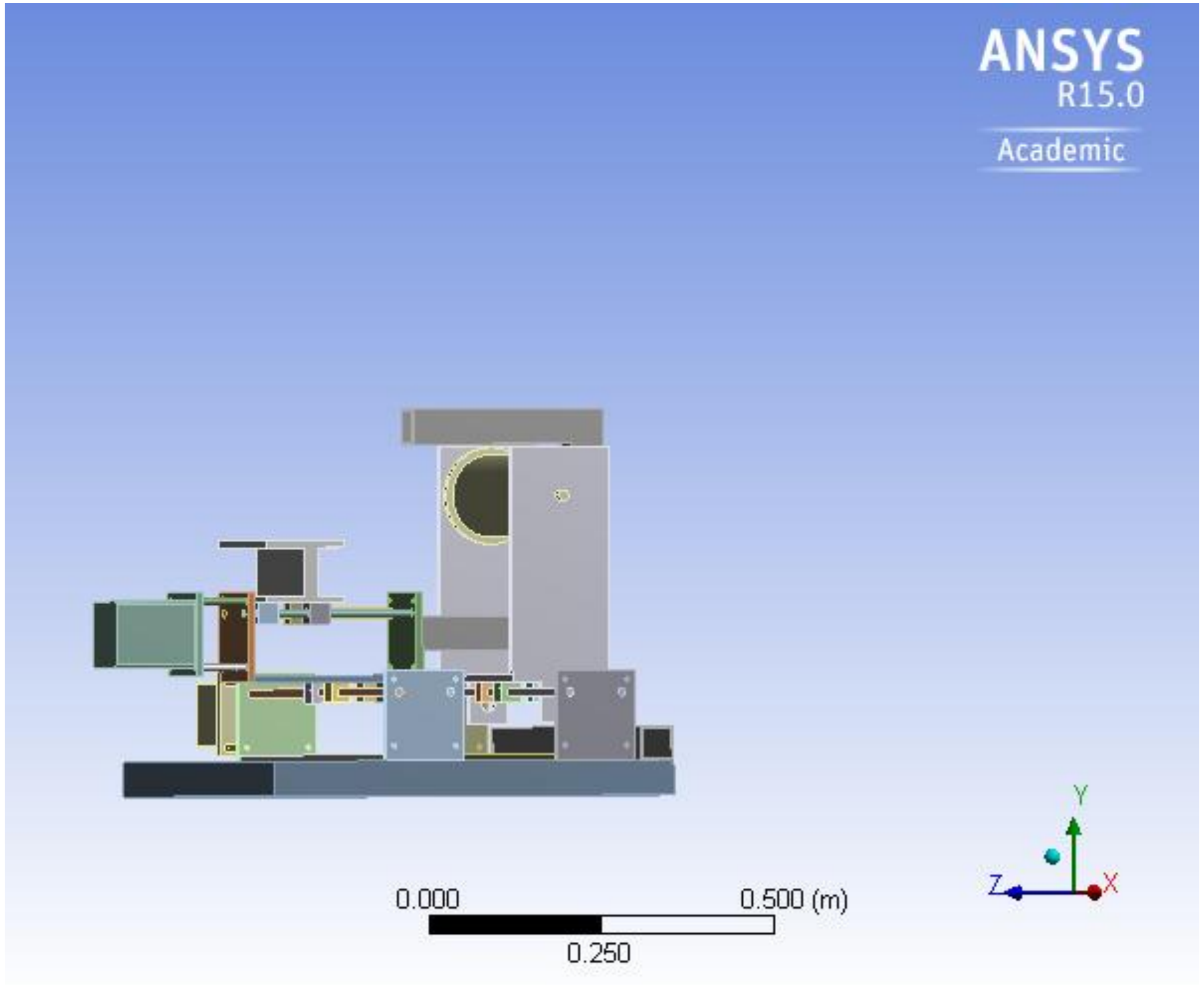
MOTOR SUPPORT

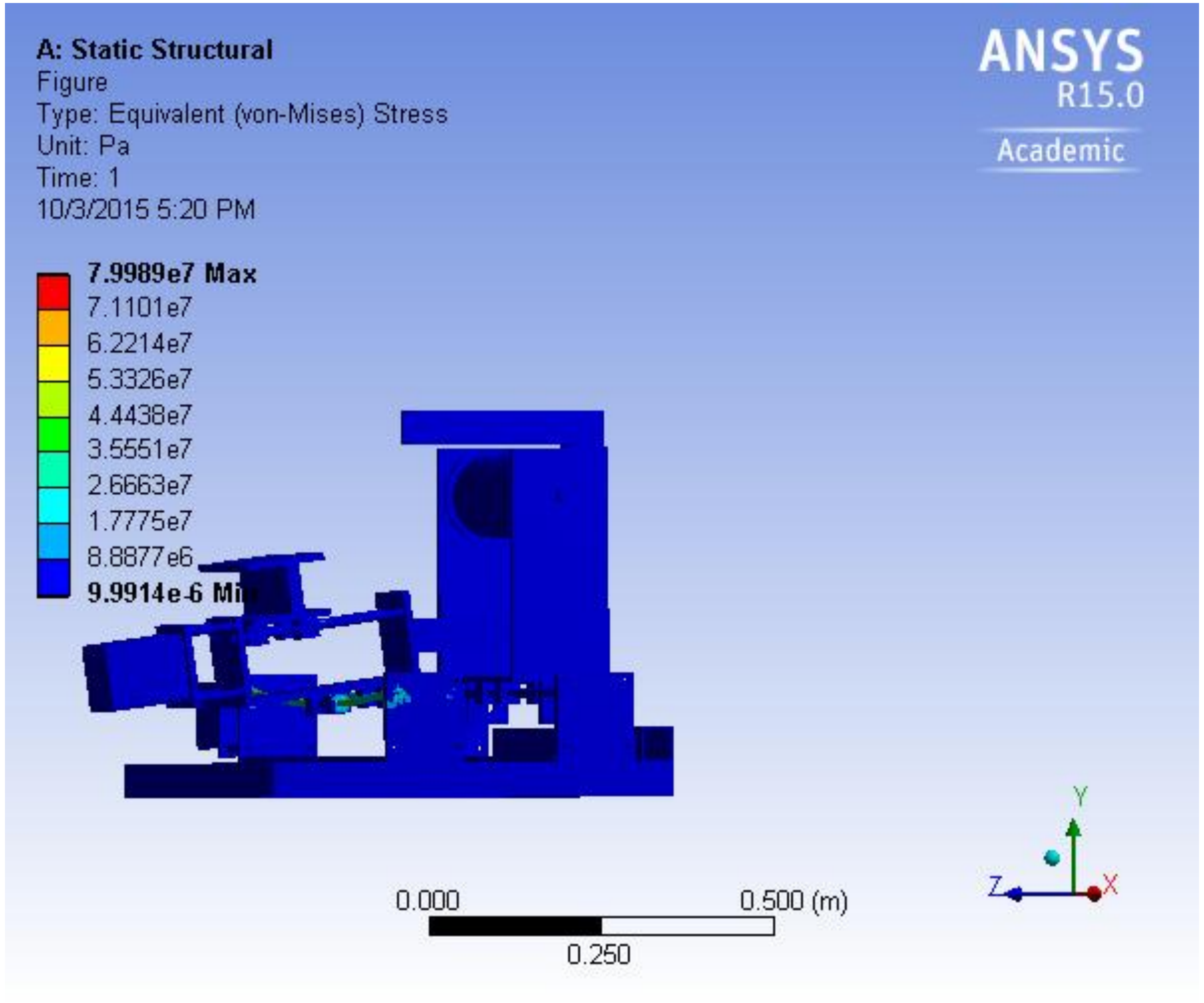
Ansys Analysis

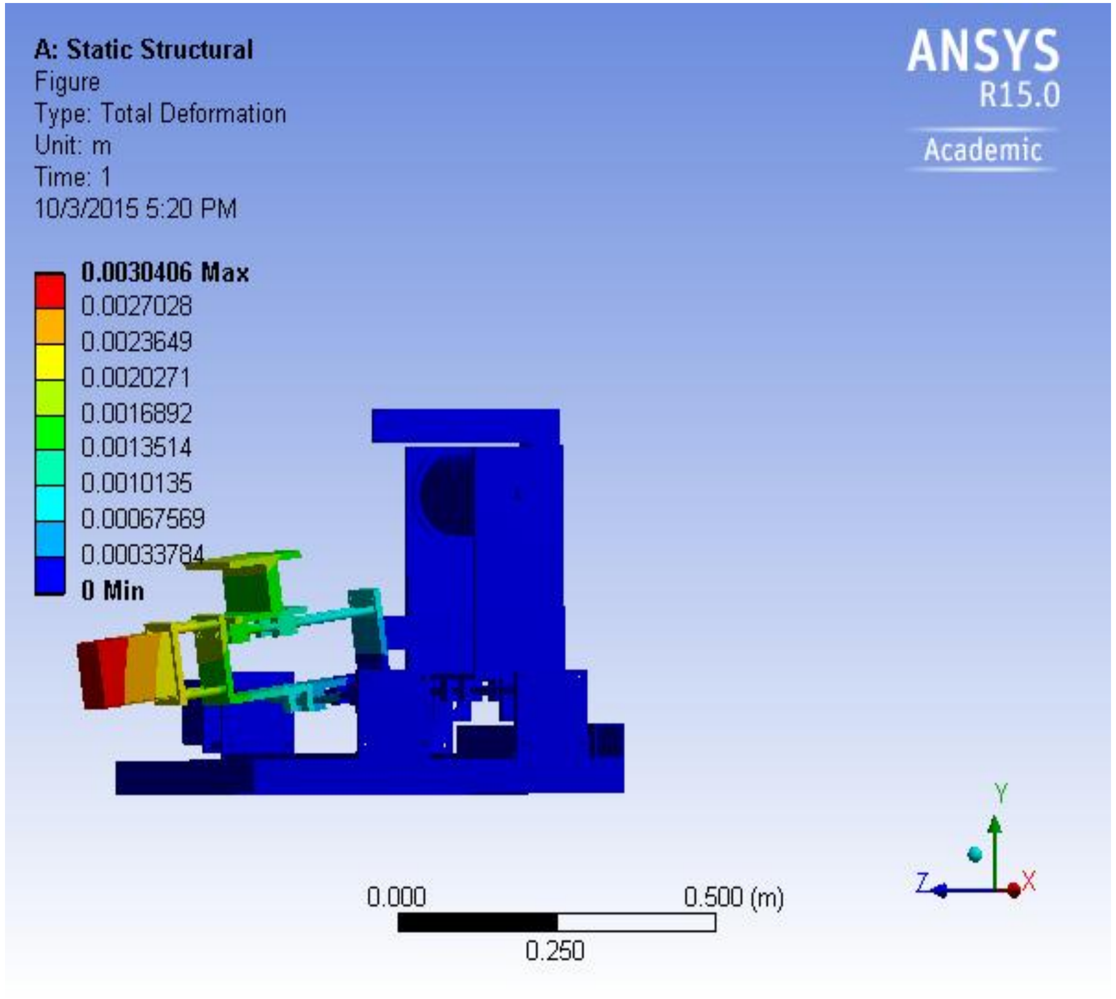


Tensile Ultimate Strength Pa
4.6e+008

Structural Steel > Tensile Ultimate Strength

Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007 ohm m





- Maximum strength of M.S. is 450 Mpa and This machine M.S. strength 79.9933330111 Mpa
  Deflection 3mm approx.
- In this analysis when apply load on machine 79.9933330111 Mpa then deflection is 3mm.
- For this deflection apply the external guide way or change the size of guide way to reduce the deflection.
- Changes in machine design:- due to deflection of 3mm so 8mm diameter guide rod is changed to 12mm and 12mm diameter
- Rod is changed 20mm

MARKET MACHINE SPECIFICATION & COST ANALYSIS

electronica

EMTL Sales & Service Limited

Technical Specifications

Machine Tool	Ecocut
Max. table size	370 x 600 mm
Max. workpiece height	200 mm
Max. workpiece weight	300 kg
Main table traverse (X, Y)	250, 350 mm
Auxiliary table traverse (u, v)	30, 30 mm
Max. taper cutting angle	± 5°/100 mm
Max. wire spool capacity	6 kg
Dry run speed	80 mm/min.
Wire diameter	0.25 mm (standard) 0.2 mm (optional)
Generator	**ELPULS - 15**
Display	Colour LCD
Min. input command	0.001 mm
Interpolation function	Linear & Circular
Simultaneously controlled axes	X, Y, u, v
Min. resolution for X,Y,u, v	0.001 mm
Data Input / Output	➢ USB 2.0 ➢ Keyboard ➢ RS232C Isolated serial interface
Input power supply	3 phase, AC 415 V*, 50 Hz
Connected load	3 kVA
Average power consumption	1.3 to 2.3 kVA
Dielectric Unit	
Dielectric fluid	Deionised water
Tank capacity	140 Litres
Paper filter	10 μ Single cartridge
Optional Mineral Filtration System	

18,25,000/-

COST ANALYSIS OF PROJECT MODEL

SR NO.	PART NAME	COST (Rs.)
1	Guide Rod-2 (12mm)	1500/-
2	Guide Rod-4 (8mm)	1000/-
3	Guide Rod-2(20mm)	2000/-
4	Sliding Bearing With Housing-4(20mm)	1200/-
5	Sliding Bearing With Housing-4 (12mm)	1000/-
6	Sliding Bearing With Housing-8 (8mm)	1500/-
7	M.S.Plates	2400/-
8	M.S. Bars (50 X 50mm)	1450/-
9	Wire Drum	400/-
10	Pully-2 (Dia. 95mm, teeth-54)	2160/-
11	Pully-4 (Dia. 30, teeth-18)	1000/-
12	V-Groove Bearing-5	250/-
13	Lead Screw-1 (Dia. 20, lengh-370)	1250/-
14	Lead Screw-2 (Dia. 8, lengh-620, 270)	1000/-
15	Stepper Motor-2 (25kg)	14000/-
16	DC Motor -1	2500/-

SR NO.	PART NAME	COST (Rs.)
17	Wire Rill (Molybdenum)	1100/-
18	Filter	1000/-
19	Nozzel	200/-
20	LN Keys, Bolts	500/-
21	Pulse Generator	2,50,000/-
	TOTAL:-	**3,15,210/-**

Conclusion:

- In this project the modeling work is completely finish with all dimensions and also the analysis of design with structural analysis is done and the result of analysis of design is safe.
- The size of the model is smaller than the market model and also the cost of model is lower than market model.
- This model is used for small scale industries and college laboratories.

PROJECT PLANNING AND SCHEDULING

	Dec	Jan	Feb	Mar	April	May
Project Define						
Industrial Survey						
Pre-Experimental Survey						
Design Components of Machine						
Design Software						
Manufacturing of Different Machine Part						
Assembly						
Apply Automation in WEDM						
Experimental Work						

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Thank You