

Pick and Place Robotic Arm for Lifting Grinding Wheels in Industry

Dr.T.C.Thnauja¹, Sandhya.M.Sudi²Professor, Dept. of VLSI Design and Embedded Systems, Centre for PG Studies, VTU, Belagavi, India¹P.G. Student, Dept. of VLSI Design and Embedded Systems, Centre for PG Studies, VTU, Belagavi, India²

ABSTRACT: In the modern industry, companies achieve competitive advantages in terms of production value, speed and efficiency by implementing innovative ideas of automation. In the present trend human labor is used for picking up the heavy grinding wheels and hence compulsory use of robots is required. This project proposes an advanced mechanism which picks up the grinding wheels and places them at required position. The conventional method of picking up by finger gripping the objects is replaced by magnetic gripping mechanism. Among various mechanisms available, the magnetic gripping mechanism is selected. To demonstrate, a prototype robotic arm which can rotate 90 degrees is used and the control system of the robot is designed using ARM LPC 2148 controller and embedded C language. The robot is completely autonomous and a single switch is used for starting the operation. By implementation of this idea in industries 90 percent of the human labour can be reduced and the cost of damage due to mishandling of wheels can be reduced.

KEYWORDS: Magnetic gripping, ARM LPC 2148, Embedded C

I. INTRODUCTION

This paper presents the prototype of the proposed methodology of picking up grinding wheels by magnetic grippers. A Grinding Wheel is usually a tool of precision that is composed of abrasive grains held together by a 'bond' or bonding material. It helps in cutting the material accurately to the required dimensional and provides with surface finish. Since these wheels are very heavy, there is a need for robots to pick them up from manufacturing unit and place them at required position. The robotic arm grippers are available in various types such as vacuum grippers, magnetic grippers, mechanical grippers, pneumatic grippers. In this paper, a robotic arm which can move around 180 degrees in horizontal and vertical directions is selected for picking up the grinding wheel. The control system is initially designed and tested using Proteus v7 software. The proposed system is demonstrated by a prototype which is controlled by ARM LPC2148 controller and the controlling code is written in Embedded C language.

The work proposed in [2] presents the idea of designing a robotic articulated arm of 4DOF. The work focuses on angular movement of the arm. The main information extracted from this paper is how the 4DOF was achieved using 4 servo motors and ATmega 16 Development board.

Moreover, the work of [3],[5],[6] is very useful for further enhancement for the current method proposed in this paper. The works of these papers presents a method to develop an image processing algorithm which identifies the object between other foreign objects. After identification, the information is processed to obtain the co-ordinates which are sent to robotic arm and the arm performs the job of pick and place.

Paper is organized as follows. Section II presents the design of the control system of the pick and place system, its hardware implementation. In section III the design of robot End Of Arm Tool (EOAT) i.e. the magnetic gripper is discussed and the flow diagram represents the step by step process of the pick and place system. The simulation results obtained in Proteus v7 tool and the hardware implementation results are discussed in section IV of the paper.

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II. DESIGN OF THE PICK AND PLACE SYSTEM

The system is centrally controlled by ARM LPC2148 controller. The system is completely autonomous and hence a single switch is used to start the operation. Four single channel relays are used to control two geared DC motors. The output current of microcontroller is 3.3V which is insufficient to drive the relays and hence a driver IC ULN2003 is used to drive the relays. When the Arm controller is powered up, the execution of the program stored in the controller starts. The signals are given to driver IC ULN 2003 according to the program. The driver IC is programmed to perform pick and place at required intervals

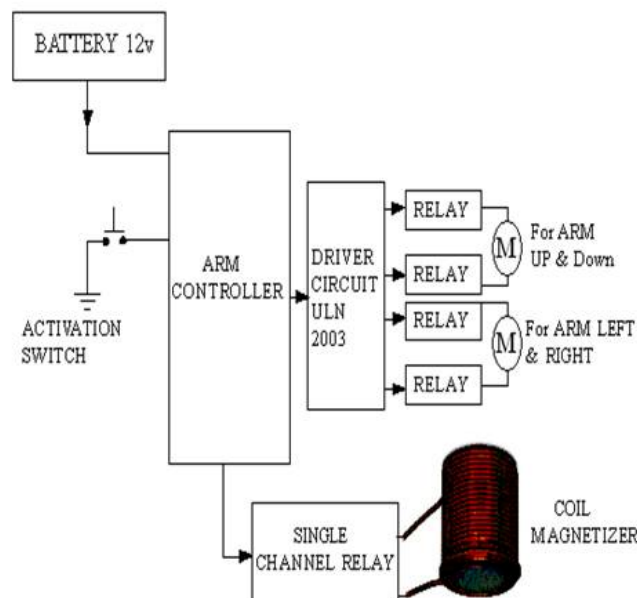


Figure 1 Block diagram of pick and place system

- **Driver circuit:** The microprocessor output is 3.3V which is insufficient to drive loads or the relays. In such a scenario, a driver circuit is used to amplify the signal.
- **Relay:** The operating voltage for DC motor and ARM LPC2148 are 12V and 3.3V respectively. The relays acts as bridge circuits between the two and protects the controller. Four single channel relays are used to drive the geared DC motors and one single channel relay is used for magnetic gripper. These relays drive the DC motors which perform the movement of robotic arm.
- **Dc gear motor:** Gear motors are used for commercial applications where high amount of force exertion is needed to move a heavy object. Two DC geared motors with 12V operating voltage and output of 45rpm are used for x-axis and y-axis movement of the robot arm.
- **Battery:** A secondary battery is used to power up the robotic arm. We use a 12V sealed Lead Acid battery to supply power to the geared DC motors since they cannot operate at 3.3V which is the output of microprocessor.

After assembling the components, the control system of the pick and place system looks as shown below

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Figure 2 Hardware Implementation

For demonstration, the robotic arm with following specifications is used

Name: Robo Bricks MobiARM

Robo Bricks is a robot from Robosoft Systems. Two DC motors of 12V, 45 r.p.m rating are used and a third motor is used in the gear box which is a 12V, 60 r.p.m motor. In the electronics part, the robot has two modules ,PCB and the motor driver module enclosed in the main body of Robo Bricks.



Figure 3 Robo Bricks MobiArm

III. DESIGN OF MAGNETIC GRIPPER

Consumers demand versatile robots due to complex operations and high costs. Manufacturers want to add value to the overall system by delivering flexible end of arm tooling in order to survive in the market. In magnetic type of grippers, the grasping action is performed by magnetic substance for handling ferrous materials. Electromagnetic grippers or Permanent magnet grippers can be used for this purpose. When moving ferromagnetic metals, the arms will be attached with the magnets with suitable strength to move the objects. Also magnetic grippers have following advantages over other grippers

- Only one surface is needed to grasp the object.
- The speed of grasping is fast.
- Distinct designs for different parts are not required for different parts.
- Magnetic grippers can hold parts with holes unlike vacuum grippers.

International Journal of Innovative Research in Science, Engineering and Technology

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- Minimum maintenance is needed and hence low cost.

Since, in the proposed method, the robot arm has to pick up the grinding wheel and place it down, both magnetizing and demagnetizing action is required hence electromagnet method of gripping is used. An electromechanical relay is used as magnetic gripper in this project. Electromagnet is the heart of the relay which becomes a temporary magnet when electricity flows through it. This part of the relay is made to act as the magnetic gripper. When the current flows through the winding, a magnetic field will be set up around the core. The magnetic field becomes stronger if the number of turns of the coil are increased. The magnetic field flows around the coil through its centre in a doughnut shape. The flux linkage is increased by the core when the coil is energized with current. The other parts of relay such as armature, spring and contact are removed and only the electromagnet part is retained. This is interfaced directly to another relay present on board. The electromagnet has operating voltage of 12V and internal coil resistance: 5 to 10 ohms.



Figure 3 Electromagnetic relay

The operation of the robotic arm can be represented by a flowchart in a generalized manner as shown in Figure 4

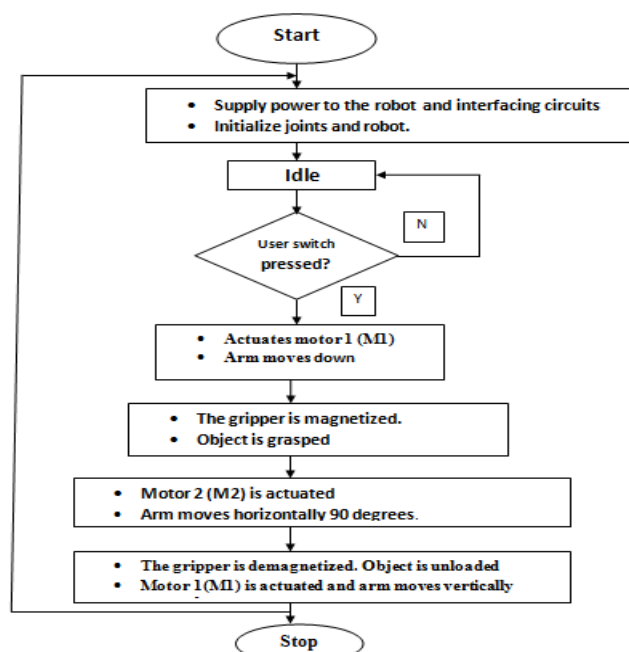


Figure 4 Flow chart of operation

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Website: www.ijirset.com

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The procedures explained above are programmed and processed in the microprocessor. It is possible to program it to make any decisions by merging artificial intelligence (AI).

When the push button is pressed, the robotic arm moves downwards along the Y axis in 7 seconds. At this point, the gripper is magnetized and waits in that position for 1.4 seconds delay and the work piece is grasped. The arm again moves 90 degree upwards along Y axis again. At this point, the X axis movement is initialized and the arm moves horizontally 90 degrees. Again the arm comes down and all this is done in duration of 7 seconds. Now, in order to place the object, the gripper is demagnetized and remains in that state for about 1.4 seconds. With this, one cycle of operation is completed. The operation is continued until it is halted manually by switching off the power.

IV. RESULTS

The results are discussed in two phases.

- The first phase shows the simulation results obtained when the designed control system was tested in Proteus v7 tool.
- The second phase results describes the hardware implementation of pick and place system.

Phase1:

To start with, the Proteus V7 software was selected for the design of pick and place system. The circuit was designed and tested. After ensuring the proper working of the circuit, the hardware implementation was done.

The flow of the simulation is as follows:

1. The activation switch is pressed
2. The arm moves downwards i.e vertical (M1 starts rotating).
3. The gripper is magnetized (LED –yellow is activated).
4. The arm moves vertically upwards (M1 rotates)
5. The arm moves horizontally back to the position (M2 rotates)
6. The gripper is demagnetized(LED –yellow deactivated)
7. The arm moves vertically i.e back to its start position.
8. The process repeats.

The LED (yellow) is activated (ON) after the first two steps mentioned above. This indicates that the flow of program is correct and the gripper is magnetized and the object is grasped. The gripper will be activated for 20 seconds.

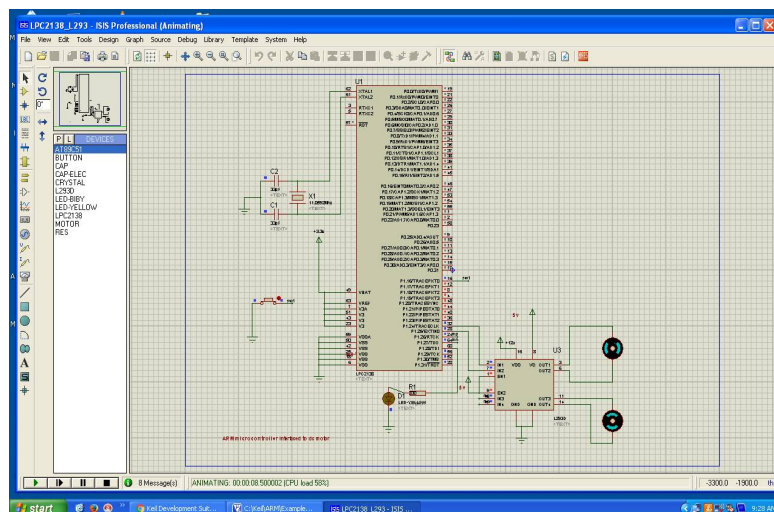


Figure 5 Simulation result part 1

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Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

The LED (yellow) is deactivated (OFF) after the first five steps mentioned above. This indicates that the flow of program is correct and the gripper is demagnetized and the object grasped will be unloaded successfully.

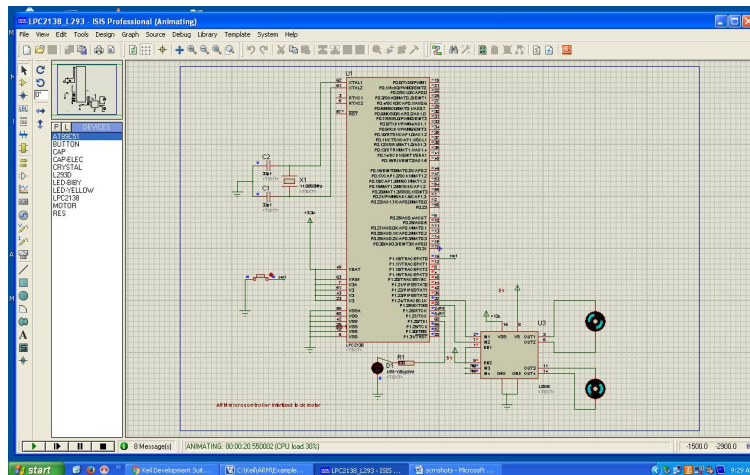


Figure 6 Simulation result part 2

Phase 2:

To demonstrate the proposed methodology, we selected a lid that is made of steel. The lid weighs about 10 gm and have hole of 6mm at the centre. The lid is spherical in shape and has a hole at centre which resembles the metallic grinding wheels.

When the controller is powered up, the instructions are executed according to the flow of program. The gripper is magnetized, lid is picked up successfully and held for 7 seconds and the gripper is demagnetized and the lid is unloaded. This effectively proves that the magnetic gripping mechanism can be used for picking up the grinding wheels in industry which is the main objective of this study.

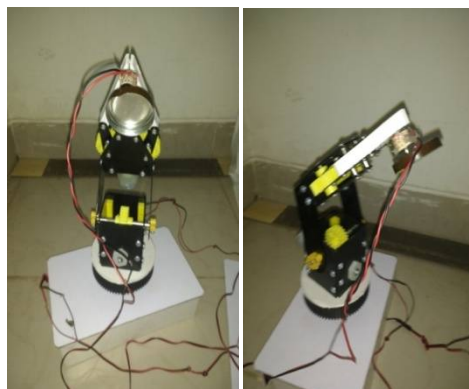


Figure 7 The product is lifted successfully

V. CONCLUSION AND FUTURE SCOPE

A steel lid with 6mm hole at the centre was selected as the product to be lifted because it is similar it is grinding wheels in physical appearance and the magnetic gripping method is selected. A robotic arm and magnetic gripper were selected for building a prototype. The control system for controlling the robot was designed by

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programming the ARM LPC2148 controller using embedded C language. The prototype proposed successfully lifts the product and hence the magnetic gripping mechanism used is successful.

Further, the functionality of the robotic arm can be increased by interfacing a pull load cell at the top of the arm, which measures the weight of the wheels simultaneously when picked up. In such case, the robotic arm will be capable of sorting the wheels according to the weights. The robot function can further be extended by connecting wireless camera, so that we can monitor the manufacturing process and also detect the presence of foreign objects or absence of the product. Minimum pressure accumulation, quiet operation and easy installation can be achieved by this.

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