ROBOTIZED ULTRASONIC WELDING OPERATION FOR PLASTIC MATERIALS

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ABSTRACT: The paper aims to present a possibility of using the ABB IRB 1600/1.2m industrial robot in a nonconventional ultrasonic welding operation. Several aspects have bob e analyzed, starting with the equipment weight, connections and economical feasibility of such a proposal.

KEYWORDS: robotics, ultrasonic welding, plastic materials.

1. INTRODUCTION

Ultrasonic welding was developed by Aeroprojects Company, now known as Sonobond. The main industries where ultrasonic welding is applied are presented in table 1.

Table 1. Industries that use ultrasonic welding.

Electrical	Staking and inserting applications Main applications include: terminal blocks, connectors, switches and bobbins (electromagnets, transformers)
Packaging	Aseptic packages
Automotive	Glove box door, instrument cluster, air diverter and mass airflow sensor.

Generally when plastic materials are used, ultrasonic welding becomes a widely used procedure. Nowhere is this more obvious as in the toy industry where the elimination of adhesives, screws and solvents, or other consumables is a bonus added to strong, safe, flash-free assemblies [4].

All ultrasonic welding systems are composed of the same basic elements:

An ultrasonic generator unit composed of a converter or piezoelectric transducer, a booster and a sonotrode (also known as a horn.

The ultrasonic frequencies at which the process is possible are typically 20, 30, 35 or 40 kHz.

Converter: Converts the electrical signal into a mechanical vibration

Booster: Modifies the amplitude of the vibration. It is also used in standard systems to clamp the stack in the press.

Sonotrode: Applies the mechanical vibration to the parts to be welded. [5]

Benefits of the process include: energy efficiency, high productivity with low costs and ease of automated assembly line production. The main limitation of the process is that the maximum component length that can be welded by a single horn is approximately 250 mm. This is due to limitations in the power output capability of a single transducer, the inability of the horns to transmit very high power, and amplitude control difficulties due to the fact that joints of this length are comparable to the wavelength of the ultrasound. [5]

2. THE ABB IRB 1600 ROBOT

Designed to be cost optimal, the IRB 1600 is as masterful in arc welding as in die casting, machine tending, material handling, injection mounding, assembly and packaging.

The main characteristics of the IRB 1600 robot are:

- Handling capacity: 6 kg
- Reach: 1.2 m
- Number of axes: 6
- Mounting: floor, wall, tilted
- Robot base: 484 x 648 mm
- Weight: 250 kg.

Although the ABB IRB 1600 robot was designed for arc welding, using an ultrasonic welding device is possible due to its flexibility to accommodate several types of grippers. The gripper can be either electric, pneumatic or a combination.

The ABB IRB 1600 robot is controlled by an IRC5 Controller. IRC5 is ABB's fifth generation robot controller. Its motion control technology, TrueMove & QuickMove, is key to the robot's performance in terms of accuracy, speed, cycle-time, programmability and synchronization with external devices. [7]

Figure 1. ABB IRB 1600 robot.

Performance

Control hardware

- Multi-processor system
- PCI bus
- Pentium® CPU
- Flash disk or hard disk for mass memory
- Energy back-up for power failure handling
- USB memory interface

Control software

- Object-oriented design
- High-level RAPID robot programming language
- Portable, open, expandable
- PC-DOS file format
- Robot Ware software products
- Pre-loaded software. Also available on CD-ROM

- Inputs/outputs Up to 2 048 signals
- Digital 24V DC or relay signals
- Analogue 2 x 0-10V, 3 x ± 10V, 1 x 4-20mA
- Serial channels 3 x RS 232/RS 422
- Two channels Ethernet (10/100 Mbits per second)
- Service and LAN
- Fieldbus scanners
- DeviceNet Gateway DeviceNet
- Interbus
- Profibus DP
- Allen-Bradley Remote I/O
- Process interface Up to 6 channels
- Connections for signals to manipulator upper arm

Figure 2. IRC5 Controller

3. ULTRASONIC WELDER

For this proposal we have chosen the MICROSONIC US 150 made Sirius Electric S.r.l.Italy. It has been designed and manufactured for the welding and the assembling of small dimensions plastic pieces such as riveting, little insets insertion and welding of very small pieces.

This fully digital generator it is easy to use, it's equipped with a backlight display and with a keyboard to enter the needed parameters.

It is possible to regulate the vibration amplitude and length.

Menus in different languages are available and can be easily personalized.

The transducer is contained into an anodized aluminum carter and it is equipped with a level switch to start the ultrasonic welding cycle.

The transducer weight and dimensions are extremely limited. [6]

Main technical features:

- Power 150 Watt
- Frequency 36 - 39 KHz
- Supply voltage 230V 50 Hz
- Amplitude regulation 50 - 100%
- Time regulation
- Multi-languages menu
- Buzzer function ON - OFF
- CAN BUS Interface
- Dimensions 170x200x120 mm

Figure 3. MICROSONIC US 150

In order to be able to use the ultrasonic welder in conjunction with the ABB IRB 1600 certain characteristics must concur. The mounting surface o the robot must accommodate the ultrasonic welder; the power supply from the robot to the ultrasonic welder must be able to supply the required power. To mount the generator on the robot the side panel of the ABB robot (marked with yellow) can be used. A special plate must be designed in order to make possible the mounting.

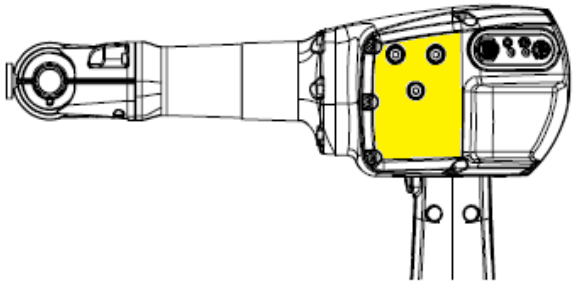

Figure 4. Side panel of the ABB IRB 1600 robot.

The electric power to the welding machine can be supplied trough the robot using the especially designer coupling.

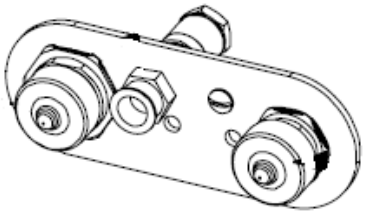

Figure 5. Standard interface.

The standard interface is composed of a pneumatic air supply, a signal connector and a power connector.

The main connector of the standard interface is situated on the base of the robot, figure 6 (the connector marked with green).

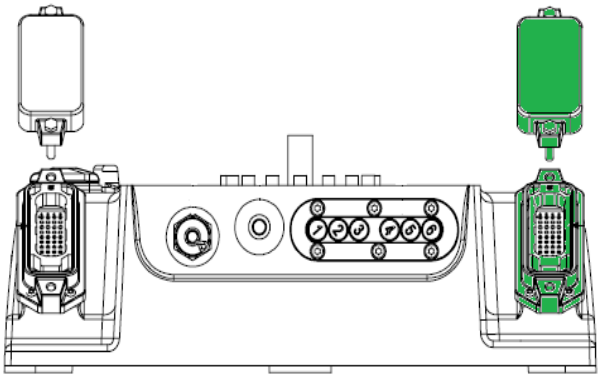

Figure 6 - Main connector board on the base of the robot.

In order to be able to operate the ultrasonic welder the power supply must be able to ensure the required power consumption. In the table no. 2 the characteristics of the interface connection are presented.

Table 2. Characteristics of the interface.

Type	Characteristics
Signal	50V/250mA
Power	250V/2A
Air	8 bar

As presented previously the ultrasonic welding machine has a power consumption of 150W, power that can be easily accommodated by the ABB robot which is capable of supplying a total of 500W trough the main connector. For mounting the piezoelectric transducer booster and sonotrode assembly to the final element of the robot there are two possibilities. The first

possibility is to custom manufacture a linking element to that can fixated on the robot or use an general purpose gripper, either electric or pneumatic, case in which only the fingers for the griper must be manufacture in order to accommodate the shape in the element. In the figure no. 7 the flange of axis 6 is presented. This flange can be used to mount either a gripper or a specially designed mounting element.

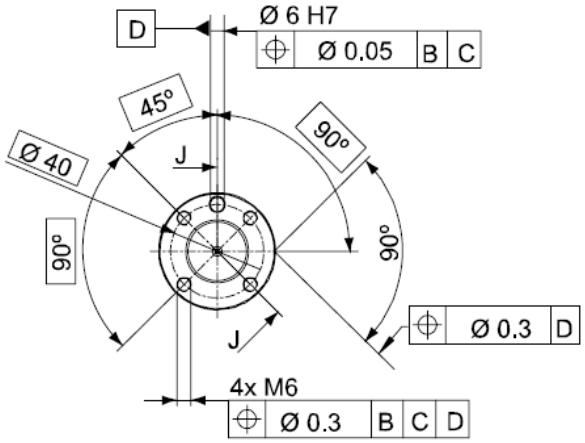

Figure 7. Robot tool flange

4. PROGRAMMING THE OPERATION

There are several ways to program the ABB IRB 1600 robot; the most common methods are by means of the Flex Pendant and using Robot Studio Online.

In industrial application the Robot Studio Online software is preferred because is more precise, fast and also allows the reduction of down time of the robot. The fist things that need to be considered when starting the program are the exact shape and dimensions of the welded part (the 3D model of the part is used in the Robot Studio Application).

Robot Studio Online is a PC software with which you work with robots, as a complement to working from the Flex Pendant. Robot Studio Online is optimized for text based programming (suitable for programs with lot of logic or complex structure) and tasks related to managing the robot's system.

Robot Studio Online can be installed on an ordinary computer running Windows 2000 or later. This computer can then be connected to one or several controllers by an Ethernet network or to one single controller by the controller's service port connection. [9]

RobotStudio provides the tools to reduce programming time of the robot system by allowing tasks such as training, programming, and optimization without disturbing production. This provides numerous benefits including:

* Risk reduction
* Quicker start-up
* Shorter change-over
* Increased productivity

RobotStudio is built on the ABB VirtualController, an exact copy of the real software that runs your robots in production. It thus allows very realistic simulations to be performed, using real robot programs and configuration files identical to those used on the shop floor.[11]

Among the main characteristics:

Virtual Robot Technology-To achieve true offline programming, RobotStudio utilizes ABB VirtualRobot™ Technology. ABB invented VirtualRobot™ Technology more than ten years ago.[12]

MultiMove- With RobotStudio 5, ABB takes its Virtual Robot Technology to the next level. It is now possible to run several virtual robots at the same time, and there is support for MultiMove, the new IRC5 technology for running several robots from one controller. [12]

CAD Import- RobotStudio can easily import data in major CADformats, including IGES, STEP, VRML, VDAFS, ACIS and CATIA. By working with this very exact data the robot programmer is able to generate more accurate robot programs, giving higher product quality. [12]

AutoPath - This is one of the most timesaving features of RobotStudio. By using a CAD model of the part to be processed it is possible to automatically generate the robot positions needed to follow the curve in just a few minutes, a task that would otherwise take hours or days. [12]

AutoReach - automatically analyses reachability and is a handy feature that lets you simply move the robot or the work piece around until all positions are reachable. This allows you to verify and optimize the work cell layout in just a few minutes. [12]

The main window of the Robot Studio application is sown in figure 8.In figure nr.9 the main menu of the application is presented. In order to realize the program for any given welding operation there are some basic steps to follow. Mainly the components of the welding station must be imported in accepted 3D format (step, vrml), the support

on which the welding takes place (table, conveyor etc), the welded pieces and the robot fitted with the welding machine.

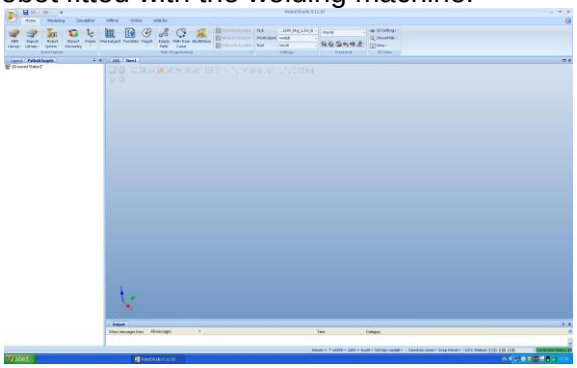

Figure 8. Main window of the Robot Studio

Figure 9. Main menu of Robot Studio Online

Having all this components, the virtuall controller is activated and each welding point is established on the two pieces. Also the orientation and trajectory of the tool are specified. Special events tat trigger certain actions can be programmed in order to fully make the operation an autonomous one.

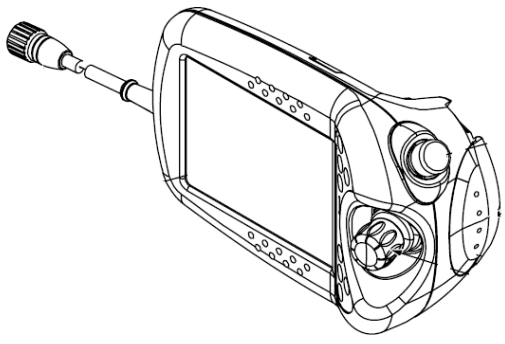

Figure 10. ABB FlexPendant.

The ABB robots can alsow be programmed by using the Flex pendant (figure 10). The use of the flex pendant hase several disadvantages among wich we mention the need to stop the production, is a time consuming process and is not a high accuracy programming. This method of programming can be used for testing some simple movements on the robot. In figure 11 the menu of the Flex Pendant is presented.

Figure 11. Flex Pendant menu

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