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Design and Development of CNC Robotic Machine Integrate-able with Nd-Yag Laser Device

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Abstract

The machining technologies and modern intelligent systems are expensive and require easy handling and integrated-able machine with various devices to perform multiple machining tasks. Computer Numerically Controlled (CNC) machines are accessible by manufacturers to perform several machining tasks due to effectiveness in handling accuracy. The majority of CNC machines are costly due to it complex but efficient machine and software design. This project is aimed to develop a cost effective and easily integrate-able CNC Machine System that is accessible to add-on Nd-Yag Laser Device. The deliberate mechanical design and the path of laser beam entering the machine and exiting the laser-head with intended electronics control structure controlled by CNC software is developed. The designed CNC Nd-Yag laser Machine is a teaching tool for workshop and is targeted to perform laser cutting and suitable engraving or welding tasks for small and medium scale industries. By testing the machine its expected positional accuracy was achieved and the control mechanism for Nd-Yag laser path reflection function was successfully tested.

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Keywords: CNC Robotics; Laser machining; Cost Effective Manufacturing; Software Control System; Workshop Teaching Tool.

Introduction

Computer Numerical Control (CNC) is a versatile system that allow user to control the motion of the tools and parts through numerical data. Application of CNC machine is to perform various machining tasks by the use of G-codes. G-code are the point-to-point coordinated programing language used in CNC machine to operate tools in x, y and z directions to achieve rapid movement, linear interpolation, clockwise or counter clockwise interpolation etc. A CNC system incorporates machine device and non-machine instrument territories. In the machine processes CNC machines are generally utilized for drill press, processing machine, crushing unit, laser, sheet-metal press working machine, tube twisting machine and so on. Meanwhile, the non-machine processes CNC consist of welding machines (bend and resistance), tape lying, and fiber twisting machines for composites direction measuring machine and electronic get together.

Nowadays CNC machine can be found in any field of manufacturing units that also includes the laser machining process. Nd-Yag laser device can be used as external laser source to incorporate with any type of laser CNC machine; such example can be found in University of Malaya machine lab that uses Nd-Yag laser device as external laser source incorporated with its CO_2 Laser CNC machine. Perhaps there are limitations in coordination system when external source is forced implemented into a ready-made system by manufacture also for example when CO_2 laser and Nd-Yag laser operations are required by the user to be used at same time for different purpose. Therefore a substitute cost effective CNC structure can be made to interface Nd-Yag laser module separately so that the user can perform experiment individually without interrupting the costly CO_2 CNC laser machine. Therefore with the rapid development of laser technology, new research on laser topic found almost every month around the world and mostly comes from higher educational institutions. University of Malaya also has no exception. Many on-going and future projects regarding Nd-Yag laser experiment are planned within mechanical engineering department. However, due to lack Nd-Yag CNC machine facility many project has to be postponed. Therefore the design and development of this CNC machine may facilitate Nd-Yag researches. CNC table is suitable for everyone who requires laser cutting, engraving or welding

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task. Although for certain situation, user can buy a new machine, yet the price is still expensive. Consumer like students or workers and even university or college may not have full budget to buy these machine. On the other hand, one of the significant goals of this project is to design and fabricate a low cost and user friendly CNC machine that might be a best solution to overcome costly CNC machines. This project will focus on the practical design of CNC machine that is able to be used as workshop tool for educational purpose to small industrial scale.

Methodology

The prototyped built for this project includes the linear direction i.e. in x and y axis movement. The maximum displacement for the translational motion at x axis is about 50 cm and at y axis is about 40 cm. K-cam software is used to control the machine parameters. The CNC machine is constructed in three stages; a) to build mechanical frame, b) to assemble electric system and c) to install control and computing system.

The modelling of the CNC machine frame in 2d and 3d was conducted using SolidWorks. By calculation of the torque for required task suitable stepper motor was selected and structure material used to build the prototype includes machine aluminum profile (of 40 x 40 mm, 40 x 60 mm and 30 x 30 mm). The main components used to build the machine are: a) NEMA 23 2-ph stepper, b) 3-axis stepper motor control board, c) motor shaft couplings, d) limit switches, d) Micro-step drivers and e) acme leadscrews.

Design and System Implementation

The CNC machine frame with selected size of machine profile is built into a cube-like structure as shown in figure 1.

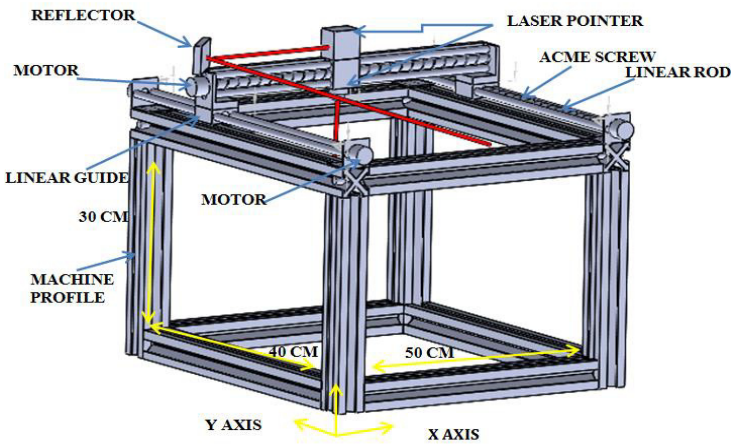

Figure 1: Isometric view of the CNC machine frame

This structure was chosen as it can provide large work space in the middle of cube-like structure for user to carry out ant laser cutting etc., experiments, and the Red beam in figure 1 is the laser path selected to utilize Nd-Yag laser device in later development stage of the system. This design is similar to three aluminum mountings attached together forming H-like shape on top of cube structural frame. Each mounting consists of 2 cylindrical rods and one linear guide to allow movement in 2-way linear direction. Linear rail guide is light and rigid plus commonly used in automated machinery such as CNC machine to achieve fast motion. Currently there are four types of linear rail guides available in the market as i) acme screw, ii) ball screw, iii) timing belt drive, and iv) linear sliding guides, each of them has their advantage and disadvantage. From the cost point of view, linear motor is the most expensive among the four types. On the other hand, timing belt has the lowest accuracy due to back lash and wears which can cause trouble especially for positioning application. After the consideration of cost and accuracy, ball screw or acme screw fits our design needs. Since we are focused onto the design of low cost and user friendly simple CNC machine, acme screw linear guides are used in the development of CNC machine.

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