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DESIGNING A ROBOTIC ARM GRIPPER FOR PRINTED CIRCUIT BOARD IN SOLDERING APPLICATION

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Abstract
With an advancement in the science and technology, the sensitivity of a mechanical system is towards the real time application, is of greater concern. A robot in which the applications are utilized in the day-day operations must be able to grasp the object with more firmness and the delicacy. Our approach are been inspired with a gripper, which is used to grip objects placed near by it. It starts search for the object and tries to grab it via gripper, which will acts as "Hand of Arm". If the object is gripped it will return to its home position. The main objective is to make designs on the printed circuit board in soldering process by using lead. The flow of lead should be in continuous according to the need. So in order to get proper design on the printed circuit board, the inductive proximity sensors have been implemented and is been used for measuring the nearby objects without any physical contact. In this a general grip force is applied by the gripper which should be compatible with the human grip force. Finger tip of the gripper should tactically apply a grip force while holding up as well as allowing the flow of lead.

Introduction
Robot arm is been developed and interfaced with 8051 microcontroller for its respective operation. Robotic automation system is growing rapidly in advance taking the place of the human work force [1]. One of the best benefits in this change provides the human work force with the time to spend on more creative and in realistic tasks. The highest usage of robots is in spray painting, material handling, and in the arc soldering. The Spot welding and spray painting applications are mostly used in the automotive industry. Thus the number of automation robot stations are been growing up very rapidly. Typically, a robotic stations are comprised of a robot, a robot controller, soldering equipment, a work clamp and motion devices is to hold work pieces accurately in its position (considering heat deformation), the robot motion devices is to move around the robot for a larger working range and better positions, sensors, and safety devices[2]. The basic method of this process is neatly explained in below Fig 1.

Design a robotic arm by using embedded C programming
⇩
The arm gripper is kept at constant by interfacing programming
⇩
Inductive proximity sensor is been attached
⇩
By using the sensor, distance is been measured for the flow of lead at constant
⇩
Printed circuit board is been kept, were the soldering process is done
⇩
The output is been shown by implementing the circuit.

Fig.1. Methodology of design in robotic arm gripper for printed circuit board in soldering application.

Experimental work
Thus the experimental procedure and experimental setup are been discussed in the following sub-sections,

Description of the system components

The robot and the controller: A robot is programmed to move the lead torch along the soldering path in the given orientation. The robot is typically designed of a large number of links and linkages, which are interconnected by gears, chains, belts, and screws. The majority of industrial robots are actuated by linear, pneumatic, or hydraulic actuators, and electric motors. In most of high-end robots currently they use AC servo motors. At which they have replaced the usages of hydraulic actuators and DC servo motors at recent. AC servo motors are essentially free maintenance, which is important in industrial applications. In a soldering robot system, the lead is attached to the wrist of the robot, ie. gripper which has two or three axes of motion [3]. As the technology

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develops, there is less application for the robots with a two-axis wrist motion. The robot has the most effective motion whereas the center point of gripper is aligned with the center line of the upper arm. A robot with a 3-axis lower arm and a 3-axis wrist will permit the flow of lead action that is necessary for a complicated soldering process. The lead can be moved to satisfying all angles requirement, such as, the work angle, transverse angle, travel angle, and longitudinal angle. The controller is the brain of the robotic soldering system. This is because the controller stores the robot programming and soldering data, and performs the necessary computations for robot control, and typically by a high-speed microcontroller. The controller gives a signal to the actuators and the motors by programmed data and position, speed, and other information obtained from inductive proximity sensors. The controller is now integrated to govern not only the robot but also any peripheral devices, such as manipulators [2]. When the system is needed to solder a particular point in printed circuit board that has complicated geometry, then the simultaneous coordinated control of the integrated controller are been inevitable.

Position and force control: In addition to the enrich the tactile sensations described above, humans excel at the manipulation because they can move competently through free space but quickly transition to regulating grasp force during the object contact. Replicating the fluidity of human grasping with a high-impedance parallel jaw gripper, which it requires well the designed position and force controllers. To facilitate a generic presentation of our approach, in this mathematical constants have been used in the article which are designated with the all capitalized naming convention. The PR2 gripper is said to be a geared mechanism, so it lends itself well to position control. We have defined its position xg in meters and velocity vg in meters per second [1]-[2]. The gripper velocity follows same sign as position, with the positive values indicating that the hand is opening. We found here, that we could achieve some good position tracking via a simple proportional derivative controller with an additional velocity-dependent term to overcome the friction.

ie,

E = KP _ (xg–xg,des) + KD _ (vg –vg,des) - sign(vg,des) - EFRICTION. -- (1)

Here,

E is the motor effort (N),

KP is the proportional error gain (N/m),

KD is the derivative error gain (Ns/m),

xg,des and vg,des are the desired gripper position(m) and velocity(m/s) respectively. EFRICTION is a scalar constant for forward friction compensation, which is applied to encourage motion in the direction of vg, des. Note that motor effort is defined as positive in the direction that closes the gripper, which is opposite to the sign convention for the motion variables. We have developed a force controller that drives the desired position and velocity terms based on the error between the desired force and the actual force.

Geared dc instrument motor: The 1271 series geared instrument dc motor is ideally suited to a large range of applications requiring a mix of low speed operation and little unit size. The integral iron core dc motor provides swish operation and a two-way variable speed capability whereas the gear head utilizes a period of time metal spur gear train rated for an operation in torque up to 0.2 Nm. The unit, that is appropriate for mounting in any angle, provides reliable operation over a large close temperature range and is supplied with an integral VDR (voltage dependant resistor) electrical suppression system to reduce electrical interference. The 1271 series unit offers a spread of substances quantitative relation choices for in operation speeds from 5- 200 revolutions per minute and is ideally suited to applications wherever tiny size and low unit value are necessary design criteria.

Manipulators: A robot has some limited working range and accessibility, therefore in many cases the manipulator has to be considered. A manipulator is a device which acts for holding the work piece and is moved around (typically with linkages) for better access and soldering positions. The advantages of a manipulator include:

1. A manipulator can be easily moved around the work piece for the best soldering positions.
2. A manipulator can also reduce the variation in the lead and the lag angles of the tip.
3. Soldering can be performed in a stable flat position by a synchronized and can simultaneously control the robot and a manipulator.
4. Any hard-to-reach positions are often accessed in addition, and simply by moving the robotic arm.
5. A manipulator will increase the operating range of a fixed floor mounted on mechanism or an inverted mechanism.

In general, a robot can maintain a better flat soldering position which will produce a better deposition and, thereby can reduce any repair work by the cooperation with a manipulator. This also makes possible higher soldering speeds and, thereby, can increase in the productivity. There are two basic types of actuation systems used here for manipulators; namely, the indexing type system and the servo-controlled system [3]. The indexing type system is used in common for economic models and is commonly actuated by pneumatic and the AC motors. This method of system is usually controlled by signals for target position with constant speed. Servo-controlled kind system is employed for speed and direction. This could be a fashionable system since it's a complicated structure with the servo motors, worm gear reducers, and therefore the encoders or resolvers. However, the servo-controlled type system has some higher accuracy and variable speed control in both the directions of rotation. Thus the errors are compensated by the feedback control.

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Sensors: Sensors are used for collecting the information from the robot, peripheral devices that process and transfer its information to a controller within the soldering, it's essential to contemplate deformation from a high heat input and thus, a closed-loop system control with a sensor is important. Also, in an automatic soldering system the errors are caused by producing tolerances of manipulator and also the work pieces have to be thought-about. Various kinds of sensors for robot is been utilized in completely different concern. The right type of sensors must be chosen depending on the application.

Sensor types:

Contact type (soldering seam tracking):

Mechanical type: Roller Spring. Electromechanical type:

1. Two probes across the seam line.
2. A probe in the seam line. Electric control type with probe.

Non-contact type (Various Purposes)

Physical type:

1. Acoustic – arc length control.
2. Capacitance – distance control.
3. Eddy current –seam tracking.
4. Induction – seam tracking.
5. Infrared radiation – penetration control.
6. Ultrasonic – penetration and the quality.
7. Magnetic – detects electromagnetic field.

Through-the-arc type:

1. Arc length control (arc voltage).
2. Weaving with the electric measurements.

The Optical/vision (image capture and process):

1. Vision sensors.
2. Laser sensors.
3. Optical-electric sensors.

Proximity inductive sensor: The proximity inductive sensor is a sensor which is used to detect the presence of objects around the place without any physical contact. The proximity inductive senor often emits an electromagnetic field or a beam of the electromagnetic radiation and that appearance for changes within the field or by comeback signal. The thing being sensed is commonly observed because the inductive sensor's target. Totally different inductive device targets are demanded on the various kinds of sensors. As an example, a capacitive photoelectric sensor may be appropriate for a plastic target; an inductive proximity sensor continuously continually needs a metal target. The maximum distance this sensor can detect is been defined as "nominal range"[4]. Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity inductive sensors having a high reliability and the long functional life because of the absence of mechanical parts and because, lack of physical contact between sensor and the sensed objects. Proximity inductive sensors are also been used in the machine vibration monitoring, used to measure the variations in the distance between a shaft and its support bearing. This is common in every large steam turbines, compressors, and motors that uses the sleeve-type bearings.

Track, gantry, column, and peripheral equipment: When the work pieces are too large for the robot workspace, or a robot cannot reach some interior soldering points, peripheral devices such as a track, a gantry, or a column should be considered. These devices have benefits of increasing their work area, flexibility, and also the multiplied productivity. Also, it's attainable that a robot may fit on a multiple of work pieces and, thereby, increase its time. For the economical use of those devices, it's advantageous to supply all the axes of the system (including the robot and peripheral devices) with the coinciding or a synchronized control operation. The standardized and modularized system may be chosen based on the load carrying capacity, stability, accuracy and repeatability, where the maximum number of axes that the controller can handle. However, the productivity is proven by practice is the most important criteria.

Track: Track is to increase the working range of the robot and is mounted on a track as shown in fig. The track also provides flexibility for the future consideration of the size of the work piece. In addition, a track is beneficial once the breadth of the pieces is a smaller amount than 1meter and a travel distance larger than 1.5meter that is needed. Most typical work pieces for track application are the automotive panels, tractor frames, bed and furnishings frames, rear axle instrumentation doors, and therefore the PC racks. For an exaggerated arc time and therefore the productivity, the conception of 1 robot with multiple work stations is employed. This is also illustrated in Fig.2.

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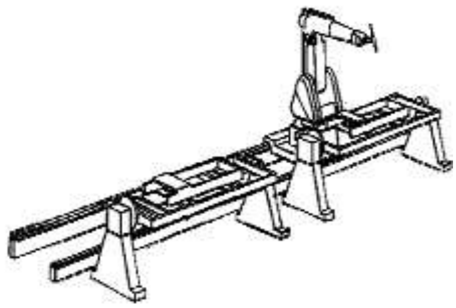

***Fig.2 A Robot Mounted on a Track*.**

Gantry: A gantry is a steel structure where the robot is suspended and been inverted. Using a gantry, a robot can solder the work pieces of different sizes. A very large work piece can be soldered with multiple robots suspended on a single gantry or multiple gantries. Figure.3 shows two robots suspended from a gantry (i.e., a grinding robot and a soldering robot) working on a double station manipulator. Those two robots suspended from a gantry is been shown in Fig. 3.

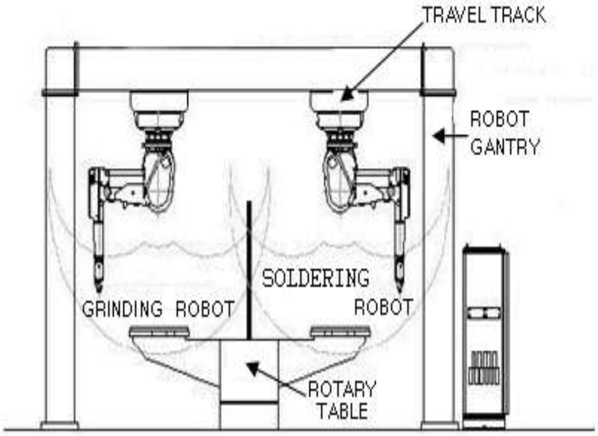

Fig. 3 Two Robots Suspended from a Gantry.

Column: A column is developed from concept of modularization. While the track moves in a single horizontal direction, where the column may fix the robot or move the robot in a vertical direction and a horizontal direction [5]-[6]. A column occupies less space in the plant and makes the possible of efficient utilization on the space. Also, the wirings of soldering wire, the power and signal cables may also be placed in a duct inside the column used to avoid unnecessary exposure. As shown in Fig.4, a robot suspended from a column may have better accessibility and weld position than a floor mounted robot. There are some stationary (fixed), traveling, rotary, and rotary/traveling types of columns.

Soldering fixtures: Manufacturing of soldering fixtures, it requires experience and to know-how it works. A designer should have a profound knowledge of tolerances of work pieces before and after soldering. Also, a designer should obtain information from experienced soldering experts [5]. The geometry of a fixture is based upon the geometry of the work piece and the clamping device of the manipulator. The fixture should guarantee a good soldering position and should be protected against heat, smoke, and spatter. A picture of robot which is suspended from a column is been shown in the Fig. 4

Safety: A Soldering robot system should be on a firm foundation so that any vibrations will not produce a shaking effect on the system. Also, the emergency switch button (with colors of yellow and red) should be located at a position that is easily accessible. The switch should stop the robot without shutting off the power [7]. There should also be a safety fence to protect the work force from spatter and arc flash. Fig.5 shows a complete system of a safety fence. For safety, the robot operator should have to be an well trained on robot speed, working range, emergency stopping, and the functions of teach pendant. The training should also provide the operator with the opportunity to become familiar with the robotic system. While designing a robot system, sample time for system modification and operator coaching is indispensable [8].

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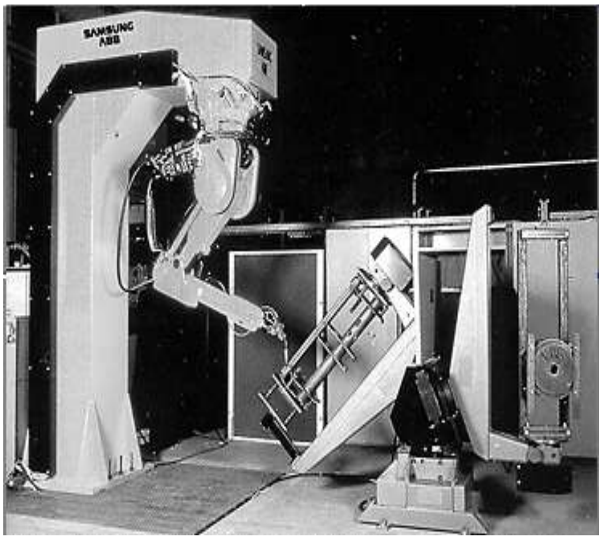

Fig.4. A Robot Suspended from a Column

Also, obstacles within the operating space of the operator ought to be eliminated and also the system ought to be designed in order that the soldering is performed at a secure distance from the operator. For this purpose, a manipulator ought to be designed with twin stations with safeguards in order that the operator will work safely on loading and unloading.

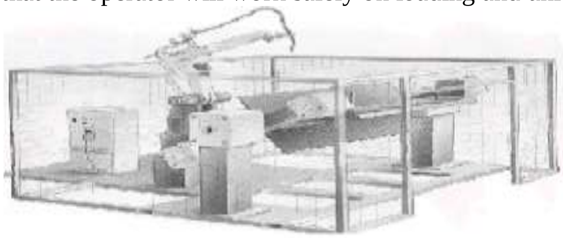

Fig.5. A complete system of a safety fence.

After the system is designed, installed, and tested, all detailed information in the design. The processing which should be documented and have to be transferred to the operators.

The robot program

Programming method: In initial generation robots were programmed by the manual operation. However, in fashionable technology, there are four common strategies for mechanism programming namely:

1. Programming by a Teach Pendant: The operator uses a frenzied teach pendant for the robot teaching and also the program writing. Teaching is applied for the tool center point (TCP) and also the liquid crystal display board is adopted for its menu guide. It's simple to use however restricted in applications and extension [9]. A teach pendant is that the most well-liked device in robot programming 604 Industrial artificial intelligence in the Programming, Simulation and its Application.
2. Programming by the Manual Lead-Through: A well trained soldering expert will hold the holder near the torch and program by manual lead-through. This was common in first generation robots, however, in modern technology, it only used for spray painting robots.
3. Programming by a Robot Language: The mechanism is programmed by a program language employing a monitor and a keyboard. There exist many command, motion, and operation level languages [10]. The operation level language solely describes the ultimate goal of the method, and also the sequence of motion and information are generated mechanically. This programming technique remains noticeably in research stage.
4. Programming by a Simulator: A graphic simulation is performed and it's translated into the language of the mechanism. This can be conjointly mentioned as off-line programming.

Soldering data: Soldering data is special data of parameters that are used in the soldering method. The soldering information consists of begin data, main data, end data, and weaving data information.

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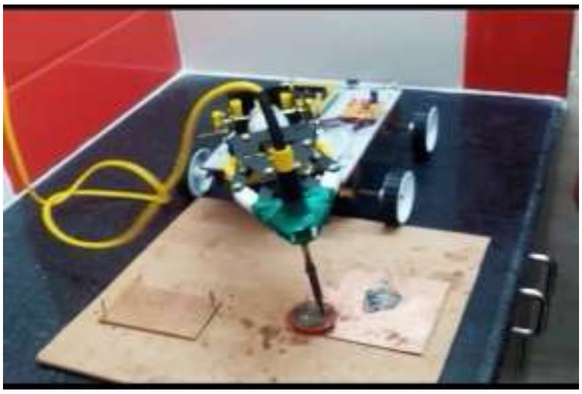

Fig.6. Working model.

Conclusion

Currently the experimental set-up which are been described in this above contents are fully based on the robotic arm gripper which is used for the soldering purpose and are accessible only from the department of robot. Thus in working mode is shown in Fig 6 is been processing with this concept. Sensors will be used for the user evaluations, the experiment documentation and the educational support material are under development. Thus this is easy way for soldering the printed circuit boards in a safe manner and also can extract this concept in huge machinery systems for future uses**.**

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