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Faculty of Mechanical Engineering
Faculty of Electrical Engineering

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PRODUCTION AND COMPUTER-AIDED TECHNOLOGIES

AUTOMOTIVE AND TRAFFIC ENGINEERING

QUALITY AND ECOLOGY

PREFACE

The contemporary development of a society requires increased productivity and production quality in all fields of industry. In electrical and mechanical engineering as well as information technology this is most obvious in basic production processes and other engineering activities. In the last decades, new techniques and technologies have seen intensive advance and their application in production systems has also been increasing.

Contemporary production is nowadays computer integrated by applying software that enables simultaneous product and manufacturing process design and complete CAD/CAPP/CAM integration of design and production.

These accomplishments, present in the developed countries, are within reach and can be acquired by intensifying our education, scientific research and development efforts, which include presenting the most important results of the past few years at this Conference.

The DEMI conference is a major meeting for presentation of new research and development results in electrical and mechanical engineering as well as information technology. The aim of the DEMI 2015 Conference is to present scientific and professional accomplishments and possibilities for their application, but also to set course for future research and development, in order to improve manufacturing aspects of industry by introducing new technologies.

The Conference includes the following thematic fields:

- Production and Computer-Aided Technologies
- Energetics and Thermal Engineering
- Mechanics and Design
- Mechatronics and Information Technology
- Automotive and Traffic Engineering
- Quality and Ecology
- Maintenance of Engineering Systems and Occupational Safety Engineering

117 papers will be presented at the Conference. The fact that there are 89 papers submitted from abroad reflects the international character of the Conference.

The DEMI 2015 Conference is an opportunity for researchers and engineers, both from the academic community and industry, to get together, to exchange experiences and to define the state of affairs in the industry as well as to create preconditions for the development of new capacities and ambient for new investments.

The Ministry of Science and Technology of the Republic of Srpska has supported the organization of this Conference, thus contributing to the improvement of scientific-research and development activities in the field of electrical and mechanical engineering as well as information technology for which the organizer of the Conference is very grateful.

On behalf of the Organizing Committee of the Conference, we would like to express our gratitude to all domestic and foreign authors as well as to the members of referee teams for their reviews.

In Banja Luka, 20 May 2015

Chairman of the Organizing Committee
Prof. Vid Jovišević, PhD

PREDGOVOR

Savremeni razvoj društva nameće potrebu stalnog povećanja produktivnosti i kvaliteta proizvodnje u svim industrijskim granama. U oblasti elektrotehnike, mašinstva i informatike to posebno dolazi do izražaja u osnovnim proizvodnim procesima i u procesima inženjerske djelatnosti. U posljednjim decenijama ostvaren je intenzivan razvoj novih tehnika i tehnologija i njihove sve veće primjene u proizvodnim sistemima.

Savremena proizvodnja je danas kompjuterski integrisana primjenom programskih sistema koji omogućuju simultano projektovanja proizvoda i tehnoloških procesa, i postizanje potpune integracije /CAD/CAPP/CAM/ projektovanja i proizvodnje.

Ova dostignuća u industrijski razvijenim zemljama moguće je dostići inteziviranjem domaćih napora u oblasti obrazovne, naučno-istraživačke i razvojne djelatnosti, što se ostvaruje prikazivanjem na ovoj Konferenciji najvrednijih rezultata koji su postignutu proteklih godina.

Konferencija DEMI predstavlja vodeći skup za prezentaciju novih rezultata istraživanja i razvoja u oblasti elektrotehnike, mašinstva i informatike. Cilj konferencije DEMI2015 je da se prikažu naučna i stručna dostignuća i mogućnosti njihove primjene, da se odrede pravci daljeg istraživanja i razvoja u cilju podizanja tehnološkog nivoa industrije uvođenjem novih tehnologija

Konferencija obuhvata sljedeće tematske oblasti:

- Proizvodne i računarom podržane tehnologije
- Energetika i termotehnika
- Mehanika i konstrukcije
- Mehatronika i informatika
- Automobilski i saobraćajni inžinjering
- Kvalitet i ekologija
- Održavanje tehničkih sistema i inženjerstvo zaštite radne sredine

Na Konferenciji će biti izloženo ukupno 117 rada. Iz 9 inostranih zemalja je prijavljeno 89 radova, što ukazuje na međunarodni karakter Konferencije.

Konferencija DEMI2015 je prilika za okupljanje istraživača i inženjera sa akademske zajednice i industrije, u cilju razmjene iskustava i definisanja stanja u oblasti industrije i stvaranja preduslova za razvoj novih kapaciteta i ambijenta za nove investicije.

Ministarstvo nauke i tehnologije Republike Srpske je svojom podrškom omogućilo organizovanje ove Konferencije, što daje doprinos unapređenju naučno-istraživačke i razvojne djelatnosti u oblasti elektrotehnike, mašinstva i informatike, na čemu im se organizator Konferencije zahvaljuje.

U ime Organizacionog odbora Konferencije posebno se zahvaljujemo svim domaćim i stranim autorima, kao i članovima recezentskog tima na izvršenim recenzijama.

U Banjoj Luci, 20.05.2015. godine

Predsjednik organizacionog odbora
Prof. dr Vid Jovišević

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SPECIFICS OF THE DESIGN FOR CNC PLASMA CUTTING

Bogdan Nedić[1], Marko Janković[2], Milan Erić [3] Gordana Globočki Lakić[4] Branislav Sredanović[5]

Summary: *This paper presents software which is used for new product development, planning, and realization of production in CNC plasma cutting. This software is described through the CAD, CAE, CAPP, and CAM systems. The paper analyzes the possibilities of the software systems, their communication, the selection of appropriate software, with the emphasis on modules and problems characteristic of the plasma cutting industry. Their use enables CNC cutting, whereby a number of presented advantages and novelties are implemented in the industry, compared to traditional plasma cutting.*
Key words: plasma cutting, CAD, CAM, CAE, CAPP

1. INTRODUCTION

By integrating CNC technology and plasma cutting technology obtained is a sophisticated technical system, whose implementation is achieved technologically the most economical metal cutting process in terms of speed, accuracy and cutting price. With modern processing systems for plasma cutting was performed complete integration of CAD and CAM software, enabling process control in all stages of development and manufacturing.

At the present time when the time interval required to comes from ideas to the realization of the finished product drastically reduces, increasing the importance of training engineers for software application in industrial production. Their use is achieved not only the automation of design, analysis, testing, reducing time required that product appears on the market, but also to decrease: the development costs, the cost of any errors that may appear on the product, loss of material which occurs as a result the application of inadequate machining parameters and inadequate tool чонстручтион, ect. Today, these software tools and technologies short determined as PLM - Product Lifecycle Management system.

The software which used for new product development, planning and realization of production can be classified into the following groups [1]:

- software for the design and construction using computer (CAD),

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- software for the analysis and simulation of product behavior in different conditions (CAE)
- software for the design and planning of technological processes (CAPP)
- software for preparation processing, program development and management of CNC machines (CAM).

In this paper are presented possibilities of some softwares which used for plasma cutting, their connections, the selection, etc. which are presented the knowledge which has to dispose engineer engaged on the development and design of new products in whose production used technology CNC plasma cutting.

2. CAD

Using these software enabled the transition from the traditional way of designing on automated way utilizing a computer [1]. Besides new ways of designing with computer, it enabled and the transition from of the traditional way of production to computer controlled processes. Specifically, at the plasma cutting instead of manually of keeping the torch and cutting, it is possible to use CNC plasma device.

At the CAD software is defined configuration of parts which should cut with plasma. They can designed very complex forms of parts. In addition, in order to create complex sets that occur assembly and welding of individual complex parts, constructively introduced "slots" that facilitate positioning of the individual parts, where without the use of additional tools for positioning during assembly can achieve high accuracy. Slots tolerance in CAD software are defined and up to two tenth of a millimeter (Fig. 1), which is limited by the precision machinery, and keeping the cutting process, not CAD software.

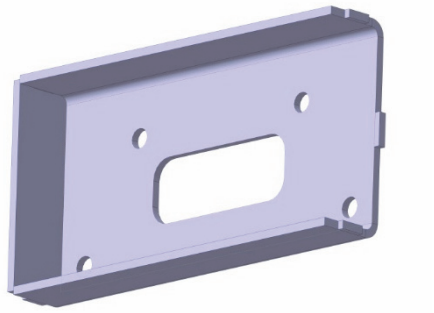

Fig. 1 *Using slots for positioning parts in assembly*

Traditional way of cutting sheet metal and plate in a small serial production mainly requires a lot of dressing and operations after cutting (finishing contours, drilling holes in seat, etc.), while the larger series requires a large number of pattern, press tools or specialized machines for making appropriate contour. Using CAD software and CNC plasma cutting machine can get very precise contours that is not necessary require rework or perform any additional operations cutting or drilling holes.

The CAD software does not have special modules for plasma cutting as well as CAD software developed for the needs joust of plasma cutting. Application of the software for the design of parts is the same at the all parts that are made by 2D cutting processes: plasma, laser, water jet.

To generate a configuration for cutting, can be used any CAD software: AutoCad, EasyCAD, GenericCad, SolidWorks, SolidEdge, ProEngineer, CatiaV5, SIMENS NX, PTC Creo, etc .

In the following section are shown the advantages of using the module for sheets - sheet metal in the most commonly used 3D CAD software (SolidWorks, Autodesk Inventor and CATIA V5), with a focus on the specifics of solving a series of problems encountered when making parts from sheets which can be obtained by cutting plasma.

When modeling sheet metal parts should observe the next items:

- thickness of the material is the same everywhere,
- edges can be very close to each other but can not touch,
- bending radius can not be cut
- on unfolding state can not come to overlapping or touching surfaces and edges.

These rules are "integrated" in the tools of module for sheet metal CAD software. It is clear that the use of these modules can see the advantage of using 3D CAD software in the sheet metal industry. These modules are a big help, a constructors which first confronted with this issue.

Getting unfolded states

If, after plasma cutting, is necessary to perform bending parts is desirable to use 3D CAD software which having modules for sheet metal. They have the option of automatically obtain developed states and the bending line on technical drawing from a 3D model.

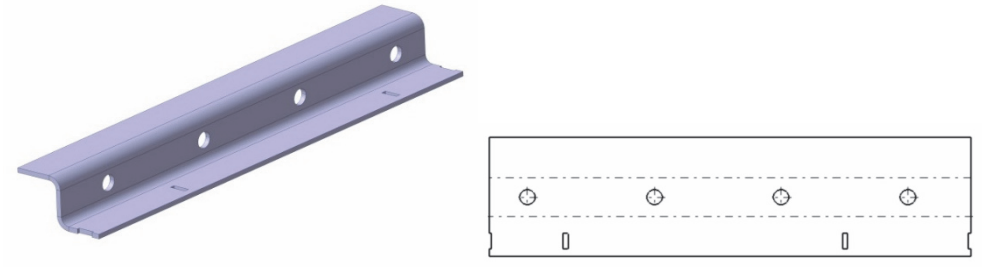

Fig. 2 *Getting unfolded state (CATIA V5)*

SolidWorks besides to obtaining the bending line has the possibility light obtaining direction of bending which reduces the possibility of errors due to not understanding the technical drawings by the operator [2].

For parts where the bending is necessary, it is possible to use modules that are not intended for sheet metal, but the unfolded state, or more precisely DXF files can only be obtained introduction of the model in the mentioned module. Specifically, in CATIA V5 in these cases use the tool *recognize*.

The command *recognizes* may be encountered under different names depending on the CAD software, so for example in Autodesk Inventor called *Convert to Sheet Metal Parts*, but the function is the same as in CATIA V5.

Using module for sheet metal exclude the possibility of obtaining the edge that can not be obtained by 2D cutting.

Collision edges or surfaces on the unfolded state

One of the specifics when working with sheet metal is that the edges on the developed state may not overlap or touch. CATIA V5 module for sheet metal have tool *Overlapping,* which can be checked collisions on the unfolded state (Fig. 3).

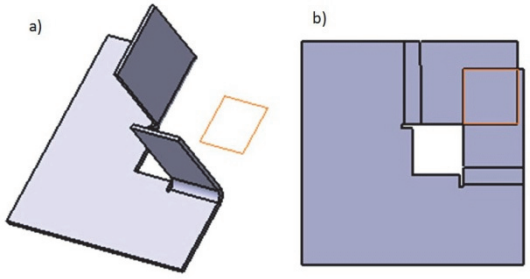

Fig. 3 *Overlapping edge on unfolding state [3]*

Corner relief

When bending sheet metal special attention should be paid to the corners where the two sides meet. At such places should be performed *corner relief* (removing excess material that occurs due to bending). For this there is automatic possibility (Fig. 4 obtained by CATIA V5). Autodesk Inventor pro has tool *Corner Seam* for working with edges. It defines the distance and geometry edges on the corner (Fig. 5).

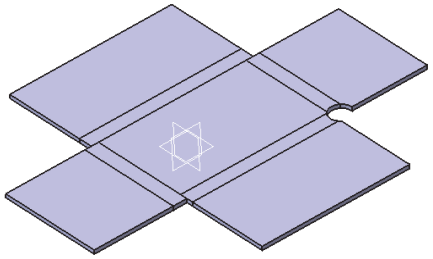

Fig. 4 *Corner relief*

Fig. 5 *Defining corners at Autodesk Inventor pro [4]*

When creating 3D models, in addition to great possibilities sheet metal module CAD software, it is necessary to consider the possibilities of CNC machines on which will perform cutting, because plasma cutting devices, have a specified constraints [5].

Another example of adapting 3D models to machine, is setting geometrical shapes when creating DXF, DWG,.. files for some CNC plasma machines. If part on unfolded state compris geometrical shapes such as ellipses, parabolas, sometimes, when creating DXF files, this kind of geometry is necessary to approximated by linear segments.

On which software to decide always is a complex issue. Based on the presented when it is complex shapes which after cutting needed to bend, then should choose a 3D CAD software with modules for sheet metal, because they are the shortest path from the model to a DXF file.

3 CAE

One of the characteristics of CNC plasma cutting is that the obtained contour is not necessary rework, do not any additional operations cutting or drilling holes. Therefore, in addition to all the benefits of 3D CAD software have over the traditional construction method, it is desirable modeling solutions to check analyze and optimize.

One of these software solutions is DFMPro, which analyzes construction in the CAD environment. It has a module for sheet metal. It is integrated with platforms: NX, SolidWorks, Solid Edge, PTC Creo, CATIA and Inventor. In his system are integrated rules and guidelines that have been validated in industry. These rules, using the Rule Manager, can be easily upgraded and adapted to the specific company, process or machine.

For parts from sheet metal and plates that are cut and bent exist optimal value radius, distance between the edges and holes, minimum distance between holes... With DMFPro [6] in such positions can be optimized:

- Distance holes or slots from bend radius. Some recommendation is that this distance is not less than 2 mm.
- The minimum diameter of the holes, slots, openings... Recommendation for plasma cutting is that the minimum radius of the holes may be equal to the thickness of the material. Of course, these recommendations can be adjusted depending on the price and quality of plasma devices.
- The minimum value of bend radius. If the bending radius is too small, it can lead to deformations (cracking) material in the bending zone (Fig. 7).
- Because facilitate production, it is recommended that all bending, which are derived from the same plane are in the same direction.
- Minimum distance between hole and contour lines.

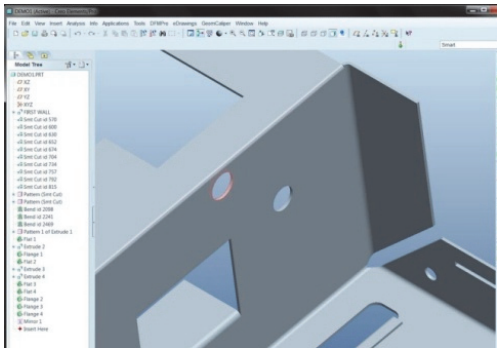

Fig. 6 *Minimum distances from the hole and bend radius*

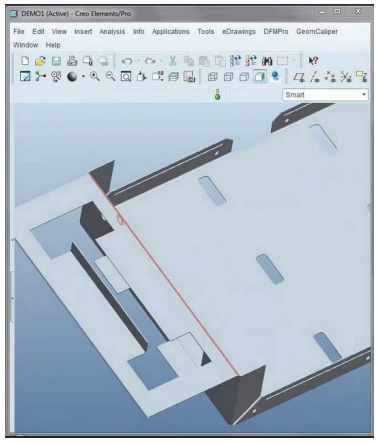

Fig. 7 *The minimum value of bend radius that will not induce the deformation of the material*

- Minimum distance between the holes and slots.
- Is there a tool and the possibility of making part. It does not mean that each 3D model can make...

Besides this technological analysis it is necessary to individual part or the whole assembly check on the vibration, heat flow... These types of analyzes are known as FEM Finite Element Method. This is important for the individual parts of plates and sheets metal as well as for the assembly (various frames, platforms, carriers ...).

There are 3D CAD software which have modules or addition for FEM analysis: CATIA V5, AutiFEM, Inventor, SolidWorks... FEM analyses have a couple of characteristic steps:

- Display 3D geometry models
- Preparation part for the analysis - creating a gird of points
- Assigning boundary conditions (loads and constraints)
- Troubleshooting
- The visualization of results
- Analysis of the results
- Change in design, namely changes in the CAD model
- Re-perform FEM analysis

For FEM analysis, exist a specially developed software. One of the most famous is FEMAP, which has a wide application range. It is used in complex product systems and processes. As CAD software is independent and has good access to the leading 3D CAD software such as Pro/Engineer, Catia, NX, NX I-deas®, Solid Edge, AutoCAD and SolidWorks.

4. CAPP

Technological preparation of production is largely represents on definition quality solutions of technological process made of product. Systems design of technological processes can be understood as a "bridge" between the product design and the process of its production. The application of modern CAM systems and introduction of CNC plasma devices and modern technological systems of various purposes in the production, significantly increasing its productivity and flexibility.

The problem arises in the design phase of technological processes, which, on the one side it is necessary to satisfy the requirements of product designers, on the other side, to take into account the technological possibilities of production. The active use of computers in this area lead to the development of CAPP - Computer Aided Process Planning. The tendency of these systems is to appropriately uses logic operation of technologists and to made simulate of them operation by using computer programs. Development of CAPP system is a very complex task, due to the diversity of products, also because of the complexity of the design and planning of a large number of complex activities which make up the technological processes in different production conditions. This has resulted in impossibility to develop adequate universal commercial solutions CAPP system. As a consequence, a implementation level of CAPP system in the industry is still low, so the activity of designing technological processes often represent a bottleneck in the integrated production environment.

When designing a new production process, it is necessary to performe:

- major planning of production,
- planning a necesery material,
- planning of capacity,
- planning of equipmet,

- designing of technological processes.

Some of the software which is intended for solving the above mentioned tasks are: DELMIA, JobDISPO, 3DVIA Composer, SolidWorks Enterprise PDM, itd.

5. CAM

Further course of use constructive documentatation, takes place through the preparation for production and this activity takes place in the departments of technology companies where preparation occurs technological documentation.

After designing a product or part using CAD software, it is necessary to define the production technology. Because today, for cutting metal parts using modern CNC plasma machines, defining production technology involves defining and creating "G" code on which basis the machine will perform the necessary operatios. Today, the generation of code (programs) can be performed automatically on the basis of CAD models using CAM software.

CAM softwares can load different drawing formats: DXF, IGS, CADDY, PLT, etc. Software PlasmaCAM can even upload and formats that are not traditional for CAD software HPGL/2, which enables the transfer design from any Windows environment, for example, drawing from CorelDraw or PDF. This option involves installing special Windows drivers for printing high resolution, thereby creating a virtually ploted file which will loaded into PlasmaCAM [8]. In addition to these there is CAM software which using 3D CAD software interface (ProNes –CAM software with SolidWorks, Inventor, Pro/ENGINEER).

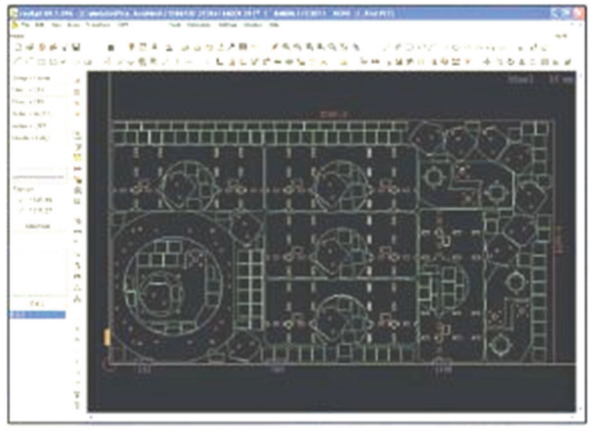

Fig. 8 *Deployment shapes for cutting in software METALIX [8]*

CAM software today go beyond the classical tasks of CAM and called CAD/CAM software. They have CAD modules. These modules have less features than conventional CAD software. They are used for the obtained unfolded state, correction of the preformed 3D models (add radius, etc.). Today all serious manufacturers of equipment for plasma cutting with the machine offered and CAM software in different variants depending on the complexity of the cutting process, the number of machines that need to be managed... During the development such solutions are overcome of common frameworks CAM - software, so with them now is possible to performe planning,

storage, documentation and analysis of the technological processes and integration with other business systems.

6. CONCLUSIONS

In the design for plasma cutting, conventional 3D CAD software has an advantage, while the *sheet metal* module should be used. One should always pay attention to the fact that after CAD other software should be used, therefore a method of CAD modeling should be adapted to other software. During modeling, the possibilities of a machine in CAD should be considered.

Thus, in order to reach the final goal (the final product) it is always necessary to use a few types of software and to think about their "communication". The connection between CAD and CAM is usually made by means of DXF files, a special link, or by using the same interface.

CAD and CAE software tools have "integrated knowledge" about the specifics that characterize sheet metals, so the constructor's job is made easier. CAE software should be used as early as possible in the modeling phase to discover bad solutions on time.

The low level of implementation of CAPP system in the industry forces users to rely on ready-made solutions of equipment manufacturers.

When choosing CAM software, manufacturer's recommendations should be followed because they adapt software very well to machines and the customers' needs. With CAM software it is possible nowadays to perform planning, storage, documenting and analysis of a manufacturing process as well as the integration with other company's business systems. New software goes far beyond the tasks of the fields that it is designed for, therefore software covering CAD/CAE/CAPP and CAM systems can be expected under the same interfaces in the near future.

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