ABSTRACT

Name: Deepak **Team name:** Panther CNC

Topic: Design and development of a low cost CNC laser cutting and engravging machine.

INTRODUCTION

CNC machines due to their immense capability and performance have become an integral part of the manufacturing field at all levels. With the rapid growth of manufacturing sector in India, CNC machines are imported for extremely high prices with added shipping and customs costs, along with their maintenance and service being another costly issue in India.

The aim is to develop a low cost CNC laser machine for cutting and engraving plastics (acrylic, polycarbonate, nylon, delrin), rubber, etched metallic sheets, cloth and other fabrics having a wide range of applications in manufacturing, fashion &textile, plastics, and rubber industry. The product line can be expanded to CNC laser sintering and CNC router machines in the next two years.

PROJECT DESCRIPTION

The work started in November 2013 with the design of the Gantry (XY Movement system) which is the crutial part for machine's function and performance.

Gantry motion and drive

The machine is designed to be very compact with outer dimensions being 950mm X 700mm x 320mm weighing 30Kgs and works on a 40Watt CO2 sealed water cooled laser tube and having a work space of 28" x 18". The gantry is made of modular aluminium 1010 extrusions with custom designed pulley bearing shaft assemblies and T2.5 PU synchronized Belt drive. Hiwin HG-15 linear bearing guideways are used for linear motion in X and Y directions.

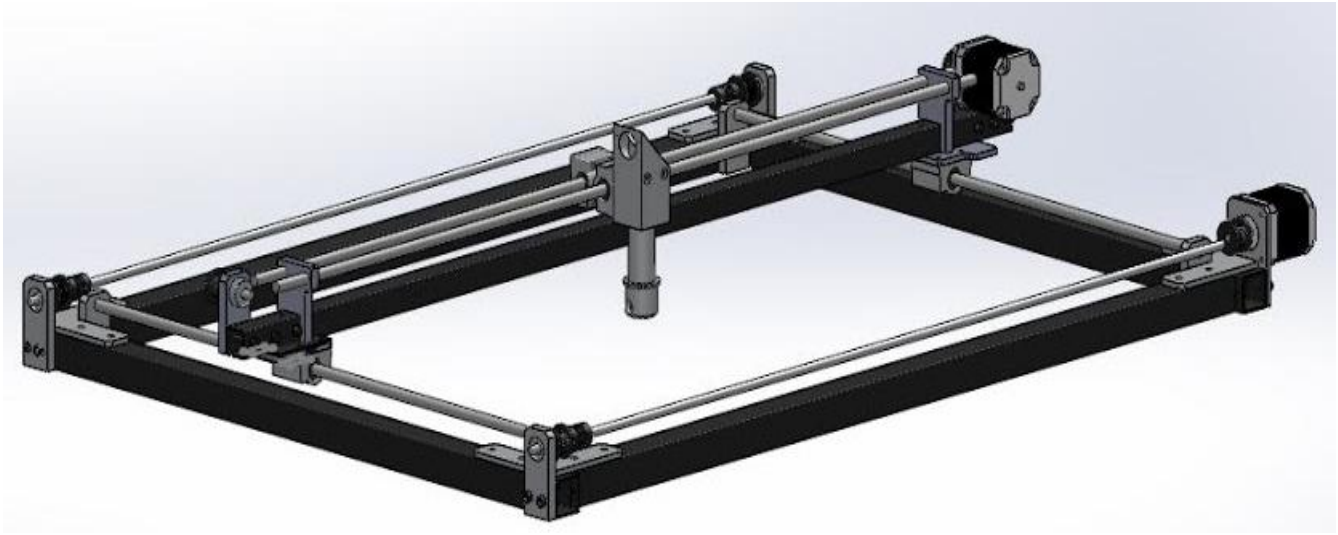
The Gantry is driven by 18Kgcm Stepper Motor (SY57STH76-2804A) for Y axis control and 12.6Kgcm Motor (SY57STH56-2804A) for X axis control using 2 Leadshine sinusoidal current control technology drivers running on 1/32 microstepping for smooth and accurate movement.

Electronics, User Interface and control

The electronics consists of a separate power supplies for laser, motors and a central board which breaks input-output signals for the motion and laser control, IR motionlimit switchs, relay controlled water cooling, air assist system and exhaust, other safety features and runs a user friendly interface with a control panel for switches and LCD display on the machine. Artsoft **Mach3** computer numerical control software is used to control the whole machine including the laser and drive motion running with transmission via parallel port.

PROGRESS TILL NOW

The project started in November 2013. An iterative process was followed and 3 versions of the motion gantry setups were designed and fabricated. Currently the 3rd version of the Gantry is in the testing process.



A CAD model of the 3rd version Gantry

3rd version of the 2 Axis Gantry in the testing stage

The present system has minute problems out of which some issues are rectified.

Non parallel guideways in Ydirection due to errors in the fabrication process which can be eliminated by precise positioning using dial gauge and by changing the LM shaft mounts. Bending of the X direction linear bearing shafts due to load as they are only supported at the ends and deflect even on application of small forces.

So it is decided to switch to industrial grade Hiwin linear guideways HG15 which allows the rail to be mounted on the surface of the frame and has zero vibration smooth motion ball chain bearing block.

Pulley eccentricity caused due to fastening of grub screw and inaccurate drilling which causes the system to undergo cyclic loading with changing tension in the belts resulting to deflections of the shafts and load on the bearings. Using multiple grub screw arrangement solved this issue and will be implemented in the new design.

Resonance caused by stepper motors which is transmitted to the whole system during motion causing severe motor torque loss and stall condition. Particularly at low speeds at a particular frequency the motor starts a de-synchronization because its natural oscillating frequency has been reached. It is found that running the motor in microsteps 1/8 or even less is solving this issue.

Speed-Torque trade-off which leads to missing steps in the motor. The speed-torque curve for the present stepper motors is very steep and has a small working domain and range. But the machine needs to reach variable speeds for cutting and engraving materials of different properties and thickness. Switching to high torque bipolar motors running in microstepping mode will solve this issue to a great extent as they maintain high torque at both extreme high and low speeds.

These problems were taken into consideration out of which most of them are with the manufacturing issues. The 4th version of the system which is currently in the design process will have them all rectified and the final rigid gantry would be ready by the end of summer which makes way for further development of the machine.

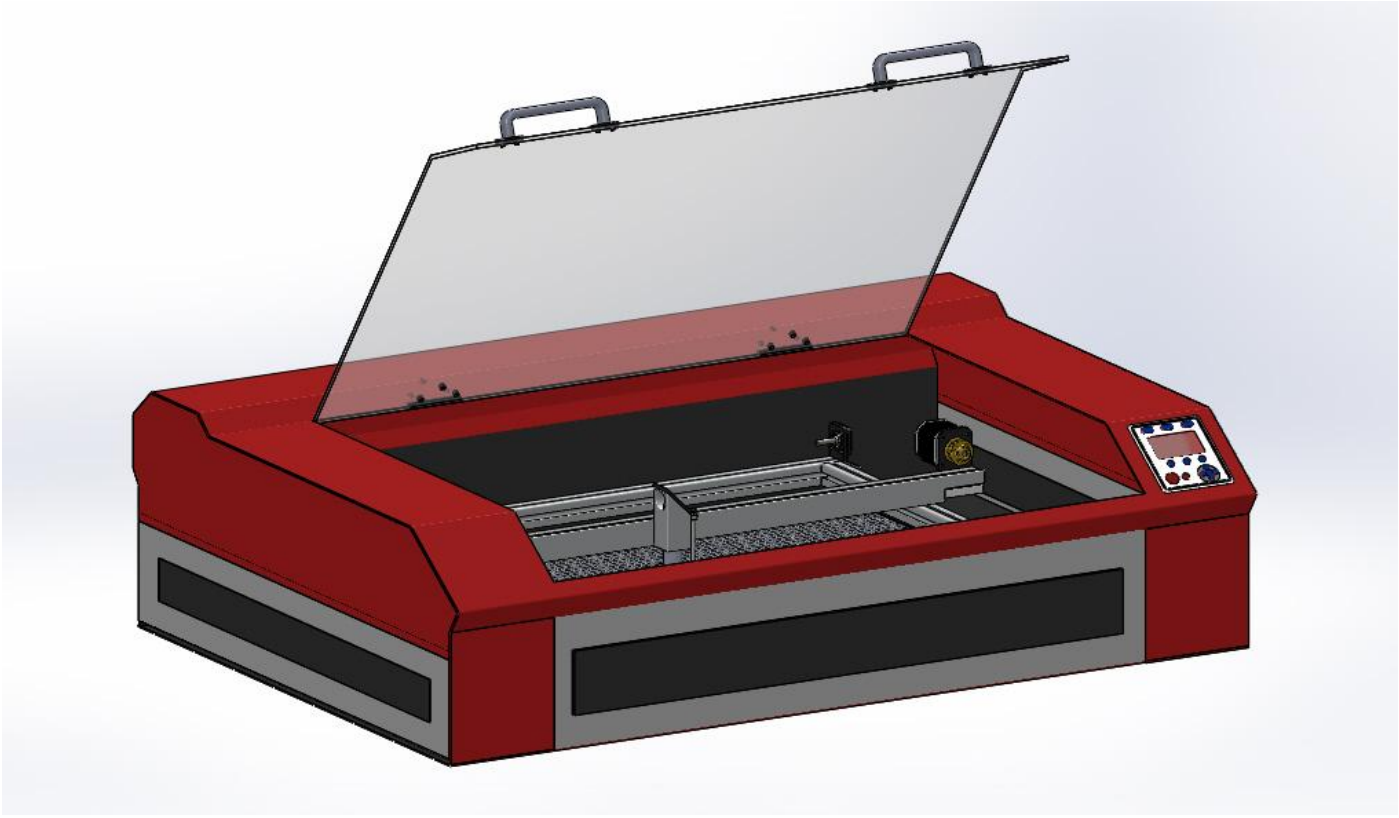
COMPONENT COSTS

Hiwin (HG) LINEAR RAILS	4500
Hiwin Bearing blocks	3300
1010 Extrusions	1600
SY57STH76-2804A stepper motors	1900
SY57STH52-2804A stepper motors	1150
Leadshine Motor contollers	9000
Custom bearing assembly (Fabrication costs)	500
Custom shafts	500
Air assist system	2500
Flying optics system	1000
Hard Copper Mirrors and Znse lenses	4000

PLAN OF ACTION (Summer)

The plan in the first phase is to start with bearing pulley assembly design and installing them in the new 4th version gantry along with the HG Hiwin linear guideways as soon as the testing is done. This would take 15 days as the work is already in progress.
Next 30 days will be spent on developing the flying optics and control board design both simultaneously with a team member completely focussing on control board development and testing. The flying optics includes fabricating the gimbal adjustable optical mounts for the Cu mirrors, lens holder in the laser nozzle and mirror-laser alignment for the laser path. The final 15 days (phase-2) will be spent on integrating the control board with power supplies, drivers, limit switches, relay control for air assist, exhaust, water cooling peripherals and testing the control board with CNC software running on the PC.

FURTHER DEVELOPMENT OF THE MACHINE (Next 6 monthhs)



Next 6 months down the line the aim is to complete the machine with all parts and peripherals integrated and tested. With the present calculation the machine is expected to be completed in 80,000INR excluding R&D costs which may cost another 30000INR.