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Automation of Small Scale Industries

Abhilash Yadav
Mechanical Engineering
Ramaiah Institute of Technology
Bangalore, India

Mallikarjun T
Mechanical Engineering
Ramaiah Institute of Technology Bangalore,
India

Pratush Maheshwari
Mechanical Engineering
Ramaiah Institute of Technology
Bangalore, India

Shashank R
Mechanical Engineering
Ramaiah Institute of Technology
Bangalore, India

Abstract:- Integrating digital, intelligent and remote access in the systems are the need for today's industry. The manufacturing industries are rapidly switching from mass production to customized production. The rapid development of improved methods in manufacturing technologies and integration of all the engineering principles from across the branches like deep learning, data science, artificial intelligence and mechatronics in the industries help in increasing productivity.

Automation of small-scale industries refers to incorporating features such as automated conveyors equipped with robotic arms for performing all the lifting, a variety of sensors to control and monitor the processes and a smart machining station that can be integrated along with the rest of the process to perform the actual machining operation.

Automation involves the use of an array of sensors for the process of data collection and processing the data in real time to control the manufacturing process using electromechanical, hydraulic or pneumatic actuators to control the process. The data collected by the sensors can also be used to develop a database for monitoring the entire process.

This paper proposes the control of the industrial process by using a microcontroller, a single board computer, and an ESP 12E based MCU. The main aim is to develop a low-cost remote control system for industries with compatibility to any smartphone. It provides the advantages of smart control. The entire system is connected to the internet makes it possible to access and operate the entire system remotely from all across the world.

Industry 4.0 is a strategic initiative being introduced by governments all across the globe. The prime objective of the initiative is the transformation of industrial manufacturing landscape by incorporating the new advanced technologies to streamline the entire process. Industry 4.0 is all about eliminating the limitations inherent in a system that is more human dependent. These systems aim to automate the processes that involve hazardous environments for human laborers or in some cases where the production capacity and quality may get compromised by the very nature of human-based labor.

The Industry 4.0 systems apart from automating the entire flow and making the various parts of the system work as a single integrated system with all the parts continuously working in perfect harmony by continuously being controlled by a single so-called brain of the entire system, aims to improve the overall workflow by integrating features like improved features for human safety, real-time data logging, measures for easy troubleshooting, remote access, reduced operation time, and better product quality.

I. INTRODUCTION

The paper aims to discuss various components of a system that we developed as a test setup for analyzing the various problems and challenges faced by small scale industries in adapting to automation. Automation is playing a key role in transforming the way products are manufactured across all the industries. The large industries have hundreds of thousands of dollars to pool into the research and development of intelligent automated systems that further improve their production efficiency as well as their production quality thus keeping the small scale industries at a disadvantage. The biggest challenge the small scale industries face in adapting to such advanced systems that can help them to compete against the large scale industries is not the lack of funds for setting up an intelligent automated system on a small scale but rather a lack of knowledge to acquire such a system and lack of funds to pool into R&D. The system we developed as a test setup includes a belt conveyor system that has a pair of IR sensors to detect the workpiece and trigger the entire workflow as well as keep live count of the number of workpieces that have passed through the manufacturing line. The next component is a robotic arm that is built using fused deposition molding, uses six servos as actuators and is controlled by using an Arduino microcontroller unit that makes the arm compatible with teach pendant method which can prove to be very useful in making the system adaptive to any changes in the work requirements. The actual machining operation is laser engraving and it is done by a CNC laser engraver that uses Arduino and a compatible CNC shield that uses A4988 stepper motor drivers to control the stepper motors that drive the screw rods to control the movement in the X and the Y direction. Load cells underneath the work surface of the CNC laser

engraver detect the workpiece and trigger the operation. Once the operation is completed the robotic arm picks up the workpiece and places it on the packaging line. The entire process is synced to a web server hosted on a raspberry pi that can be accessed from anywhere through the internet. A temperature and humidity sensor along with a smoke detector has been integrated into the system that monitors the system to detect any overheating or fire hazards. A cooling fan is also included to ensure proper functioning the system monitors the temperature and humidity and controls the fan speed to ensure a suitable condition for the smooth functioning of the entire circuitry. To ensure the safety and avoid any accidents a PIR sensor to detect human presence along with a Microphone module to detect any noise created in case of a mishap have been placed. A bright red colored LED is placed on the conveyor that is triggered if it is approached from the wrong side. In case of any fault or anomaly, the system is brought to a pause and a notification on the web interface is sent to the operator to rectify the issue. Once the issue is rectified the workflow can resume from the point where it stopped. The web server that is hosted on a local server and is hence free of cost is used to display data on a website that lists out the parameters that are essential for monitoring the system and ensuring its smooth functioning, further the entire system can be controlled using the website including absolute emergency stop. The test setup clearly established that a very cost-effective way to automate small scale industries and boost their production using off the shelf electronics components is available.

II. COMPONENTS OF THE SYSTEM

❖ *Sensors*

A. DHT 22

The DHT 22 sensor is a low-cost basic temperature and humidity sensor with a digital as well as analog pin for reading the temperature and humidity readings. The readings can be read at intervals of two seconds. The suitable temperature range within which the sensor can work reliably is -40 to +80 degree Celsius. The humidity reading can be from 0 to 100 % with an error of up to 2%. The module is very compact in form and lightweight. The current consumption of the device is not more than 2.5mAmps and this makes it especially suitable for systems which might need to run on battery power.

B. Gas Sensor

The MQ2 gas sensor is a sensor used typically in the detection of gases making it suitable for use across a variety of industries to detect any faults. The sensor can detect alcohol, propane, Methane, LPG, CNG, and Hydrogen. The sensor in our test setup was used to detect any fumes that might arise in case the circuitry begins to melt caused by any short circuits. The sensor has a fast response stable and long lifetime and a wide detecting scope.

C. PIR Sensor

The passive infrared sensor works by detecting infrared rays emitted by all warm bodied living animals. The sensor has a single output pin which goes high or low depending upon whether anything has been detected or not. There are two adjustable potentiometers that can be adjusted to adjust trigger range and time interval for which the output pin remains high after any movement is detected.

D. IR Sensor

The IR sensors used on the conveyors use active sensing an IR emitting diode and a black colored photo-diode work together to detect obstacles in their range which is adjustable by using a potentiometer. IR sensor module used in the test setup had a digital as well as an analog pin that can be used to read the output.

E. Microphone

The microphone sensor LM393 has a digital as well as an analog pin that can be used to detect sounds as well as read their intensity and has a built-in potentiometer to adjust its sensitivity.

F. Load Cells

The load cells consist of a physical element that can generate an electrical signal in response to any deformation.Commonly used strain gauge load cell was used in the setup for detecting the workpiece on the CNC laser engraver. The signal produced by the load cell is too weak to be detected by the microcontroller and be converted into any useful information. Therefore a level shifter in the form of load cell shield is used.

➢ *Web Interface*

The web interface is hosted on a local LAMP(i.e Linux, Apache, Mysql and PHP) server that could be run on any computer in our case for the test setup the raspberry pi 0W was used. The Arduino collected the data from all the sensors and equipments and sent the data to raspberry pi over a serial connection that is read by a python script that reads the serial data stream and then stores it in a Mysql database from where the data is read and displayed on the website running an HTML and a PHP script. The website can also be used for controlling the entire setup as every component is connected to a relay that can be used to turn it on or off. The website can also display notifications in case of any faults that the system might run into, thus the presence of a website to operate the entire system makes it truly an automated unit with IoT based monitoring and control.

➢ *Laser Engraver*

Engraving is the process of carving a pattern into a hard surface. Typically it's done by manual methods by making use of a wide variety of hand engraving tools. This is a laborious process and requires a long time for the person to acquire the skills required to carry out the operation. Fortunately, CNC machines can be used to engrave very sophisticated patterns. CNC engraving is sometimes purely utilitarian, such as adding a serial number to a portion. Other times it's an embellishment of art. The

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sort of CNC Engraving Machine you've got will determine most of the tools you need for making the engravings. The laser can be used in two ways to engrave. First, if the laser engraver is sufficiently strong, the material can be sliced. Second, even if cutting the material is not strong enough, using a method called Laser Marking it can discolor it in a visually unique manner. Laser engravers can be easier in many respects than devices using rotating cutters. The reason is a straightforward XY position is going to be enough – no Z axis with the laser is needed. They also have the big benefit that no force is imparted to the workpiece by the laser beam, so securing work is not a problem. The workpiece often rests on the table of the laser machine with nothing but the help of gravity.

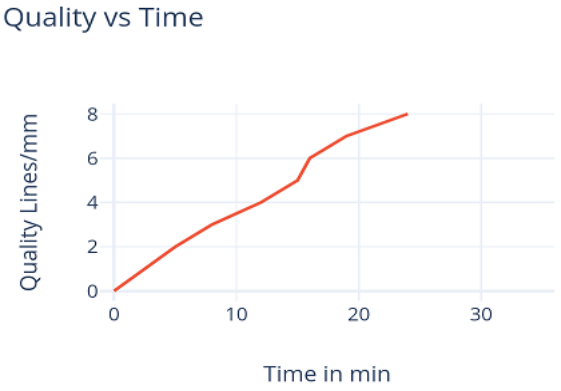

Fig 1:- Laser Module

The laser is a semiconductor device that is comparable to a light emitting diode in which at the junction of the diode instead of visible spectrum light the laser beam is produced. Laser diodes can transform electrical power to light directly. The doped p-n-transition, driven by voltage, enables an electron to be recombined with a hole.

Radiation is generated in the form of an emitted photon due to the fall of the electron from a greater energy level to a reduced one. This emission is spontaneous. When the process is continued, stimulated emission can be generated and light can be generated with the same stage, consistency, and wavelength.

The beam emitted from the controller enables patterns to be traced onto the surface. The direction of the controller, the intensity, the speed of motion, and the spread of the surface-oriented laser beam. To suit what the laser can do, the surface is selected. As the laser beam can be designed to carry energy to the surface in a way that transforms a large proportion of light energy into heat, a laser can extract material very effectively. In most non-reflective products, such as wood, plastics, and enamel surfaces, the beam is extremely concentrated and collimated. The point where the laser touches the surface (the terms "object" and "laser beam" can be used interchangeably) should be on the focal plane of the optical system of the laser and is generally associated with its focal point.

Typically this point is tiny, maybe less than a fraction of a millimeter (depending on the optical wavelength). When the laser beam moves over the surface, only the region inside this focal point is considerably impacted. The energy supplied by the laser causes a shift in the material surface at the focal point. It can heat the surface and then vaporize the material, or the material may break (known as "glazing" or "glazing up") and flake off the surface. Generally speaking, cutting through a metal part's paint is how the material is laser-graved.

Laser Head Size	33x33x63mm
Driver Board Size	65x43mm
Material	Aluminum + Brass
Output Wavelength	445nm~450nm(Blue Purple-Ray)
Output Power	Max. 2.5W, Average 1.6W
Operating Voltage	DC 12V
TTL signal	Yes, low level (0V): OFF, high level (5V): ON.

Table 1:- Specifications for the Laser Module

➢ *Laser GRBL*

Laser GRBL is a software package that is used for controlling the CNC shield and by means of a UI based layout. It allows the user to upload a variety of supported format of images to be processed the CNC operation. The firmware can be flashed onto a microcontroller unit such as an Arduino and the GUI can be run on Windows or Linux pc. After uploading the image and selecting the appropriate machining speed and desired quality for the operation the software generates suitable G-codes or for performing the operation. The software supports the most common image formats like JPEG, PNG and even raster images, the UI displays estimated time till completion and the cursor can be seen moving across the image work window to facilitate easy monitoring of the current status of the job. The GRBL software serves as a low-cost alternative to the parallel port based motion control commonly used in large Industrial level machines. The software, however, is capable of producing results which are at par with its more expensive counterpart. The GRBL firmware is developed to make it possible to design develop and operate a CNC system at an affordable price by using off the shelf electronic components and microcontroller units like the Arduino Uno or the Arduino mega.

A. Stepper Motors

A stepper motor also referred to as a step motor or stepping motor is a type of brushless DC electric motor that divides a full rotation into a large number of equal steps. The position of the motor can then be ordered to move and hold for feedback at one of these steps without any position sensor as long as the torque and speed of the motor are carefully sized to the application.

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Stepper Motor Specifications	
Type:	NEMA 17
Drive system:	Unipolar
Step angle:	1.8° full step 0.9° half-step
Phase/Windings:	4/2
Voltage & Current:	12V at 400 mA
Resistance per Phase:	30 ohms
Holding Torque:	2000 g-cm
Detent Torque:	220 g-cm max
Weight:	0.24 kg
Max continuous power:	5 W
Rotor Inertia:	22 g-cm^2
Bearings:	Ball
Mounting hole space diagonal:	1.73 in.
Mounting screws:	3 mm Dia. 0.5 mm pitch
Shaft diameter:	0.197 in. (5 mm)
Motor footprint:	1.7 in. × 1.7 in.
Motor height:	1.5 in.
Ambient temperature:	-10°C to +55°C

Table 2 - Specifications of Nema 17 Motor

➢ *Arduino CNC Shield*

When constructing your CNC or stepper control board, you want a well-designed board that will house your stepper controllers and enables simple parameter setup (Example setting the stepper controller steps with jumpers). This CNC shield is a well-designed board that takes the difficulty with your own hardware design and enables you to concentrate on just coding the Arduino.

- GRBL 0.9 compatible. (Open source firmware that runs on an Arduino UNO that turns G-code commands into stepper signals)
- PWM Spindle and direction pins
- 4-Axis support (X, Y, Z, A-Can duplicate X, Y, Z or do a full 4th axis with custom firmware using pins D12 and D13)
- 2 x End stops for each axis (6 in total)
- Coolant enable
- Uses removable A4988 or DRV8825 compatible stepper drivers
- Jumpers to set the Micro-Stepping for the stepper drivers. (Some drivers like the DRV8825 can do up to 1/32 micro stepping)
- Compact design.
- Stepper Motors can be connected with 4 pin Molex connectors or soldered in place.

Runs on 12-36V DC. (At the moment only the DRV8825 drivers can handle up to 36V so please consider the operation voltage when powering the board.)

❖ *Plots and Figures*

Fig 2:- *https://photos.app.goo.gl/euT69gyK7BM7BBFS8 All the pictures, plots and figures relevant to the research can be found by scanning above QR code or by visiting the link.*

III. CONCLUSION

The project is aimed at proving that a low cost and efficient model of a fully automated material handling and processing line can be developed by carefully combining the principles of mechanics, robotics, and Internet of things. The entire prototype used in testing was built from scratch within a period of merely three months thus highlighting how effortlessly we can integrate the principles of automation to benefit the small scale industries that contrary to their names account to nearly half of the entire GDP of our nation. The government not only in India but all across the world are taking initiatives to promote the use of modern technology and concepts like IoT, Mechatronics, Artificial Intelligence, Data Science and Machine Learning to morph the way things have been manufactured since the third industrial revolution. The fourth industrial revolution is here and we as a nation must enable our industries at every level to make the best use of it. The research done was to investigate in general the possibilities of integrating these principles in small scale manufacturing however the design can be modified to suit the specific application.

The intuitive controlling and handling methods used to feed the input through wireless access points across the globe make it very suitable for use by small scale industries

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