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ADVANCED MACHINING TECHNOLOGIES FOR PARTS WITH COMPLEX WALLS

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Abstract: *The paper presents the machining process with NC programs of a representative part for a grouped technology, viewed in a computer integrated manufacturing system. The manufacturing conception of the part was developed according the flexible manufacturing system principles, optimizing the total length of tool paths with SURFCAM program. The part is a lift-up bracket, made of aluminum alloy (zycral), with complex walls, which is subjected to static transitory loads and strong vibrations. As a result of a static and dynamic analysis, there were determined the critical sections that had to be taken into account by the manufacturing process.*
Keywords: *bracket / complex walls /high speed cutting*

1. INTRODUCTION

Today, in the world, competition requires the development of new products in no time, decreasing the time between product demand and its supply on the market. During the designing of a product, most of manufacturing enterprises apply a linear approach. This approach was required by the organization of the enterprise and the flow of information between different services. A company willing to keep or win market segments has to try to achieve a partial overlapping of activities or parallelization of the life cycle. This brings a gain of time and reduce the time of launch and commissioning of the product distribution.

Increasing manufacturing flexibility involve new combinations of information related to resource exploitation. Flexibility is the quality of a technological system to adapt to different production tasks, both in terms of shape and size of the product, and in terms of technological operations.

Studying results of current researchers in the field, we see the trend to pass from the description of phenomena during the cutting materials to their prediction. Thus, the most intense research aimed among others at modeling and simulation of processing and developing practical recommendations on cutting parameters selection in integrated manufacturing.

The choice of process plan parameters such as fixture layout design, operation sequence, selected tool path strategies and values of cutting variables had to be judged before machining [1].

The milling process simulation in a transient 3D virtual environment allowed the prediction of the part thin wall deflections and elastic–plastic deformations during machining. It was allowed the prediction of the work piece non-linear behavior during machining due to its changing geometry, inelastic material properties and fixture–work piece flexible contacts, too. And also the modeling of the effects of initial residual stresses (residing inside the raw stock) on part deformations may be estimated.

The stability prediction for metal cutting operations usually involves a process and a structure model. The challenges in research are therefore to improve the reliability of stability prediction methods for given machines and processes [2].

For performing optimal high speed milling operations, it is necessary to examine the geometrical and topological information of the work piece's virtual model. Then, the high speed cutting suitable machining strategies may be applied.

There was adopted the technological criteria consisting in obtaining the required accuracy and roughness for finished parts from the stage of finishing process. So, the adjust operations for removing tools traces were eliminated.

According to the geometric criterion, the optimum is achieved by minimizing the total length of tool paths. This is achieved by using SURFCAM Velocity 4.0 program. This dedicated program offers available facilities for modeling the manufacturing of the surfaces on NC machine tools, with the possibility of tools path generation and their post-processing. Efficient, reliable tool paths on the most complex surface geometry with the highest quality surface finishes may be created using this program.

SURFCAM systems produced by Surfware provide modeling and manufacturing solutions for surfaces and their machining on NC machines. SURFCAM allows using models created by other CAD systems through conversion different kinds of folders.

Using SURFCAM Utilities modulus, some of the following folders can be converted: Initial Graphics Exchange Specification (IGES), Drawing Exchange Format (DXF), Ford Standard Tape (FST), Chrysler Standard Format (CSF), CADKEY Advanced Design Language (CADL), General Motors Design Format (DES), ACIS format (SAT), European Automotive formats (SPAC, VDA) etc.

SURFCAM presents a pre-defined library for cutting tools and machining materials. This library contains over 500 standard cutting tools and it may be practically unlimited enriched by the user. SURFCAM Velocity 4.0 provides the possibility of generating the trajectories of the cutting tool for multi-surfaces through Z-level roughing and Z-level finishing operations. It enables the

NC programmer to move and control any combination of the machine's axes.

2. THE PART MANUFACTURING CONCEPTION

2.1 The Description of the Problem

The problem is to achieve an advanced conception for manufacturing complex parts subjected to static and dynamic transitorily loads, such as a bracket for power lift for trucks.

A power lift used in vehicles body shops is described as the type which comprises a bearing plane provided in the lower part with a lifting and lowering group. The lifting group comprises a related lifting/lowering mechanism of a scissors arrangement, corresponding to each of the lateral sides of the bearing plane. It is constituted by 2 pairs of parallel brackets, articulated between them in the middle section. One pair of parallel brackets of the lifting group is provided with rollers which slide on the ground along a trajectory parallel to the longitudinal axis of the plane. The other pair of brackets is hinged to the ground corresponding to the movable lower ends.

The mechanism is operated by at least one fluid dynamic actuator. It has one end articulated to the lower arm of one of the two pairs of parallel brackets. The other end is articulated by means of a corresponding stirrup to the upper arm of one of the two brackets. The power lift is characterized by the fact that the stirrup is hinged to the related bracket. It is provided with a roller in related motion and kinematic coupling in the first part of the lifting phase, with a surface suitably inclined relative to the ground, defined by a related shaped block. The bracket is a component of the truck resistance structure, a first class part, which supposes supplementary safety measures and, implicitly, supplementary quality assurance measures.

Likewise parts were manufactured on universal machine-tools or, recently, on 2&1/2 axes NC machine-tools. The part manufacturing process approach on universal machine tools involves a major manufacturing preparation, the bigger execution time and serious problems in assuring the quality of the product. The manufacturing process on 2&1/2 axes NC machine-tools leads to complex surfaces generation with stock to leave for the final operation of adjusting the boundaries, in order to eliminate the milling traces [3].

The processing on NC machine tools with 5 axes will lead to [4]:

a. shortening the time of the conception of the manufacturing preparing;

b. enhancing the quality of execution especially by eliminating human intervention;

c. process repeatability and part interchangeability are obtained;

d. reduced rate of scrap;

e. parts with technological difficulties such as complex walls, considerable depths, can be machined;

f. elimination of adjustment operations and improved quality of the obtained surfaces;

g. increasing the flexibility of the process.

The examination of surface roughness evolution for thin wall milling concluded that high-speed milling operations of thin walls are often limited by the so-called regenerative effect. This effect causes poor surface finish and the manufacturers are interested in having a prediction of the surface roughness of the finished part [5]. The stability and variable surface roughness investigation based on both simulation and experiments proved the strong relationship between surface roughness and vibration during machining. It may be noticed that the link between the vibration amplitude and the surface roughness is too complex to give predictive values. High speed cutting aspects in the CAM system, leaded to a significantly reduced programming time to produce high speed cutting appropriate tool paths [6]. These high speed cutting aspects may be: optimal technology and strategy suggestion, machining safety requirements and process stability for different strategies.

2.2 The Part Manufacturing Conception

In order to manufacture the part with the geometrical configuration as shown in the figure 1 and 2, the following steps are performed:

1. The 3D model part elaboration starts from the part drawing using ProEngineer programming environment;

2. The critical sections determination are found by using the finite element analysis in COSMOSM program, performing static, dynamic and heat transfer through importing the 3D model. The geometrical and shape optimization are performed as well reducing the width of the walls considerably (approx. 20%) and saving a lot of material;

3. The ProEngineer model is imported in SURFCAM Velocity 4.0 in order to perform the NC programs;

4. The tools trajectories are obtained for each operation using SURFCAM, taking into account the determined configuration of the critical sections and avoiding the appearance of supplementary stress during the process [7];

5. The post-processing programs and the part execution on the NC machine [8].

The final form of the bracket part will be as shown in fig. 6.

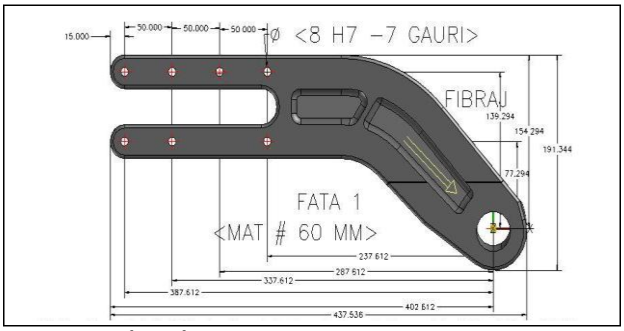

Fig. 1. View of Part face 1

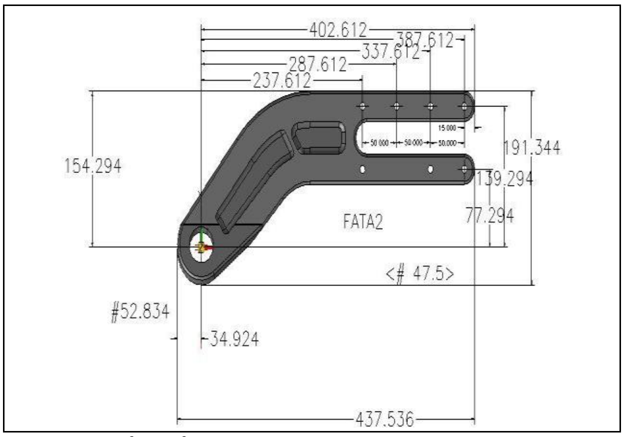

Fig. 2. View of Part face 2

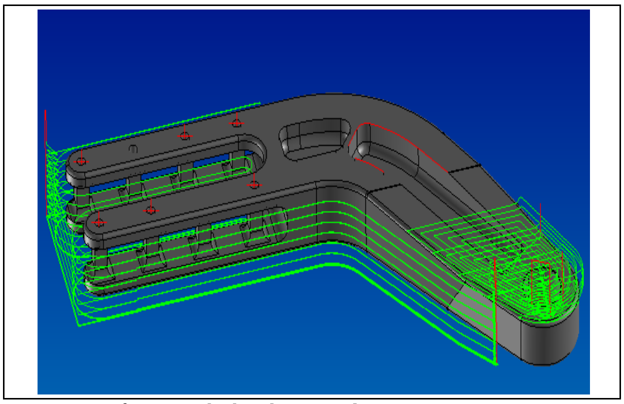
Fig. 3. Manufacturing the brackets – tool routes

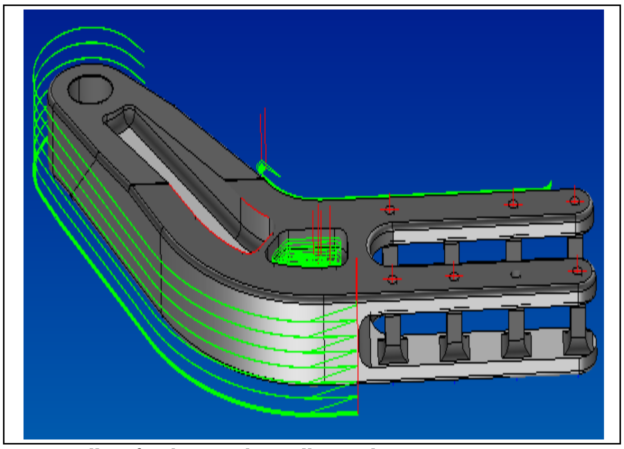
Fig. 4. Milling finishing pocket walls – tool routes

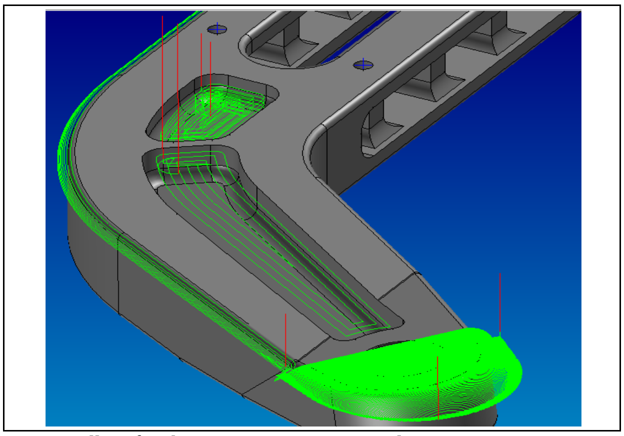
Fig. 5. Milling finishing exterior contour - tool routes

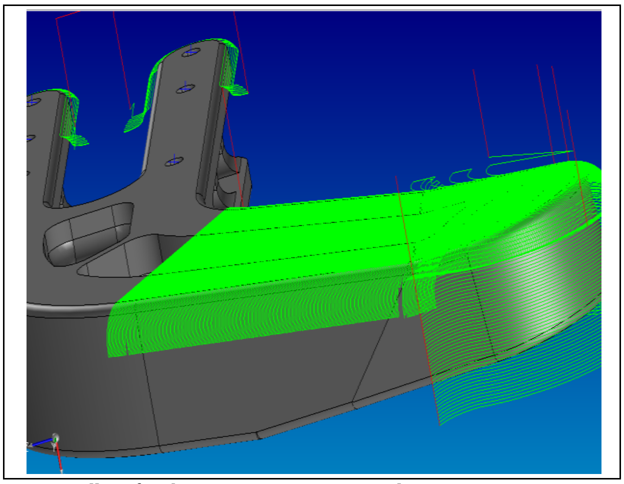
Fig. 6. Milling finishing exterior contour - tool routes

3. SIMULATIONS AND OPTIMIZATION OF COMPUTER PROGRAMS

After getting the routes of the tools, the computer simulation of all processing operations is done, respecting the established order by the technological route [9].

Checking generated paths is made by SURFCAM Verify module that allows real time viewing of the model processing starting from the semi-finished part the user wants. So, the user may obtain a quick look of the process of material removing and the processing errors can be detected.

It aims to obtain the correct geometry and required surface quality, to eliminate unwanted interferences, material missing from surfaces and edges. After computer simulation analysis, the tools paths are restored for obtaining the optimal joining of all processing operations. It has to take care so the finishing cuts step setting is enough for not causing an overheating of the part and additional tensions appearance [10].

All processing operations running on a given model are recorded by an operations manager (CN Operations Manager), where they are represented in the chronological order of their execution. This operations manager allows the post-processing of the tool paths for the chosen NC machine-tool. In machining simulation, the nominal cutting path is given in a form of NC code at selected sampling points [11].

4. CONCLUSION

Despite the significant developments in NC simulation, it is still difficult to identify the deflection impact on the process of metal removal. It is also difficult to predict and achieve the compensation of the component errors in machining process and machining simulation.

The processing technology optimization was made for a part whose geometric configuration allowed the group technology approach, providing manufacturing flexibility and CIM activities for that group of parts.

The principal purpose was to increase the speed of batch processing by optimizing the total length of tool paths and pallets using. This fact allows the parallel execution of the part orientation and fixing operations with the processing on the machine-tool. So, a better utilization of the time machine and a shorter manufacturing cycle will result.

This research work was motivated by industrial requirements of concurrent engineering, standard product data models and an integrated manufacturing environment, which are further reflected in process planning. The conclusions of the work may be elaborated as the information modeling in this area addresses the problem of capturing and representing manufacturing information related to resources and processes.

The interaction between the different types of models could provide a description of the products, how they should be manufactured, and what manufacturing resources should be used. This would provide an information platform upon which several different computers based tools to support the innovation process can be built.

It was realized the processing technology optimization not only under geometric criterion, but also under technological criterion. According the geometric criterion, the optimum is obtained primarily by minimizing the total length of trajectories (curves) with which the whole area is covered. It is important to get it in terms of maximum accuracy providing from the geometric point of view and in terms of a calculation effort as lower as possible.

Among the technological criteria there were considered the maximization of the tool capacity of cutting. The great importance, as a condition for general optimum, is to establish the direction of processing trajectories so that to allow a comfortable manual finishing. It is about giving a convenient direction to the "rifles" marking processing trajectories. So, they may be easily attacked by the tool of the adjusting worker, on a parallel direction to the direction of finishing.

In order to reduce the weight and the overall size of the automotives, component parts with complex walls are frequently used. Their machining requires special attention for not introducing additional tensions in the critical sections. These critical sections are determined by finite element analysis, using previous experience of authors in optimizing and modeling the complex walls parts.

Also, the finite element analysis and optimization saves 20% of material, providing the small widths for walls where the model is not overloaded. Thus, interdisciplinary approach of the construction and technology design, of execution and control, makes the parts with complex walls to require advanced technologies for processing.

Using of lightweight alloys as titanium alloys and others more resistant in mechanical terms will be a future research direction for improving processing technology of the parts with complex walls.

Their machining implies high speed cutting using adequate tools and coolant in order to avoid thin walls deflection and overheating.

Necessary tools are made of carbide with special coating for edges increased durability and prevent deposit formation on the edge.

Such processing tends to increase costs so that the ratio between quality and costs becomes a limitation of the research in this field.

Their milling process simulation in a transient 3D virtual environment, based on a comprehensive finite element analysis of the model, may predict the part thin wall deflections and deformations during machining.

The future approach will try to find a practical way to model the cutting force using finite element method in order to predict part deflection during machining simulation.

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