# Automated TIG welding machine

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## Aim

Try to design a simple automated TIG welding system (using parallel kinematics/manipulators).

## Machine

A fully automated welding system, given by Mitsubishi was modelled using CATIA. The machine consists of a robotic arm/manipulator which has 2 rotational degree of freedom and the machine has 2 translational degree of freedom.

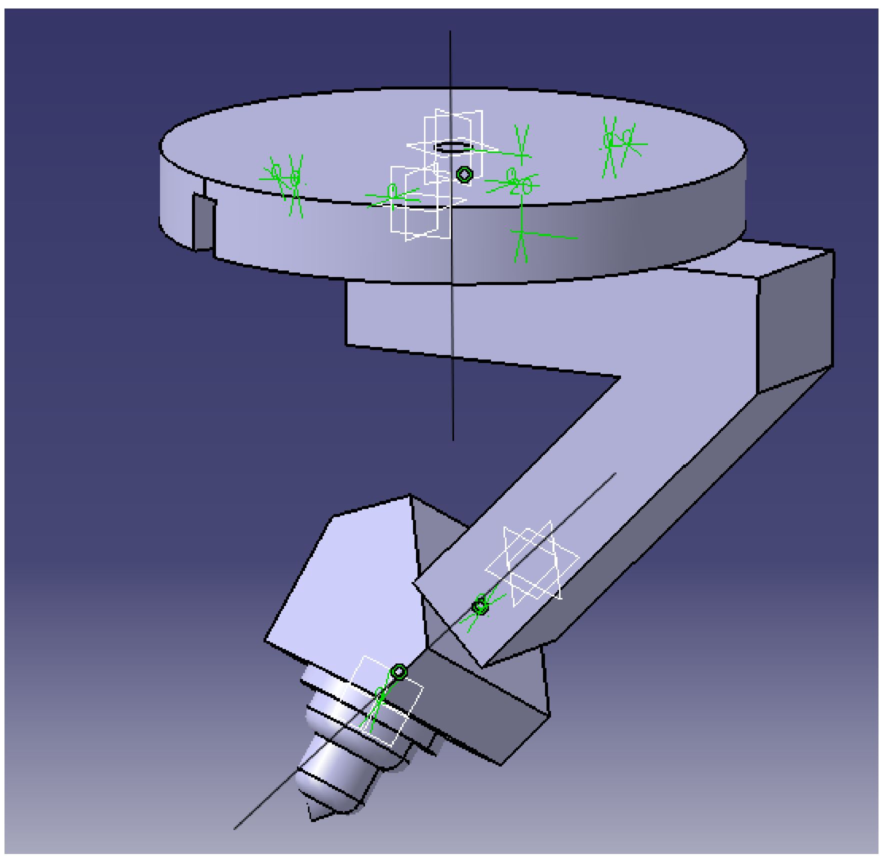


**Figure 1. Manipulator arm**

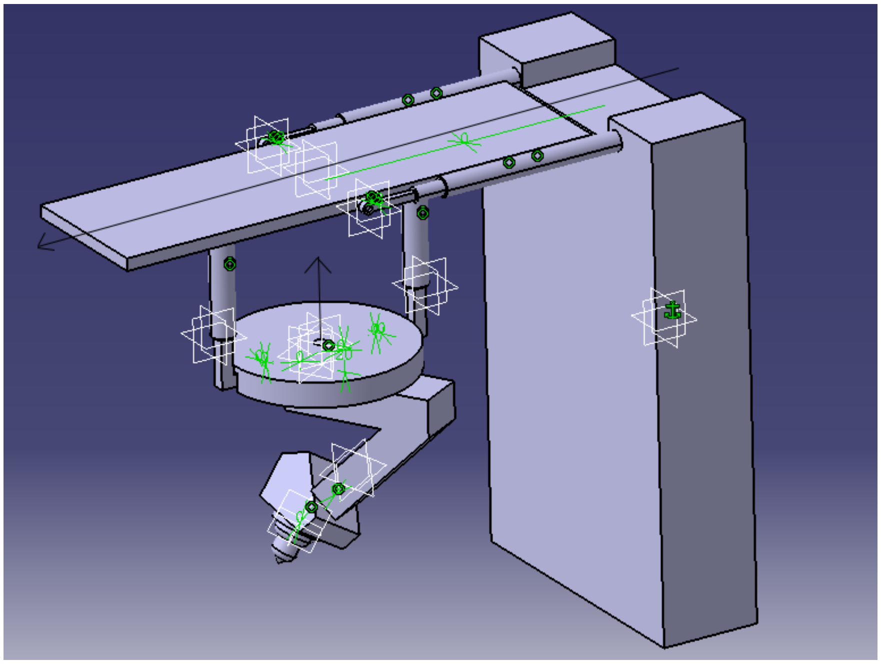


**Figure 2. Welding Machine**

# I. Machine Parts

## A. Cross slide and carriage

The machine consists of a cross-slide which can translate(say in the y direction), which is mounted on the carriage.
This is connected to suspension systems which can be pneumatically controlled and moves the arm-mount vertically up or down(say z direction).

## B. Manipulator Arms

The manipulator arm has 2 parts, one is the connector arm, connected by a revoulte joint to arm mount containing the suspensions, allowing only rotational motions about it and can be actuated. For a given rotational speed, since we have eccentricity for the nozzle, if the speed is maintained we can easily carry out seam welding or welding in a circular region.

## C. Nozzle

The nozzle is mounted on the second part of the arm, which again has a rotational degree of freedon about the arm, which can be actuated.

The nozzle is used for a proper regulation of the shielding gas used in the welding process.This component is responsible for directing the shielding gas to the weld pool and protecting it from contamination. Without proper gas flow, the final weldment can be prone to problems like excessive spatter and porosity that cause downtime for rework. Also, having the wrong nozzle for an application can cause overheating and lead to premature consumable failure.

### D. Bed

The bed translates in the x-direction, where the objects to be welded are clamped.The bed essentially can act as an electrode too.

Say for tube and pipe joining, all necessary components including clamp-one weld heads(on bed), operator pendants, controllers, welding power sources(on body), water coolers and track rings(on the nozzle mounts) if necessary can be incorporated easily.

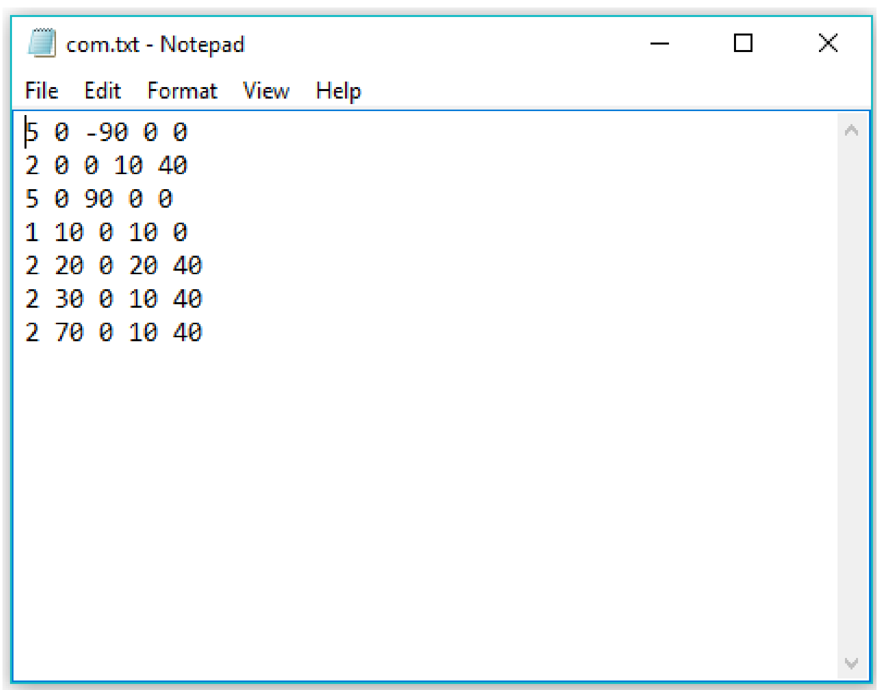
Together, these components deliver the precise arc control and monitoring capability required by code-regulated power generation applications in power plants, chemical plants or refineries.

## II. Machine Coding

The code to be given as an input to the machine in order to carry out the welding process, to simulate the manipulator arm to carry out the required movements along the defined axis of the machine, a simple logic can be used.

### Input

Input is given in the form of text file. The format of the file is explained in following paragraphs.



```
5 0 -90 0 0
2 0 0 10 40
5 0 90 0 0
1 10 0 10 0
2 20 0 20 40
2 30 0 10 40
2 70 0 10 40
```

**Figure 3. Sample input file to the machine**

#### *1. Rapid traverse*

This will happen at the maximum feed and no welding will happen in this phase.

Format:[1][Final X][Final Y][Final Z][0]

*2.* ***Linear motion***

This will do welding in linear motion without any rotation of welding head. The angle of welding head with the welding surface remains constant. The motion is governed by user input of feed value.

[2] [Final X] [Final Y] [Final Z] [Feed]

*3.* ***Circular motion(Over a sphere)***

This is used for welding in circular arc over a sphere at a given feed motion of the welding head. In this case, there is continuous rotational motion in welding head to keep the angle between weld head and welding surface constant.

[3] [Radius of arc] [angle] [angle of the welding plane from XZ plane] [feed]

*4.* ***Plane circular motion***

This is used for welding in circular arc on the XY plane at a given feed motion of the welding head. In this case also, the angle between weld head and welding surface remains constant.

[4] [Radius of arc] [angle] [0] [feed]

*5.* ***Rotation of welding head***

This is used to rotate the welding head to make it at perfect angle for welding.

[5] [Rotation about X-axis] [Rotation about Y-axis] [Rotation about Z-axis] [0]

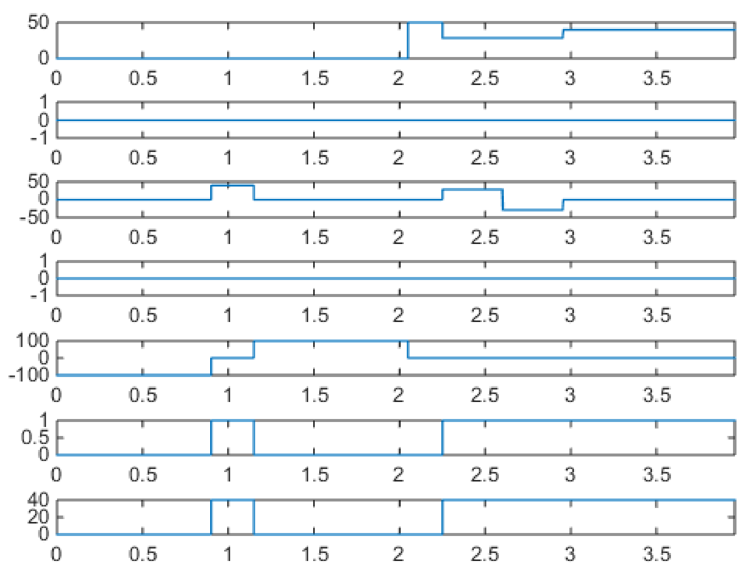


**Figure 4. Control signal for respective actuators**

## III. Modelling of actuation systems

This work presents a Matlab Simulink modelling of a 3-DOF manipulator.
Currently Industries use PID (proportional, integral and derivative) control systems for Robotic manipulators. This particular method has a wide range of applicability, ease of implementation and is very robust.

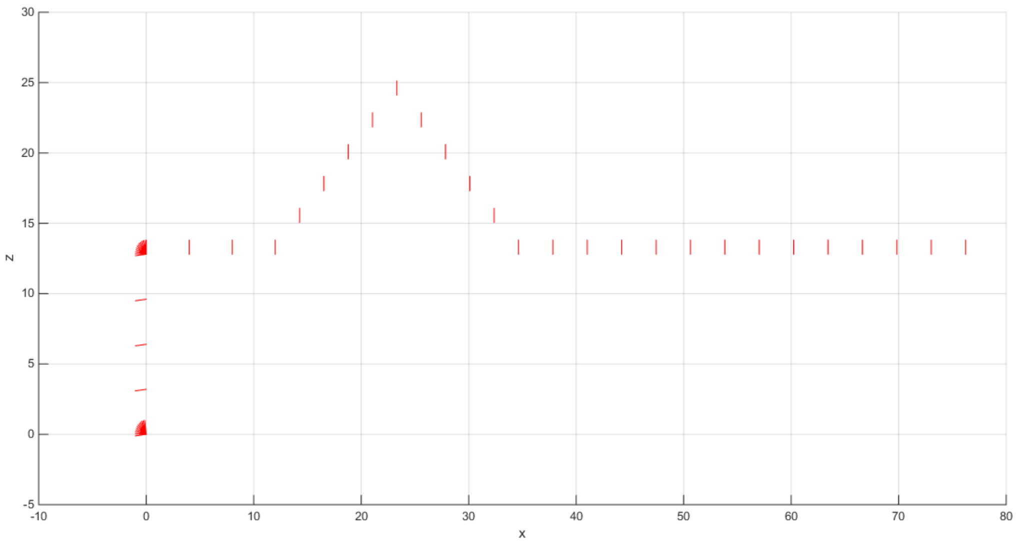



**Figure 5. Motion of the welding head**

With any control system, the key parameters are rise time, overshoot, settling time, and the steady state error for a step input. Using Simscape in matlab we can fine tune these parameters to our requirement. fine tuning is necessary to obtain the best possible response. MATLAB also offers a PID tuning algorithm that can help in deciding the values after an iterative process.

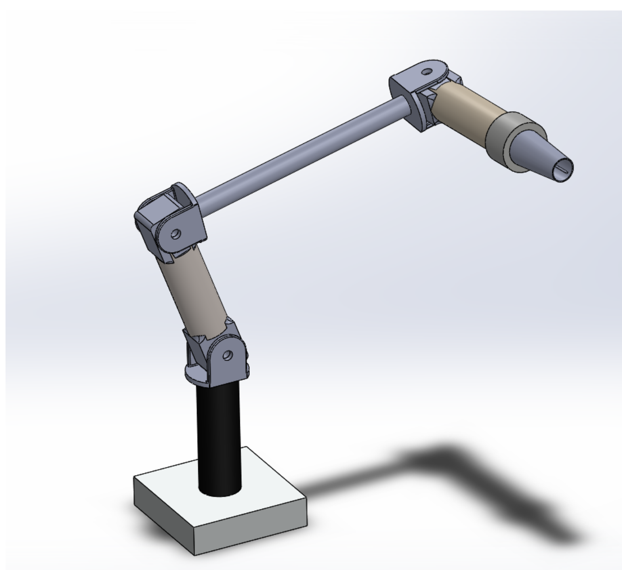


**Figure 6. Robotic Arm design for simulation**

## A. Simulation Methodology

3D simulation of the Automatic TIG welding manipulator is constructed Matlab-Simulink with simmechanics block library. The Manipulator is represented by the following blocks: the body, joints, constraints, and force. The SimMechanics block library provided us the tools to formulate and solve motion equations of complete mechanical system. We used a bridge between solidworks-matlab with some adaptations to operate the robot model that we designed with solidworks. The Simulink modeling then appears:

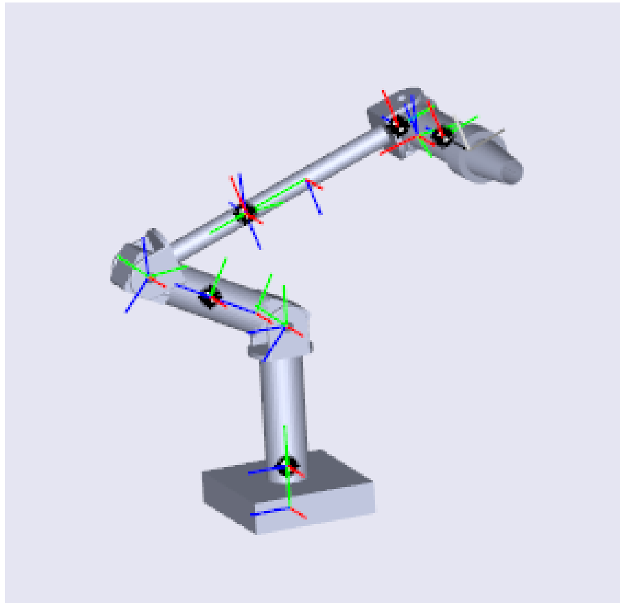


**Figure 7. Actuations given**

To simplify the simulation we have block all robot joints except the terminal element and after we applied a simple control signal. A block diagram of the robot with the actuator and the sensor is illustrated in the following figure:

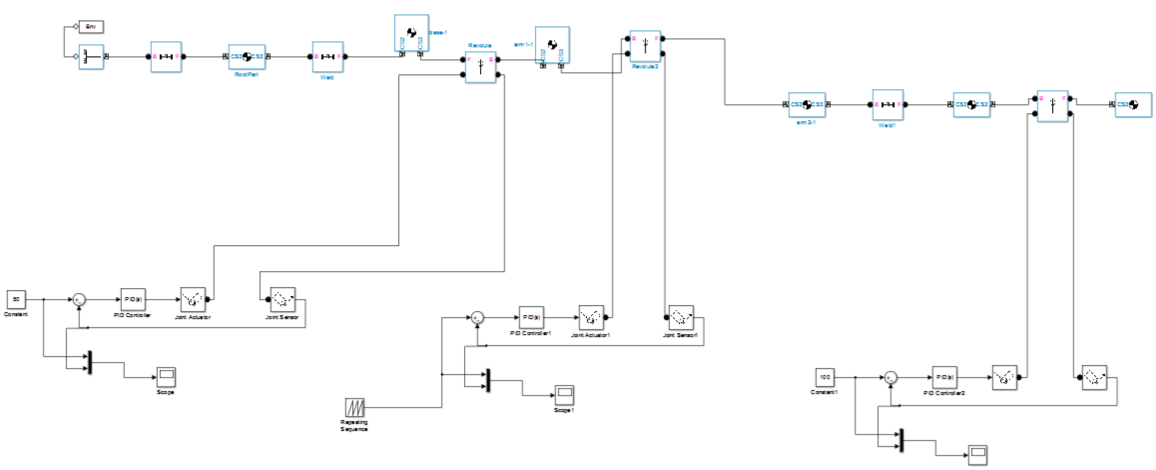


**Figure 8. Control Block Diagram**

At every revolute joint we have placed a PID controller along with a joint actuator and a joint sensor. A negative feed back is provided from the joint sensor.
By varying the constant input to the joint actuator of the three revolute joints , required motion of the Manipulator can be obtained. Here we have coded it to perform a welding operation along a circular arc which can be used for seam welding of fuselage or Pressure vessels.