

Tool path definition in Virtual Machines world

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Abstract

Virtual Machine (VM), called also machine simulator, is 3D computer model which is geometrically and functionally the same like real machine (CNC machine tool or robot). They are used mainly for different kind of syntax errors and collision detection in CNC programs. Whole simulation process is also called Virtual Machining. This kind of off-line programming require CAM software support to generate tool paths and transform them to machine commands. The most advanced virtual machining software gives more possibilities to influence machines behavior – it is not only simulation software. This article describe it based on Eureka virtual machining software.

KEYWORDS: virtual machine, virtual machining, machine simulator, simulation process, simulation software, Eureka

Tool path definition in virtual world

Tool path calculation in virtual world base on virtual model of machined parts. It is the same situation both: in CAM and virtual machine software. CAM software is specialized in machine tool programming (milling, turning or mill-turn machines) and prepare complex tool paths for any kind of complicated geometries – wireframe, solid, surface of STL (fig. 1).

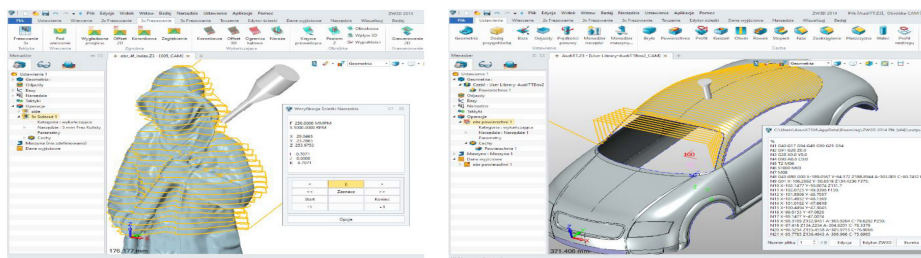


Fig. 1. Tool path defined in ZW3D CAD/CAM: 5' milling on STL from 3D scanner (left) and 5' milling on surface model (right)

Main role of virtual machines was simulating G-codes generated in CAM software, so tool path definition have not such advanced functions and parameters. They are

concentrated on machines kinematics and faithful mapping of behavior, with all G and M codes, macros and cycles. The most important is the way of program analysis. Many simulators embedded in CAM software based on CL/ATP files, raw files before processing by the postprocessor. In dedicated VM software, like Eureka, output program (the same which can be send to the machine) is analyzed line-by-line, with all signs. If any command is not recognized, simulator report error, marked in code. Each code can be visualized (with full collision detection) by moving 3D models on the screen – changing cutting tools (fig. 2 – left), fix/release or transport part (fig. 2 – right), make measurements using tool probe.

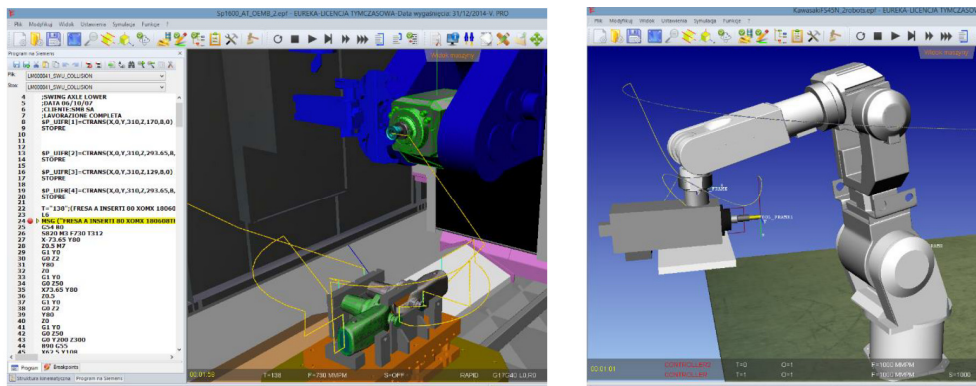


Fig. 2. CNC program simulation in Eureka Virtual Machining software: changing tool on the machine tool (left) and moving part by robot (right)

There are different ways to define tool path inside virtual simulator environment. The first one is similar to programming on the real machine in MDI mode. It means that user put control commands in programming window and then simulate them (fig. 3 – left) – similar to MDI on the machine tool. User can observe machine tool movement and build programming history. The second programming option is using JOG mode and virtual manipulator (fig. 3 – right).

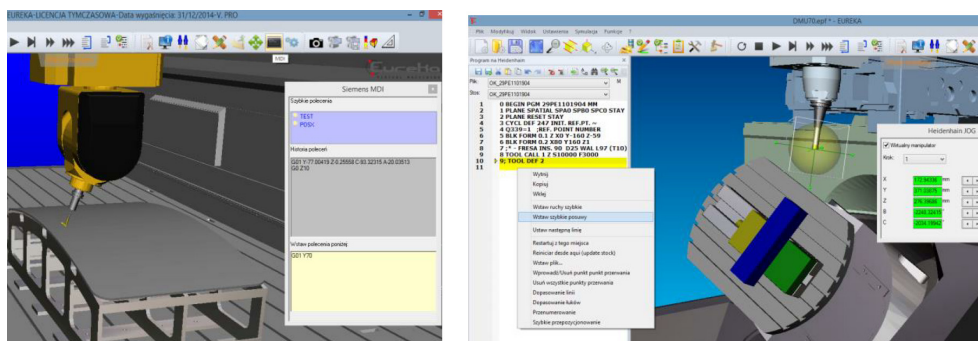


Fig. 3. Different types of virtual programming: MDI mode (left) and JOG mode (right)

This time user put positions of each CNC axis (by numbers for each axis or using sliders) and add new line with rapid or cutting movement with current position. New destination position can be also pointed by handle tip of tool and moving mouse on the screen. Small accuracy of virtual manipulator causes that it is mainly used for determination of positioning by rapid movements without cutting.

Some types of process (e.g. plasma/gas cutting, welding) don't require complicated tool paths but they must be related to the machine and part. A great programming solution for this kind of applications is tool path capture inside a virtual simulator. Similar to real robot programming with a control panel, the user indicates the sequence of tool path points and declares the type of movement (linear or circular). A big advantage is the automatic detection of the normal surface vector in the selected point. Of course, tool orientation can be changed (in the whole program or its selected part) relative to the main axis (X, Y, Z), normal to the face, based on 2 points or with fixed angles.

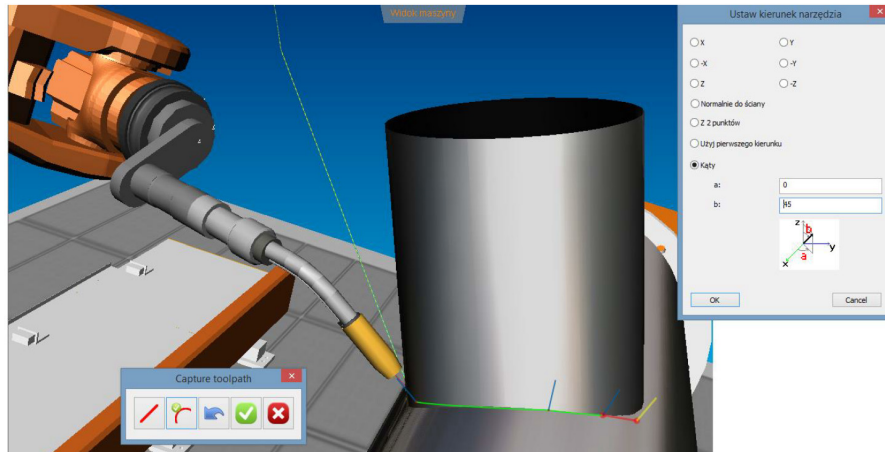


Fig. 4. Tool path capture and tool orientation definition in Eureka software

Virtual teaching

VRT (Virtual Robot Teach-in) is a new, easy, intuitive and productive robot programming method. In comparison with the existing teach-in process with a pendant, this new method has proven in one hand to be easier and faster. On the other hand, the teach-in process can be performed directly on the real workpiece even outside of the robot cell. A major advantage of this method in comparison with offline programming is the fact that the CAD model of the workpiece is not needed to generate the path. Nevertheless, the combination of both methods reduces the downtime, therefore the productivity of the robots can be increased.

The system consists of a mobile IR-Camera with a large working space and a pointing tool with integrated LEDs and a simulation software (Fig. 5), it is user-friendly and adapted to work with different robot types.



Fig. 5. Virtual Robot Teaching with Revxperts [www.roboris.pl]

There are 3 main stages (fig. 6) of VRT with VM:

1. **Generate the path** – when operator should align robot and camera by pointing on 3 coordinate points. Then using pointer unit he point all positions on the planned robot path and move the virtual robot on the screen – check reachability and collisions. Record the coordinates and the moving vectors from the real work piece by pressing the buttons for single point or continues mode on the pointer unit.
2. **Simulation and optimization** – the completed path is simulated on Virtual Machine and can be modified, changed or optimized according to the request, as well as the process parameter.
3. **Running the process**– the generated path is loaded in a post processor and is sent into the robot controller for execution.

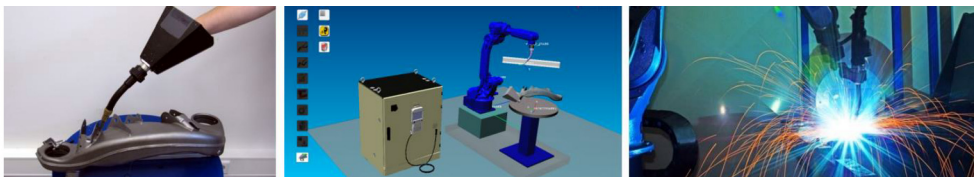


Fig. 6. Virtual Robot Teach-in sequences: generating tool path, simulation and execution

VRT is compatible for many robot types and can be used for many different type of applications:

- It is mainly used to create complex 3D tool paths in different applications like welding, gluing, cutting, painting, engraving, soldering and polishing.
- Correcting and adapting the offline created robot paths towards the real dimensions in the cell or the changes in the work pieces.
- Measuring of the robot cell, deleting the installations misalignments and correcting of the offsets.
- Measuring and aligning the robot base, user base, TCP, work piece, pointing tool and user frame.
- Automated Measuring with tactile tip, scanner and confocal laser.
- Tracking the robot movement with static and dynamic position control.

Summary

Computer Numerical Control open new possibilities for programming machine tools and robots. Real machine is not blocked during programming time and tests, so virtual methods are more efficient. Tool pats programmed with computer can be very complicated and contains a lot of control points – compare with manual programming it is huge time saving. With VM it is easier to change programs and detect collisions. The main limitations of VM (compatibility of the theoretical model with the real workstation in coordinate systems and part shape) are eliminated in VRT method.