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ROBOT APPLICATION TO SURFACE FINISH MACHINING

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Abstract

The paper describes the robot equipped with tool using to surface finish machining. Presented examples of robots using to: milling, grinding, polishing. Showed example of CADCAM system to robot machining. Idea of surface machining based on adaptation of tool position to unknown surface shape. Presents modernized system to robot control by PC. To support its position was developed in VB6 environment RoboCAM special software. Video optical systems for the surface geometry scanning is presented. The worked out system software is recognizing surface profile and changing position of` robot head equipped with tool.

Keywords: *robot machining, system control, surface scanning, milling, grinding*

1. Introduction

Industrial robots are used in many ranges of contemporary manufacturing [1-4, 8, 9, 11]. The kinematics possibilities of robots [1, 3] and applied software [10] make possible their use in the different jobs. Industrial robots in manufacturing processes are most often practiced in: welding, the assembly, manual works, painting, surface machining [1-4, 9-12].

Cutting processes are used to rough machining [1, 4, 9] (Fig. 1a). To finishing [3, 9, 11] (Fig. 1b, 1c) grinding process was used. These solutions are more cheep as conventional numeric control machine using. Amongst directions of the development whereas machining tools increasing them are important versatility by applying geometric and kinematics flexibility tools (Fig. 1) [3-6, 8]. Kinematics possibilities of robots, frequently equipped in more than 5 axes machine-tool, enabled its geometric and kinematics flexibility tools for shaping and finishing. Wide possibilities of industrial robot kinematics made possible use geometric and kinematics flexibility tools idea in surface shaping [2, 4, 6, 8].

Fig. 1. Robot machining: a) milling [9], b) grinding [9], polishing [11]

Surface processing with robots are programmed using CAD model of its geometry [9, 10]. For example IRBCAM [10] converts the APT-CL or ISO G-code formats to the ABB robot language RAPID and supports the robot controllers S4C+ and IRC5. IRBCAM supports 3- and 5-axis machining operations and is suited for rapid prototyping, cutting, milling, grinding, surface finishing or mould production of wood, foam and ceramic materials and light metals (aluminum). In addition to traditional machining, the IRBCAM software can also be used for water jet, plasma and laser cutting, gluing, as well as painting. Typical accuracies that can be achieved with an ABB IRB-type robot is 0.3mm, a repeatability of 0.1mm and a workspace volume with radius up to 3.9 m. IRBCAM supports external axes linear and rotational), which can extend the workspace and enables an object to be machined from all sides in one setup. Very large objects can be machined this way, for example moulds and plugs for marine applications (Fig. 3).

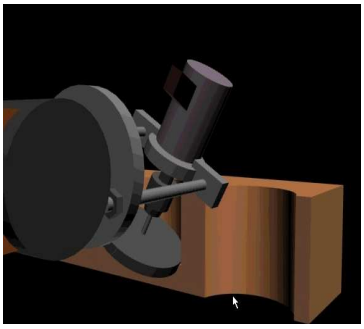

Fig 2. Using idea of EGK tools in robots machining [6]

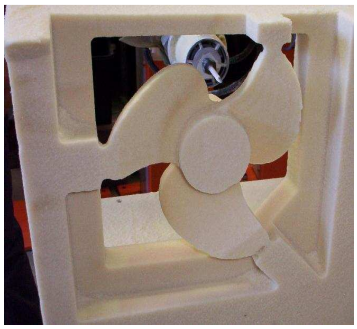

Fig. 3. Example of milling mold surface [10]

This paper describes the intelligent system to surface machining with robot equipped in modernized control system and the reverse engineering system to surface scanning and analysis.

2. Machining with active surface shape control idea

New idea of robot machining is using it to cutting unknown surface geometry [8]. This system has been worked out in Department of Production Engineering University of Technology and Life Science (Bydgoszcz, POLAND). Idea of surface machining based on adaptation of tool position to unknown surface shape. This process is similar to surface finishing by human worker. To realization this idea was build special on-line reverse engineering system which can analyses surface inclination or profile [8]. Profile of this surface can be use with interpolation system to robot tool system controlling (Fig. 4). When profile of surface is known, system can change tool position according best machining criteria. This adaptation of machining system can process with unknown geometry surface.

3. Surface scanning system using robot

3D scanning system was developed based on a synthesis of the surface points (x, z) coordinates from the scanner intersections and the coordinates x, y, z reading from robot kinematics. Reading of the IRb60 robot coordinates is possible by using the special PC robot control system developed by the Department of Production Engineering UTP Bydgoszcz [7] (Fig. 5).

Modern technology allows you to create simple scanning system [8]. To measure the coordinates of the surface a robot control system is associated with video optical scanner (Fig. 6) working in planar mode. Was used a red laser (wavelength 660 nm) with a flat stream system which generates a surface profile.

Trace of laser light on the analysed surface is captured using a USB digital camera VGA (640 * 480 pixels), which is focused in the beam plane.

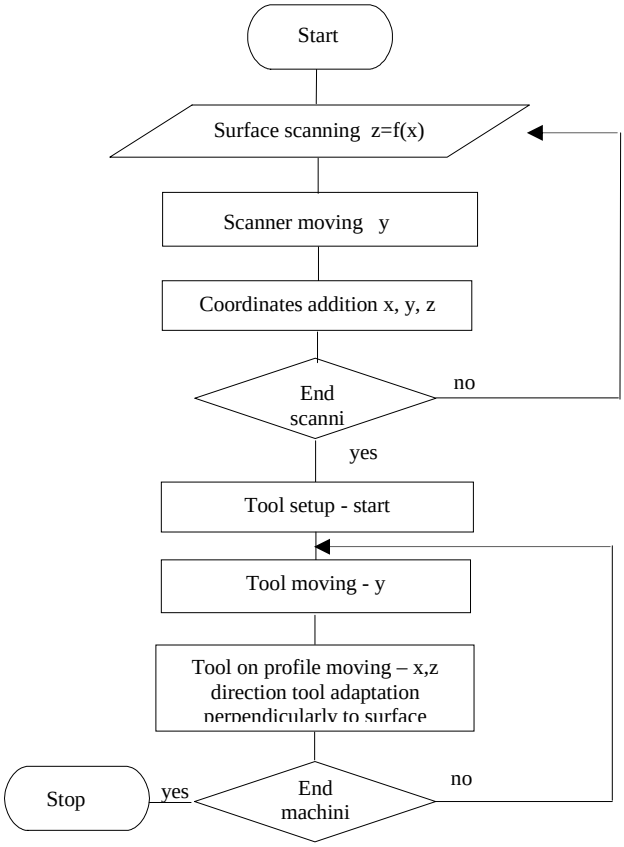

Fig. 4. Scheme of intelligent finish machining system of unknown shape surface

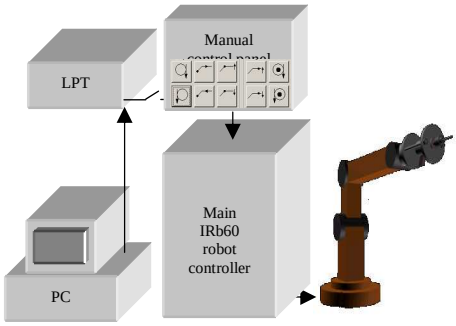

Fig. 5. IRb60 robot control system using PC [7]

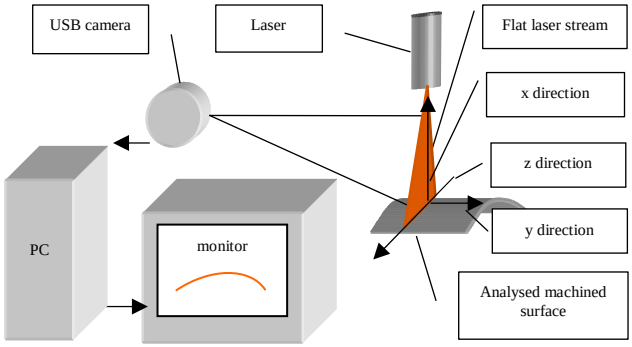

Fig. 6. Surface scanning system idea

To support its position RoboCAM special software has been developed in VB6 environment (Fig. 7).

Developed software in the field of the scanner ensures:

- support for digital cameras,
- periodic image capture,
- automatically determined coordinates of the analysed profile,
- synthesis of coordinates from the scanner system and control system robot, ·
- surface curvature visualization, ·
- record the coordinates of the scanned area to a file.

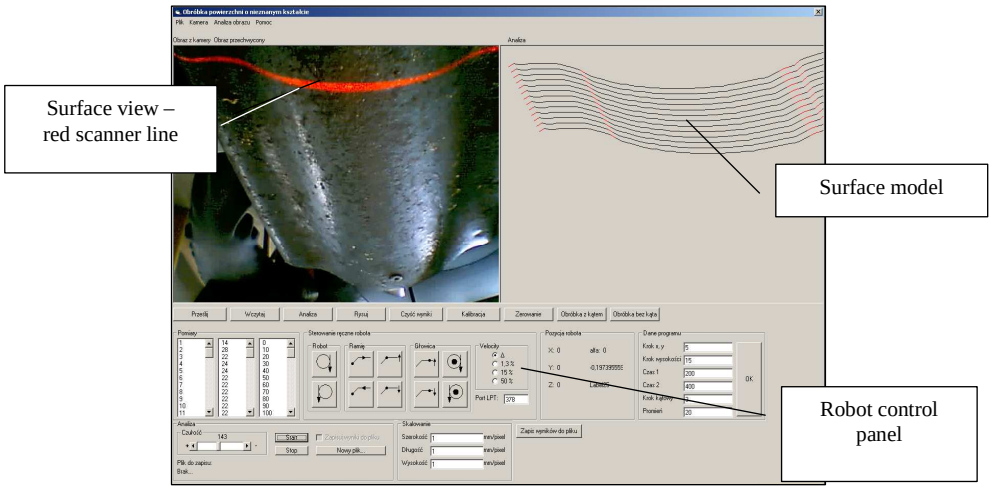

Fig. 7. Main form of RoboCAM software

Profile coordinates are determined using a specially developed procedure, which analyses the image to find points of parameters as much as saturated red - R. Due to the time of analysis, the software scans every tenth of a vertical line in search of a pixel with high density of red.

Based on the results of the search algorithm attempts to set points on the analysed surface. The R pixel readout parameter (default R = 100) has been used as a criterion surface point. The program allowed to change this value. In order to guard against erroneous readings, the software is equipped with intelligent analysis modul, together with a filter capturing interference.

4. Surface finish machining

Developed system was verified in trials, where treatment was carried out cylindrical surface profiling (Fig. 8). The robot system in addition to the scanner is equipped with tool mounted on a flexible elastic disc drive. The shield with Velcro mounted disc abrasive cloth. RoboCAM software (Fig. 7) was equipped with a data analysis module of the scanner and control functions in accordance with recognized surface gradient (Fig. 3).

During the first transition system automatically analysed the surface curvature. In the second pass, at the next positions of robot's head automatic adaptations of the robot axis tool positioning surface shape was done. Under current gradient surface mounted tool spindle axis of the robot's head change the position to normal the surface while maintaining a constant distance from tool axis machined surface (Fig. 8). There was a necessity of corrective tool head movements in the direction of x and z.

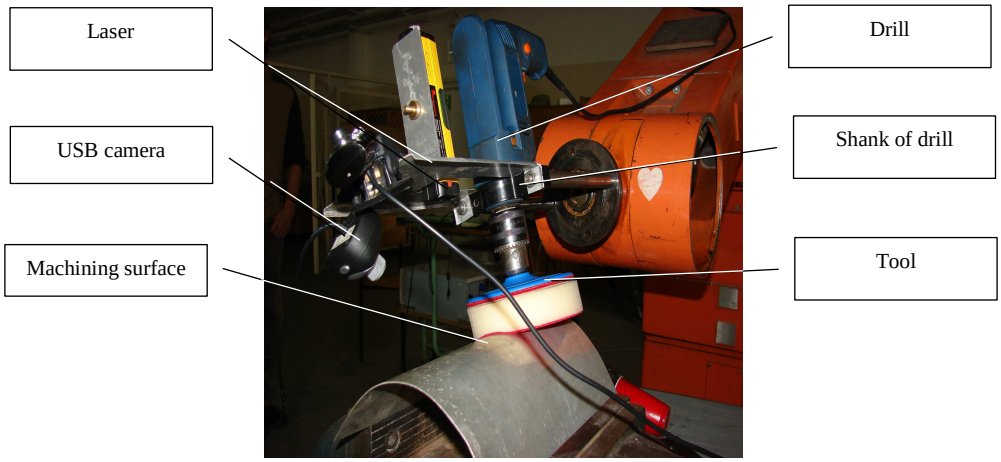

Fig. 8. View system in surface finish machining

Position of the axis were determined using the software based on previously defined space coordinates. With the flexibility of tool surface in machining followed adaptation tool curvature to the local surface curvature (Fig. 8).

In those trials the correctness of the system scan has been verifed, even under a certain distortion of external lighting. Positioning system to the surface shape tools adaptation also work correctly.

5. Conclusions

The results of this work shows the possibility to equip the robot in own surface scanning system with using low-cost USB camera. It may be useful to create virtual models of large objects and analysis of surface shape in the process of finishing. Initially verified the accuracy of the surface coordinates reading systems indicates the possibility of it practical application. In trials carried out verified the correctness of the system scan, even under a certain distortion of external lighting. Positioning system to adapt to the shape of the surface of tools also work correctly.

Developed solution to the scanner and the software can also be convenient to draw 3D surfaces. Cloud of points obtained by scanning should be sent to CAD such as Solid Edge.

Initial positive verification system developed intelligent finish machininging using a robot equipped with a tool for self-propelled, makes it advisable to continue the research work developed concept.

In further work it is advisable to use active control of surface condition, especially non-contact. This will create the possibility of finishing the surface with a given parameter of roughness. Reflectometry technique seems to be convenient. It is appropriate also to develop procedures for ensuring EGK adaptive mapping tool, using the possibility of kinematics robot. Convenient for this purpose is to use assumed in the work spindle positioning tool in relation to the robot head.

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