Production automation with the help of SolidCam tools

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Abstract: *Automation of production processes is crucial for improving efficiency and reducing manual labor in the manufacturing industry. SolidCam facilitates automation through various tools such as Automatic Feature Recognition (AFR) and IMachining that identifies and extracts machining features from CAD models, eliminating the need for manual feature programming. The software's toolpath optimization algorithms automatically generate the most efficient toolpaths, reducing machining time, minimizing tool wear, and improving surface finish. This paper presents an improved virtual simulation methodology of the milling process. The process begins with defining the toolpath and determining how to create paths that link to each other within SolidCam. With IMachining, automatic path detection is enabled, after which the tool that needs to be used is selected. When the path is selected, the processing method is determined and at the end the G code is generated which shows the coordinates for milling and additional operations if they are selected. It is also linked to the tool list that is passed on to the operators. Benefits using this kind of automation are discussed and compared with the traditional approach without using automated processes.*

Key words: SolidWorks, SolidCam, automation, milling, simulation

1. INTRODUCTION

In today's rapidly evolving manufacturing landscape, the integration of advanced technologies has revolutionized the way products are designed, developed, and produced. One such transformative technology is Computer-Aided Manufacturing (CAM). CAM systems have emerged as indispensable tools that bridge the gap between design and production, offering numerous advantages to industries across the board. By leveraging the power of computer software and hardware, CAM has ushered in a new era of automation, precision, and efficiency in manufacturing processes. CAM is the computerized process of manufacturing. This is currently applied by most of the heavy and medium industries in developed and some developing countries. CAM can be defined as the use of computer systems or software to plan, manage, and control the operations of a manufacturing plant through either direct or indirect computer interfaces with the plant's production resources. SolidCam iMachining is the de-facto standard Gold-Certified integrated CAM-Engine for SolidWorks. It provides seamless, single-window integration and full associativity to the SolidWorks design model. All machining operations are defined, calculated and verified, without leaving the SolidWorks windows. SolidCam supports the complete range of major manufacturing applications in Milling, Turning, Mill-Turn and Wire cut electro-discharge machining (Sultana et al., 2016). The great importance of all new technologies, materials, machinery, progressive methods and information tools that enable more efficient use of starting materials, produces a more cost-effective, fast enough to produce reliable and quality products and above all success in the market in an increasingly challenging competitive environment (Dubovska et al., 2013). The primary objective of CAM is to streamline and optimize the production workflow by automating various tasks, eliminating human error, and maximizing productivity. CAM software seamlessly integrates with Computer-Aided Design (CAD) systems, enabling the conversion of virtual designs and models into machine-readable instructions. These instructions, often in the form of G-code, direct sophisticated machinery such as Computer Numerical Control (CNC) machines, robots, and 3D printers, facilitating the efficient and precise manufacturing of complex components and products. CAD-system includes three main components (Holovnia et al., 2021):

1. CAD is a technology aiming at applying computer systems in order to facilitate the projects creation, modification, analysis and optimization.
2. CAM is a technology that lies in applying computer systems with the aim of planning, managing and controlling manufacturing operations through a direct or an indirect interface with the manufacturing resources of the enterprise.

3. Computer-aided engineering (CAE) lies in applying computer systems in order to analyze the geometry of CAD, modeling and studying the product behavior with the aim of its further design improvement and optimization.

CNC machine tools complete the product design and manufacturing lifecycle, and more often than not they have to communicate with upstream sub-systems, such as CAD, Computer – aided process planning CAPP and CAM. The final result from a CAM system is a set of CNC programs that can be executed on a CNC machine (X.W. Xu and S.T. Newman, 2006).

The rest of the paper is organized as follows: Section 2 presents the literature review. Section 3 presents the simulation of CNC machining process and individual acts necessary for the design of machining on CNC machining centers. Along with that, Section 3 describes the methodology and Section 4 proposed system that has been developed and tested. In Section 5 the research's conducted study is described in detail and results are presented and discussed. Finally, Section 7 holds the conclusions.

2. LITERATURE REVIEW

In the process of science and technology development, traditionally structured systems become increasingly complex. At the same time, competition on the market is growing. Under these conditions, traditional non-automated design methods are ineffective. CAM and CAD technologies have revolutionized the manufacturing industry, offering numerous benefits throughout their history. Scientific and methodological aspects of CAM/CAD system implementation are revealed in the following papers.

Ciric D., Lalic B. et al. (Ciric D. et al., 2021) introduce a bibliometric analysis approach to review mass customization scientific production. The most productive journals are mainly in industrial engineering, production, operational, and manufacturing research, among the ten most influential articles are the ones that are mostly published in journals oriented towards management sciences. The relevant papers listed below are from the field described in the aforementioned paper.

Ficko M. et al. (J. Balic et al., 2000) researched the automatic programming of CNC machine tools. They explored the various ways of programming in CNC machines. The paper defines the areas of development of the CAM program crucial for the development of such programming.

In their work, Jorge Andre´s et al. (García Barbosa et al., 2014) used parametric programming in order to get higher flexibility of the manufacturing process. The ball milling process was simulated and verified in a virtual model of the Siemens NX7 product lifecycle management machine tool. This process was developed with an additional module of integrated simulation and software verification.

Rozmarina Dubovska, Jaroslav Jambor and Jozef Majerik introduced (Dubovska et al., 2013) an improved methodology of the virtual simulation of turning and milling technological process of the selected components in the CAD/CAM system. During the experiment, it was proven that the simulations of the proposed cutting paths work in the real world.

Nazma Sultana et al. (Nazma Sultana et al., 2016) researched a Simulation Study of a Spur Gear Machining and G-code Generation for CNC Machine. In the paper, SolidCam iMachining is studied and the detailed procedures of the machining process of a spur gear from stock material.

Nikola Vitulic, Zoran Jurkovic and Mladen Perinic in their paper (Nikola Vitulić et al.,2011) show the implementation of advanced CAD/CAM systems and simulation tools used at the Institute for Industrial engineering and management for designing processing processes and tools. The paper presents virtual simulations and verification of machining on an automated turning machining center with a new one defined post-processor for the control system EltroPilot and provides an overview of the current state of conventional NC programming as well as StepNC.

Boogert, et al. (R.M.Boogert et al.) developed a module which automatically calculates tool paths and cutting conditions for metal cutting operations in which necessary algorithms had been designed to generate reliable numerically controlled programs.

CNC machines appeared in 1980, and with them came the need for automatic production of components. Roberto S.U. Rosso Jr et al. (Roberto S.U. Rosso Jr et al. 2020) paper proposed a novel approach to use this standard with an emphasis on CAD/CAM systems and vendors as well as machine control vendors.

Y. V. Petrakov and A. V. Myhovch introduced (Y. V. Petrakov et al. 2020) analysis of the control made of two straight arcs of a circle. The analysis is automatically integrated into the iMachining Solid CAM module for processing parts.

In their work Jie Yan and Danqing Chen (Jie Yan et. al, 2019) use the connector terminal's three-dimensional entity as the model. The model is imported into the software for 3D analysis of finite elements. The Logopress 3 plugin in SolidWorks is used to suggest mold designs.
Ciric D. et al. (Danijela Ciric et. al, 2020) researched application of ICT solutions in manufacturing companies in Serbia. The research showed that in order for Serbian companies to start the process of reindustrialization and keep pace with trends, it is necessary to implement all or at least some elements of Industry 0.4, including the application of various software solutions.
In their work, Djakovic M. et al (Dakovic M. et al., 2020), showed systemic risks in the engineering industry. The focus of the paper is the time per tasks and the delays. Simulation of CNC machining process explained below significantly reduces budgetary risks.
SolidCam is used to mimic the NC programming processes, as well as the processing of molded parts simulation. Although this trend of application and development of SolidCam systems is encouraged, it is necessary to look back at previous experiences, proposed methodologies and devices, in order to reach significant conclusions in future research and for researchers to contribute to the development of this field.

3. METHODOLOGY

Organizations may successfully deploy production automation with the use of SolidCam tools by following the methodological stages, which will boost productivity, lower costs, and enhance product quality in manufacturing operations.
The major stages of the SolidCam manufacturing project creation process are (SolidCam, 2021):

- CAM-Part definition

This stage includes the definition of the global parameters of the Manufacturing Project (CAM-Part). A number of Coordinate Systems, that describe the positioning of the part on the CNC machine' have to be defined. Optionally, defined Stock model and Target model can be used for the rest material calculation.

- Operations definition

SolidCam enables to define a number of milling operations. During an operation definition geometry has to be selected, after that the tool from the Part Tool Table should be chosen (or define a new one), machining strategy and a number of technological parameters also must be defined.
Individual acts necessary for the design of machining on CNC machining centers in the CAD/CAM system.
SolidCam methods and properties used in methodology:

- Creating a 3D model
- Choosing between mill, mill turn or turning depending on what type of part has to be created and determining the geometry.
- Selecting the machine mode of CAD/CAM system and choosing which CNC machine will be used and determining the position of the coordinate system.
- A stock can be added. SolidWorks model, SolidWorks configuration can be added or clicking on a part will add a box around the extremity.
- If iMachine is used there is an option to select iMachine tool.
- When everything is set, the tool is applied and processing starts from the selected part. Selecting Simulation and SolidCam will show the tool in action.

The flow consists of steps related to activating the Solidworks program and creating a 3D model. SolidCam is integrated into the SolidWorks program. Firstly, variables related to the SolidWorks application, model, drawing, view, dimension, and annotation objects are defined. The following step is choosing between mill, mill turn or turning depending on what type of part has to be created and determining the geometry. After saving the model in SolidWorks, the coordinate system and Mac CoordSys number are defined. The next step is that the CoordSys Manager is automatically opened where the position of the coordinate system is set. After the coordinate system is set, the Milling part data window is opened where stock is set and it is also possible to get supplies. When all the parameters are set, the targets are defined, the targets represent the fields over which the simulation will be performed. The last step is to activate the simulation process, milling. After all the necessary parameters have been defined, the simulation is started.

4. RESULTS

After the 3D model has been created in SolidWorks, SolidCam tool is used and fully integrated into SolidWorks. The appearance of the SolidCam tool is shown in Figure 1.

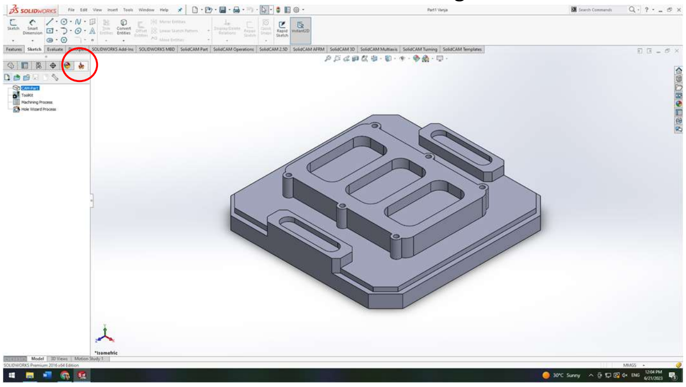

Figure 1: SolidCam tool

Figure 2. shows the CAM tree that displays options for Milling, Mill - Turn, and turning. The milling option is selected for CNC milling, a subtractive process using 3-, 4-, and 5-axis milling machines and cutting tools. The part is saved in SolidWorks and data for milling is entered. The AWEA 1000 - FANUC CNC machine is selected for simulation. The coordinate system is set, and the Mac CoordSys number, for which the value 1 is set, and position number are defined. The top center of the model box is set, and the height of axes can be modified. In the Modify by delta field, the Z axis is shifted by 2 mm.

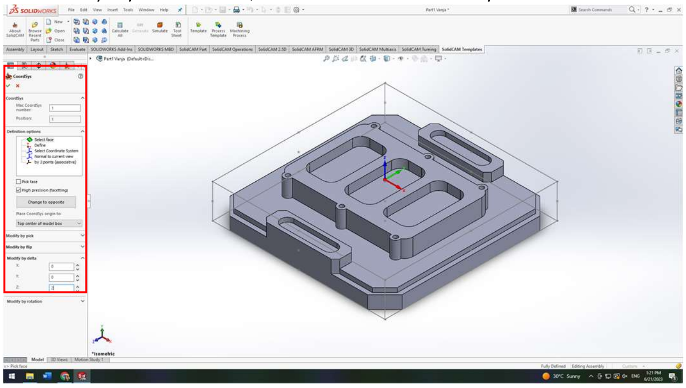

Figure 2: Setting the coordinate system

After the coordinate system parameters have been saved, a new CordSys Data window opens automatically. Figure 3. shows the parameters for the coordinate system that can be adjusted and changed at any time during the simulation setup process. In each of the offered levels (planar, radial and rear) it is possible to set the corresponding parameters. An important parameter is the clearance level. Clearance is the absolute Z location the tool rapids before feeding down in the Z axis. It is also the height the Z axis position during rapid moves to get from one cut to another with the same tool. For the displayed model, the corresponding parameters are automatically set after the previous step of setting the coordinate system.

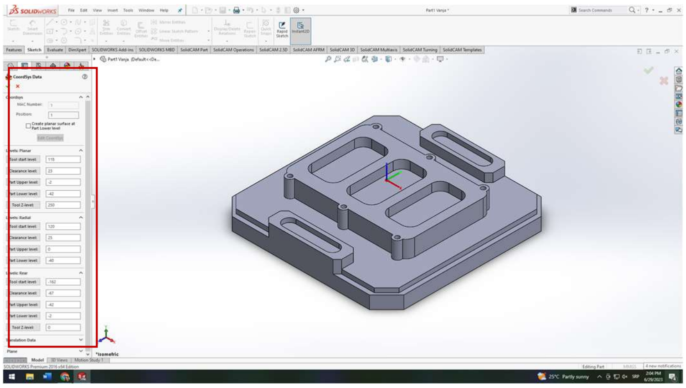

Figure 3: CorsSys Data parametars

CordSys Manager opens next. In the field shown in Figure 4., the settings of the manager that have not been changed are visible. The Milling part data window, which is also shown in Figure 4., opens automatically, where it is possible to set the stock. It is also possible to get any supplies which are needed. Stock can be obtained in several ways. First is by a 3D model from SolidWorks, a configuration from SolidWorks or, what was done in the example, just by selecting the part.

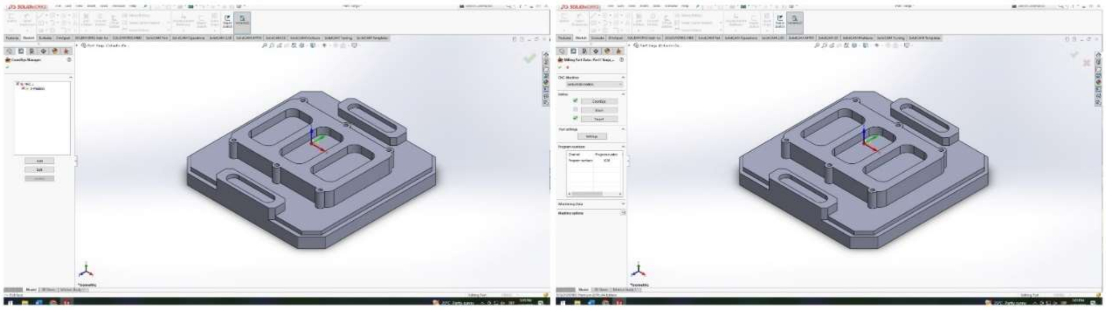

Figure 4: CordSys Manager and Miling Part Data window – stock definition

Stock enables additional box to CAD model. Figure 5. shows the parameters for the shown model. This model had a 2mm in the X, 2mm in the Y and 2mm in Z direction. After checking the parameters, adding a box around the model was selected and clicked again on tick.

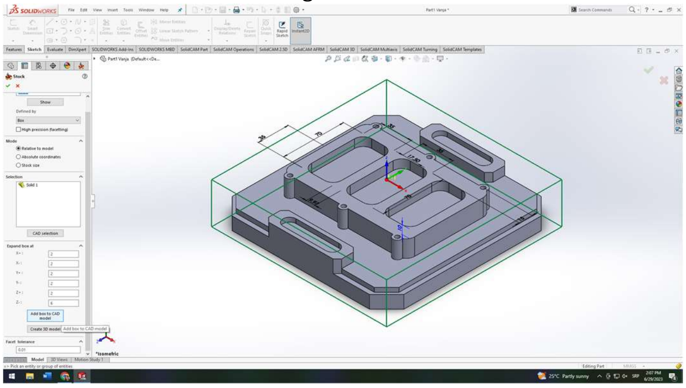

Figure 5: Adding Box to CAD model

When all mentioned parameters are set, it is finally possible to define the targets. Previously, the stock was set, which is why the model is now automatically selected. At any moment, it is possible to deselect a part and manually select it again, during which it becomes pink as shown in Figure 6.

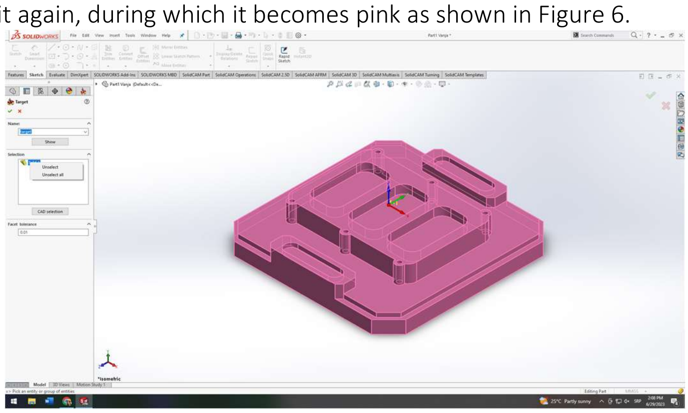

Figure 6: Defining targets

To start a simulation in Miling, click on the tick to open the Miling part data window, add additional information, and set program numbers for the part material. The iMachining database is selected, and the simulation starts with the first operation, the Profile operation. The geometry is contoured, and the tool was selected. In addition to the profile in the Level field, the upper level is defined at -2 as well as the depth profile at 40. The delta value is left at 0.When all the specified parameters are set, the selected operation is saved, after which the simulation is finally started. The simulation is started by simply clicking on the Simulate icon in the SolidCam Operation field.

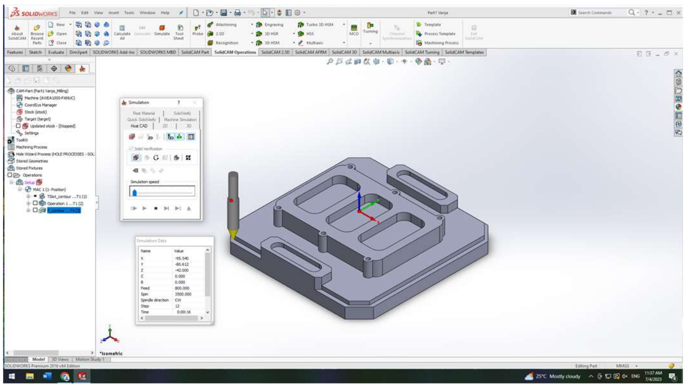

Figure 7: Simulation of object contour processing

The simulation of model processing can be shown on each individual part of the model in the same way as it is shown for the contour of the object.

4. DISCUSION

CNC machine programming requires less human labor thanks to SolidCam automation. As a result, toolpath creation is sped up and setup times are decreased, thus improving production efficiency. Automation reduces human error, resulting in consistently precise and dependable machining operations. The sophisticated algorithms and simulation abilities of SolidCAM provide fine-grained control over toolpath creation. Tight tolerances and higher surface finishes are produced as a result of this accuracy, which also improves part quality. The possibility of expensive mistakes and rework is decreased by the ability to model and test toolpaths prior to real machining. For complicated machining tasks like mill-turn operations, multi-axis milling, and 5-axis machining, SolidCAM's automation features are very useful. It makes these complex activities easier to program, enabling them to be used by a wider range of production facilities. Production expenses may be considerably decreased by automation using SolidCAM technologies. This includes lower labor costs, better tool utilization, and less material waste as a result of fewer mistakes. Cost reduction also benefits from the ability to produce effective toolpaths and shorten machining times. It might take a while to setup and become ready for machining. This procedure is streamlined by SolidCAM automation, enabling quicker machine setup and changeovers. More frequent task changes and effective CNC machine use are made possible by shorter setup periods.

5. CONLUSION

SolidCam tools have shown to be quite helpful for companies and factories when it comes to production automation. In order to streamline and optimize production processes, SolidCam, a computer-aided manufacturing (CAM) program, provides a wide range of features and capabilities. As a result, production efficiency, accuracy, and cost are all increased. The ability of SolidCam technologies to automate numerous production operations is one of their main benefits. SolidCam can automate procedures including toolpath generation, machining operations, and component programming through the use of sophisticated algorithms and intelligent programming. With this automation, less manual labor is needed, there is less chance of human error, and the manufacturing cycle is accelerated. Additionally, advanced simulation and optimization features are offered by SolidCam tools. Before starting the actual manufacturing, users can virtually mimic the machining process to look for any problems or collisions. This not only saves time, but also avoids expensive mistakes and machinery damage. Additionally, users of SolidCam may optimize cutting parameters, reduce material waste, and improve toolpath efficiency, all of which increase productivity and lower production costs. The smooth connection of SolidCam with CAD tools like SolidWorks is another essential component of production automation with SolidCam. Through this interface, design data may be transferred without any interruption, guaranteeing precise part representation and removing the need for manual data entry. Iterations may be completed more quickly thanks to the strong interaction between CAD and CAM, which also speeds up the transition from design to production. Additionally, a variety of machining techniques, including as milling, turning, wire EDM, and multi-axis machining, are supported by SolidCam. Due to its flexibility, producers can adapt various machining techniques and handle a range of production requirements under a single software platform. The manufacturing process is streamlined, setup time is decreased, and productivity is increased thanks to the capacity to handle complicated parts and multi-axis machining jobs. In conclusion, manufacturing processes and industries benefit greatly from production automation thanks to SolidCam technologies. SolidCam improves production productivity, accuracy, and cost-effectiveness by automating processes, improving toolpaths, offering cutting-edge simulation capabilities, and integrating seamlessly with CAD applications. Utilizing SolidCam technologies can improve efficiency, save manufacturing time, eliminate errors, and boost market competitiveness.

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