Identification of prismatic body parts through the cloud of points captured on Computer Measuring Machine

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Abstract. This paper aims to present an aspect of combined technology: between the use of computer measuring machine and computer numeric control machine on flexible cells for processing flexible manufacturing cell prismatic parts, in the sense of complementing each other to increase the degree of automation and autonomy in the context of increased flexibility and constant quality. It is about ensuring the robotic supply with semi-finished products of the flexible cell in the context of the automatic assurance of the off-sets of parts without stopping the manufacturing process and in the conditions of an unrestricted flexibility.

1. Introduction

The flexible manufacturing cell uses multi nest prismatic devices (with 4 faces), on board of the standardized technological pallets (500x500mm) from the APC assembly, composed of 2 active-passive alternative pallets of smaller dimensions (200x200mm or 250x250mm) located on the faces of the multi nest prismatic device, the latter accompanying the parts to be processed along the entire technological route from input to output. The flow of the parts is ensured by 2 robots and a conveyor and it takes place between a Regal warehouse and the flexible cell and then vice versa, towards the exit with the deposition of the finished parts in the Regal warehouse. The semi-finished parts are fixed on the removable pallets by the operator, forming o queue in the Regal warehouse and everything is then carried out automatically with robotic service for a time horizon of minimum 24 hours. The problem is to determine the off-sets of work pieces on the removable vanes with high precision (micron) and automatically informing the machine on each part in the context of automatic and autonomous operation of the entire system. The preparation of the removable parts and pallets sitting in the queue is accompanied by the exploration with the help of coordinate measuring machine of the relative positions between semi-finished parts and removable pallets, being the theme of this paper.
It was previously analyzed by the authors of the optimal option for solving the problem and it was concluded that the use of the coordinate measuring machine provided with probe, is the one that best meets the technical requirements and costs of the application in question.
For construction, the authors propose a short list of the main technological applications of the coordinate measuring machine, related to the requirements that appear to be necessary in the special technological case.

2. Measuring the main dimensions of the part

The following are examples of typical aspects for measuring part dimensions.

These can be achieved on machining centers, using part contact keyboards, by interrupting the cutting process and measuring resolution +/-0.001 / 0.002mm, or outside the cutting process with coordinate measuring machine measurements.

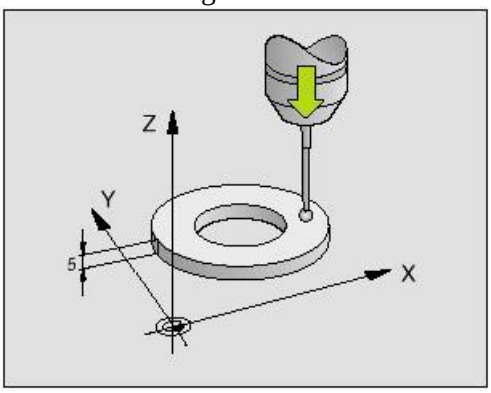


Figure 1. Thickness including calibration

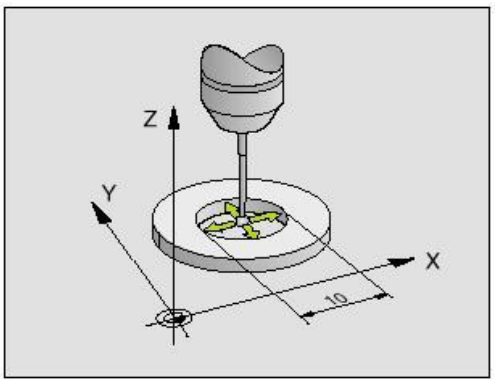


Figure 2. Diameters including calibration

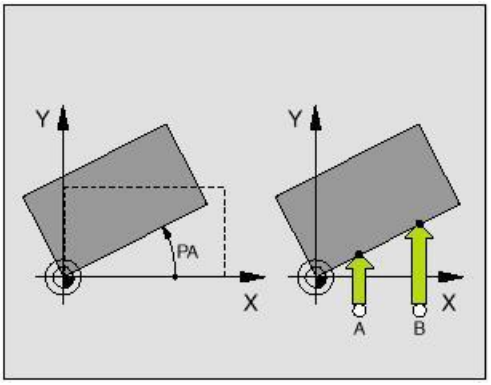


Figure 3. Angles of inclination – right including corrections

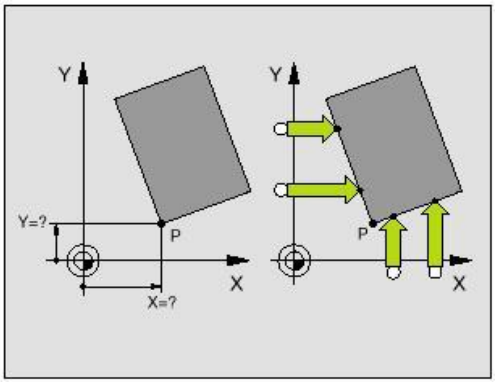
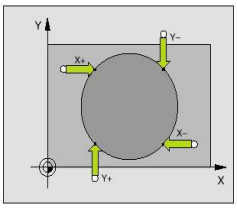


Figure 4. Angles of inclination - left including corrections



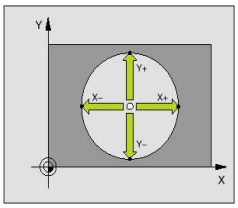
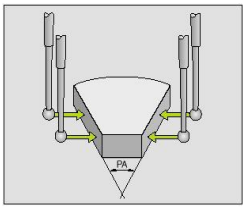


Figure 5. Diameters of bosses or bores



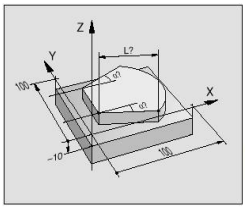


Figure 6. Non-parallel sides

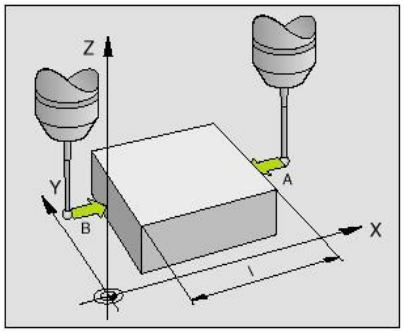


Figure 7. Lengths/ widths

The most relevant application is for the processing of prismatic parts on flexible manufacturing cell processing cells, in which it is not allowed to interrupt the cutting process, so the measurement must be performed outside the processing machine, as well as ensuring total autonomy from the operator. Here are several measurement phases, respectively for capturing and processing mandatory measurement data, but without interrupting the manufacturing process and without the direct intervention of the human operator.

3. Measurement of the main dimensions that explicitly and unambiguously define the position of the semi-finished product on the table of the processing machine (off-set of the part)

In this case, again is the problem of measuring outside the working space of the machine tool (so on computer measuring machine), during the processing of the previous part, and the measurement is made on the side of the semi-finished product fixed on a carrier pallet, which permanently accompanies the work piece at the input and up to the output of the manufacturing process, using the same micron resolution as above (+/- 0.001 / 0.002mm), and the information thus captured to arrive accurate and unaltered at the computer numeric control of the machine tool.

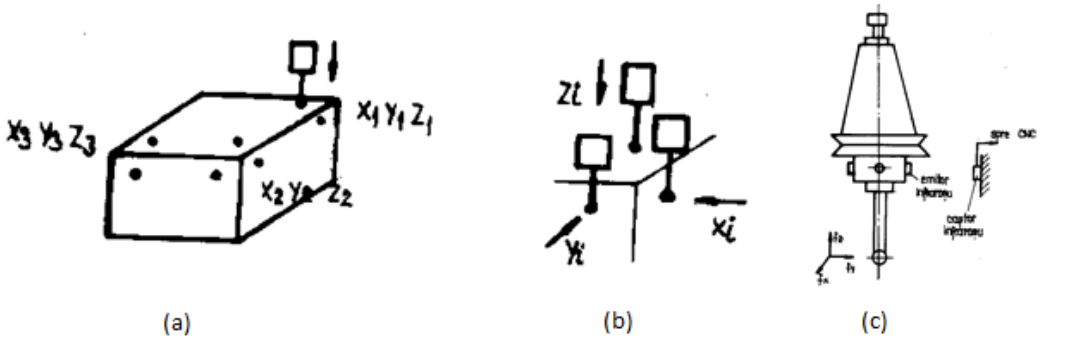


Figure 8 (a), (b), (c). Renishaw taster measuring the corners and edges of the part on the machine[1],[10]

The taster is taken from the automatic toll changing shop of the machining center for the off-set part. The information is transmitted to the computer numeric control through an infrared sensor placed on the fixed side. The disadvantage is the interruption of the manufacturing process and the need of an operator to enter the information at computer numeric control.

4. Measurement of the main technological quotas with test span, necessary for technological self-adjustments on the go, which is carried out with the short stop of the cutting process

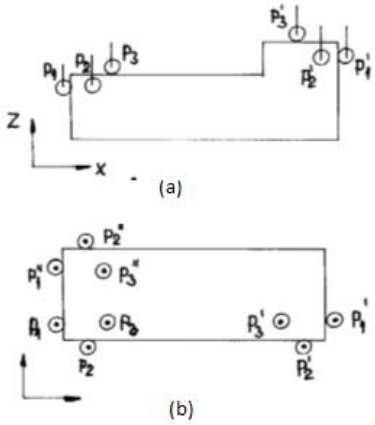


Figure 9 (a), (b). Intermediate odds with test span: linear [1],[10]

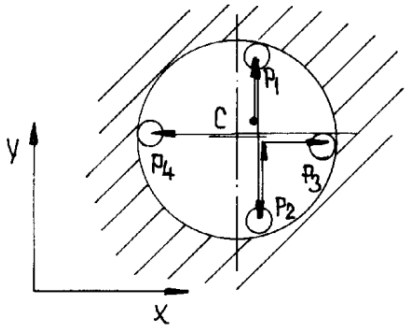


Figure 10. Intermediate odds with test span: diameter [1],[10]

Figure 11. Measurement of the part on the processing center

As showed in Figure 11, Measurement of the part on the processing center with the interruption of the processing program for the procedure of taking over intermediate dimensions with a test span in order to introduce some technological correction parameters in the finishing phase. The Renishaw taster is considered a "tool" in the automatic tool changing store and it has its own part exploration program, leading to the automatic identification of the correction parameters in the computer numeric control program. The procedure is applied in cases where the coordinate measuring machine is missing, and the frequency of measurements is reduced and limited to some essential quotas.

5. Contributions

5.1 Measurement of the main final quotas on coordinate measuring machine (with a frequency of 1:10) for the control of maintaining the processing tolerances and forcing some programmable return parameters in the middle of the tolerance field of the respective quotas

We have chosen 2 representative prismatic pieces (Figure 12 and Figure 13), which were measured on coordinate measuring at Polytechnic University of Timisoara. The results were also used to capture off-sets of parts fixed on the removable technologic palette, with measurement taking place outside the working space of the machine and outside the processing time, which is an essential condition for flexible FMC manufacturing cells.

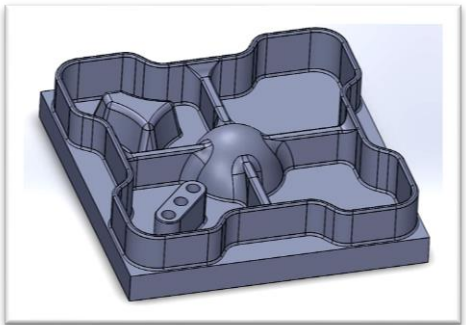


Figure 12. Representative part number 1 containing the 3D project

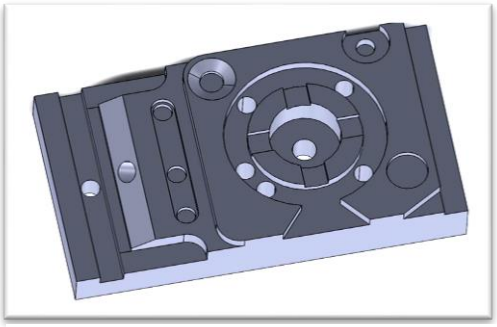


Figure 13. Representative part number 2 containing the 3D project [6]

In Figure 12 we have a representative part containing the 3D project used on the computer numeric control processing technology and on the coordinate measuring machine for the measurement and capturing of the off-sets of the part on the removable pallet and capture of essential final dimensions. In Figure 13 we have a representative part recommended by Mitutoyo for coordinate measuring machine procedures containing the 3D project used for computer numeric control technology and on coordinate measuring machine for the measurement and capturing of the off-sets of the part on the removable pallet and capture of essential final dimensions.

The removable technological palette (Figure 14 and Figure 15) is a technological device carrying prismatic parts used for the flexible cell UO 01-FMC from University of Oradea, which equips the multi nest prismatic device with 8 nests of different parts to be processed, the machine having 2 such prismatic devices (on the active-passive principle), installed on the APC module of the machine tool.

Figure 14. Removable palette with representative part number 1 on the computer measuring machine table.

Figure 15. Removable palette with representative part number 2 on the computer measuring machine table.

5.2 Determining the relative position elevations between the coordinate centers of the removable palette and the part, these representing the off-set of the part relative to the removable palette. This problem is explained briefly below (Figure 16).

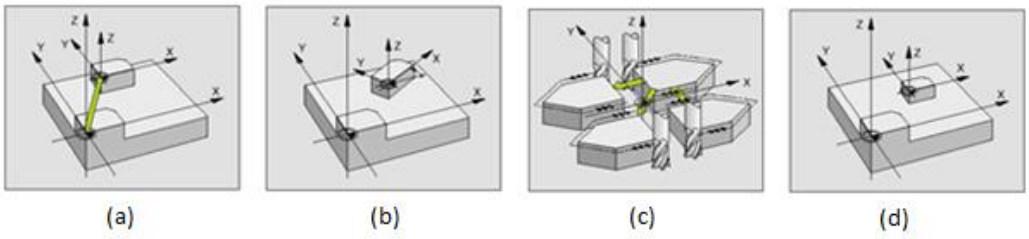


Figure 16 (a), (b), (c), (d). Automatic determination of the coordinate center of the part. [9]

The automatic determination of the coordinate center of the part relative to the coordinate center of the removable palette, or relative to the corners and sides of the removable palette, and these dimensions (representing the off-set of the part) are automatically assigned to the computer numerical control equipment in correlation with the work piece. For flexible cells this procedure is required to be performed outside the warehouse space and outside the working time.

5.3 Use of the laser orientated by the radius reflected by the contact mirror with the work piece in the standby position with robot operation

Figure 17. Renishaw laser-orientated device reflected by moving robot-assisted exploration mirror.

Figure 18. Laser-carried exploration mirror-bearing device. The mirror that reflects the laser beam at the point of contact with the piece is a tetrahedron inscribed in a sphere.

Figure 19. Flexible multi nest prismatic device explored by laser mirror. The problem is that the measurement resolution is modest by about +/-0.02 and in addition requires the presence of the operator. [2], [4]

6. The use of the computer measuring machine for capturing the point cloud limited in size, which is sectored on at least 2 zones: 1-the area of the points of the semi-finished part to be processed and 2-the area of the points of the removable pallet carrying the parts.

The 2 zones represent 2 partially overlapping entities, each with its own particularities. Example: the center of its own coordinate axes, the translation data of the coordinates of the part and of the removable pallet, the data regarding the situation of the set of point clouds in respect with the machine's center of coordinates. In the general technological case in which there is the possibility that in the nests of the prismatic device there are different parts to be processed, forming pairs with removable pallets, these pairs composed of dot clouds must be identified and the identification will be used. The identification of the "mesh" network will be used, the unification of the points that form the triangle, the determination of the centers of the coordinate axes of each, the determination of the displacements between the centers of the coordinate axes and the transmission of the information of the computer numerical control machine, processing in the form of a work piece off-set for each individual nest of the multi nest prismatic device which contains different parts.

7. Use of the computer numeric control machine to capture the cloud of unlimited points in size, which is also sectored on the areas belonging to the work piece and the removable pallet, but which will serve to create the mesh network and the 3D profile of the part respectively in order to reconstruct the original part by using the "reverse engineering" method.

This case is based on capturing as many points as possible within the point cloud, which will then be joined together by the mesh network, and in the end the final surface of the part will be generated which can be computer numeric control machined.

8. Conclusion

Of all the methods presented above, the coordinate measuring machine measurement for different purposes remains the most advantageous option. Among the most used purposes are: capturing and determining the off-sets of work pieces on flexible cells, measuring the main dimensions for every 10^{th} piece and introducing corrections, the lowest investment cost, maximum achievable accuracy, automatic operation and autonomous in flexible cell mode and unrestricted technological flexibility. The authors from University of Oradea, in collaboration with professors from Faculty of Mechanics – Polytechnic University of Timisoara, have opened a line of research that will continue until the completion and approval of the procedure.

9. References

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