THREE AXIS MACHINE TO PROCESS SMALL PIECES

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ABSTRACT

This paper describes a machine designed to process small PVC pieces, used in automobile cable testing equipment. This machine should allow several different processing tasks without too much reconfiguration, thus providing a high level of automation. The solution is based on a three axis movable platform moving inside a cage structure where several tools are attached. This paper describes the machine control hardware and software, not the mechanical structure.

The machine processes a piece at a time. The piece is placed in the platform and held in place by a gripper. The platform moves inside the cage placing the piece in the appropriate tool position, following a checklist of operations.

The machine is controlled by a PC (Personal Computer), equipped with a commercial I/O interface board and a motion control board. The software developed is composed of three modules for the different control and configuration needs. One used after the machine is physically reconfigured. The second module allows the definition of the operations to be performed and respective coordinates. This module is used when a new series of pieces is to be processed. The third module controls the manufacturing process.

KEYWORDS: Flexible Manufacturing, Stepper Motors, Movable Platform, Personal Computer Controlled Systems, Automation, CNC machines

INTRODUCTION

The present paper describes a joint project between Dinefer and Escola Superior de Tecnologia de Castelo Branco (EST-IPCB). Among other products the Dinefer Company produces workbenches for automobile test equipment, namely cable testing benches. For a particular automobile cable system only a few of these testing benches are created. These testing benches use many PVC pieces in which the cables connect, and even though they all are very similar, only a few have the exact same shape. This alone makes it unaffordable to manufacture big quantities of these pieces. Up to now the solution was to build the basic block using CNC machines and handcraft the differences (see figure 1). The operations performed are basically drill and milling. The holes in the piece can be simple or twisted. The ever-increasing demand, in the shortest time possible, in cable testing benches forces the company to consider automating the processing of these pieces.

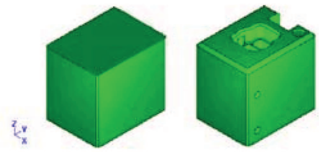
Figure 1. PVC piece before and after processing.

When this problem was presented to us (EST-IPCB) several solutions where discussed and evaluated. The machine should be easily reconfigured so that even a non-skilled worker can operate it. Since the pieces are designed in a CAD system it is desirable that the machine could interpret the CAD automatically.

Due to its smaller cost and high flexibility, the solution this paper describes was selected.

SYSTEM OVERVIEW

The proposed solution consists in a cage structure to where the various tools needed are attached, as shown in the schematic in figure 2, controlled by a PC.

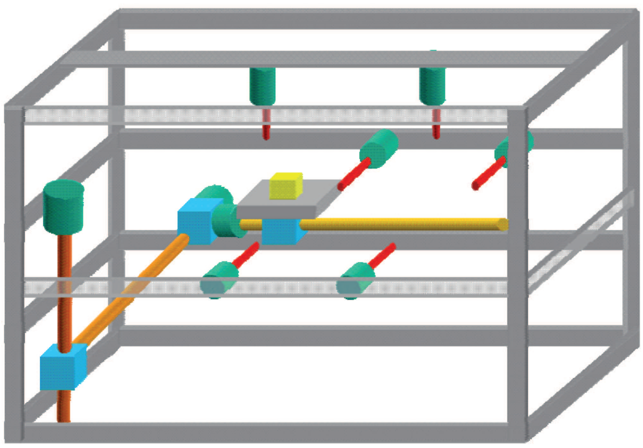
Figure 2. Scheme of the proposed solution

The machine processes one piece at a time. The piece to be machined is placed in the movable platform and hold in place by a gripper. The platform moves, in all 3 axes, inside the cage placing the piece in the appropriate tool position, following a checklist of operations.

The machine is controlled by a PC equipped with a commercial I/O interface board (read/write to the sensors/actuators) and a motion control board (for the axis motors).
This software controlled machine provides a great level of flexibility since all that is needed to process another kind of piece is change the drilling and milling coordinates, requiring no physical (tool position) reconfiguration. With a proper interface even an unskilled worker can easily change the piece layout.

HARDWARE

The hardware is divided in two main blocks:

- The cage structure and the tools
- The electronic and control layout

Since a third party constructs the cage structure this paper shall not describe it, focusing only in the control hardware and software.

A system such as this needs many input and output signals so the input/output capabilities of the PC where by no means sufficient, and an I/O board was necessary. Stepper motors where chosen as they meet the machine precision requirements and offer a smaller cost than other solutions (as AC or DC motors). To control the axes movement a motor control board was added to the project.

In order to speed up the development process commercial cards where used and, to minimize the hardware compatibility conflicts, both boards (input/output and motor control) were chosen from the same manufacturer. To speed up even further the chosen hardware was from National Instruments®, as the software development tool used was LabVIEW 6I®.

The boards are PCI7344 for motion control and I/O and the PCI6527 for additional I/O. To connect the motion board to the motors a universal motion interface (UMI7764) was added. This UMI protects the card from transients. For I/O purposes the PCI7344 also interfaces with the SCB68 for easier sensor/actuator connection and board electric safety. The same applies to the PCI6527 that interfaces with a SCB100.

For concision purposes the sensors, actuators and other electronic hardware are not described here, but they include among others: general emergency switch, entering new piece sensor, tools on/off actuators, etc. Final hardware layout is presented in figure3.

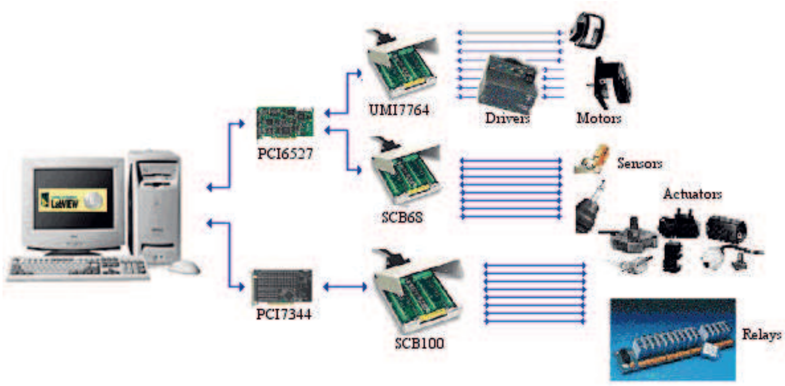

Figure 3. Control hardware layout.

SOFTWARE

All the machine control software was developed in the LabVIEW6I® environment as this offers complete integration with the hardware and is a great developing tool for acquisition and control applications such as this.

The software is divided into three main modules and an additional module. The main modules are the Machine Configuration, the Product Parameterization and the Machinating Process. The additional module is for login and users management as certain modules have restricted access.

Machine Configuration

This module can be acceded by the machine administrator only, as this is the most important one, and should be used by a skilled user. It is here that the machine is configured, that is, how many tools are present and where they are located, the dimensions of the standard piece, which operations does each tool perform, as many other parameters needed. This module also permits the creation, alteration, saving and loading of machine configurations. Note that a different machine does not mean a different cage structure. It means that, in the same cage structure there can exist various configurations, by simply attaching or detaching tools.

After the user has named the new machine and entered the standard piece dimensions he or she can add tools to the machine. For each new tool the user must specify which operation (standard drill, twisted drill or mill) the tool performs and the face it operates on. To acquire the tool position the user, using interface provided controls, moves the platform carrying a standard piece until the tool touches a referential mark in the piece. Then the position is recorded and the tool is fully operational. These is an eye-controlled operation not an automated one, as automation would require more sensors, increasing the cost of each tool, and would also increase the system input requirements. Figure 4 shows this module's interface.

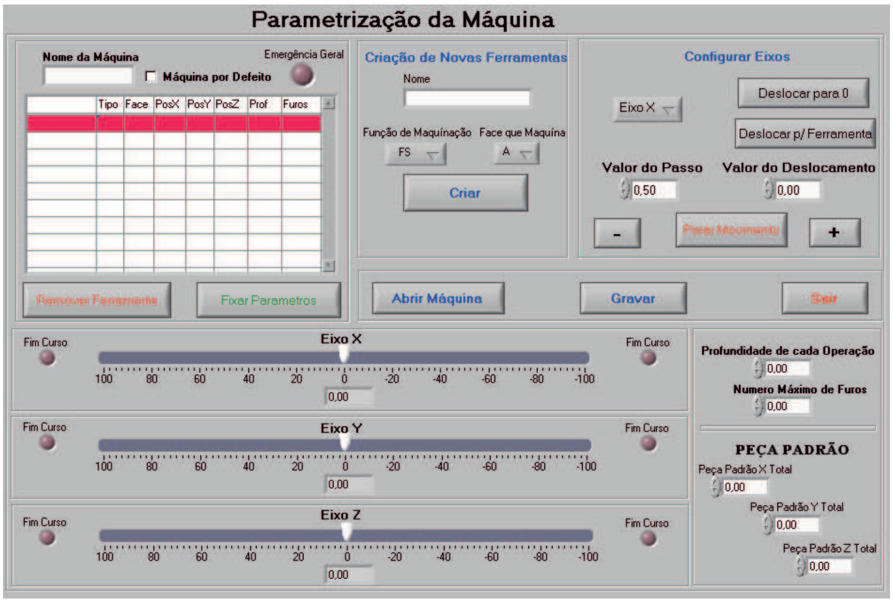

Figure 4. Machine Configuration module interface.

Product Parameterization

This module is accessible for both administrator and common user. Here are defined the steps needed to process a pieces series. This module allows the series to be created, altered, saved and loaded. Its interface is shown in figure 5.

Figure 5. Product Parameterization module interface

The product definition is simply a list of operations to be performed on the piece. This list is later executed step by step. The first thing to do here is indicate the piece's dimensions. Then, for each operation, the user only has to specify the operation, the face that its applies to and where in the piece should the operation occur. For user simplicity every operation coordinate is face relative, with the z coordinate indicating the operation's depth (for example, drilling in x=10, y=10 e z=3, indicates making a drill in face's (10,10) coordinates with a depth of 3).

Machinating Process

This module is accessible for both administrator and common user. It is the responsible for controlling the machinating process. Its interface is shown in figure 6.

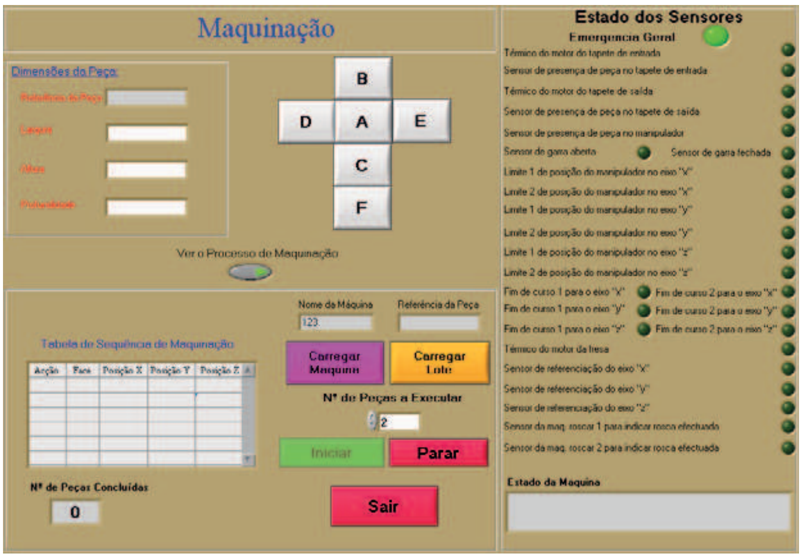

Figure 6. Machinating Process module interface

Here the user only has to load the series parameterization, specify the amount of pieces to be built and start the machinating process. This module's interface presents a graphical diagnosis board for monitoring the status of the process. The user can interrupt the process at any moment.

RESULTS

At the time of writing a prototype of the solution is being built so that we can validate the proposed work. For the time being the software control is being tested with had hoc equipment and the axis control is software simulated, but the motion card is installed and the software does communicate with it, sending orders and receiving responses. Also the proposed interfaces where thoroughly tested and successively improved.

Future work includes developing two additional modules: one for remote control and other for remote diagnosis. It also includes improving the system flexibleness such as adding more operations to those defined here.

CONCLUSIONS

This paper has presented a machine that allows, using different tools, a very low price (when compared with the process being used), easy, precise and robust solution for industrial purposes. This is a partnership where the participants are an academic institution, EST-IPCB, and an industrial company, Dinefer, Lda.

The results obtained so far with this implementation are encouraging, but more are to be expected when the prototype is finally built.

REFERENCES

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