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DESIGN OF CASTING BLANKS IN CAPP SYSTEM FOR PARTS OF PISTON-CYLINDER ASSEMBLY OF INTERNAL COMBUSTION ENGINES

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Preliminary Note – Prethodno priopćenje

Development of information technology industry provided great possibilities in the area of integration of different CAx systems, such as CAD, CAM, CAE and others. In order to successfully link systems of automated-design (or Computer Aided Design - CAD) with automated manufacturing systems (or Computer Aided Manufacturing – CAM), automation of manufacturing process planning is needed, i.e. CAPP (Computer-Aided Process Planning) systems can bridge a gap between design and manufacturing. In this paper is shown design of casting blanks in CAPP system for parts of piston-cylinder assembly of internal combustion engines in a manufacturing system.

Key words: casting blank, design, CAPP system

Modeliranje odljevaka u CAPP sustavu za dijelove klipno-cilindarskog sklopa motora sa unutarnjim sagorjevanjem. Dostignuta razina razvoja informacijskih tehnologija omogućila je značajne rezultate u području integracije različitih CAx sustava kao što su CAD, CAM, CAE i drugi programski sustavi. Da bi se uspješno povezali sustavi automatiziranog projektiranja proizvoda, odnosno CAD sustavi i sustavi automatizirane proizvodnje, odnosno CAM sustavi, potrebna je automatizacija projektiranja tehnološkog procesa izrade, dakle CAPP sustavi, koji predstavljaju most između projektiranja i proizvodnje. U ovom radu se prikazuje modeliranje odljevaka u integriranom CAPP sustavu za dijelove klipno-cilindarskog sklopa motora sa unutarnjim sagorjevanjem u jednom proizvodnom sustavu.

Ključne riječi: odljevak, projektiranje, CAPP sustav (RPPP-računalom potpomognut proces planiranja)

INTRODUCTION

Modern market conditions require high quality and low prices simultaneously with short product manufacturing and delivery times. Also nowadays, small series of products are more frequent than large volume series. This requires high flexibility of the manufacturing system, as well as the whole production process [1].

In this kind of environment, manufacturing systems with high level of automation are essential. New technologies are being introduced on a daily basis. Many of them are based on flexible automation and other high technologies [2].

In the recent years, researchers put a lot of effort in the integration of different CAx systems to achieve optimal and efficient use of intelectual and other engineering resources.

Team work, computer support and standardized integrated model for process planning and manufacturing, are highly appreciated. Design and manufacturing standards development is also based on the integrated approach to activities like concept development, design, manufacturing, and complete product life cycle [3 – 5].

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Advanced CAx tools merge many different aspects of the product lifecycle management (PLM), including design, analysis using finite element analysis, process planning, manufacturing, production planning, product testing using virtual lab models and visualization, product documentation, product support, etc. (Figure 1).

CAPP systems have one of the key roles in the integrated environment of CIM and bridge between CAD and CAM systems. However, CAPP systems are not yet developed as CAD, CAM and CAD/CAM systems [6].

One of the obstacles of CAD/CAPP systems integration is in the fact that technological meaning of geometrical shape is lost during clasical CAD modelling. Intelligent interface linking CAD and CAPP systems would be an ideal solution. That was not done because of the presentation limits of CAD model. To enhance that feature, CAD system manufacturers have created feature-based CAD systems (Figure 2).

Design features are different than manufacturing features, since manufacturing features are defined by the type of manufacturing operation and operation‘s schedule. Integration of CAD/CAPP/CAM systems based on STEP standard uses interface for standardized access to STEP databases (SDAI) for data exchange between application protocols and STEP database [10].

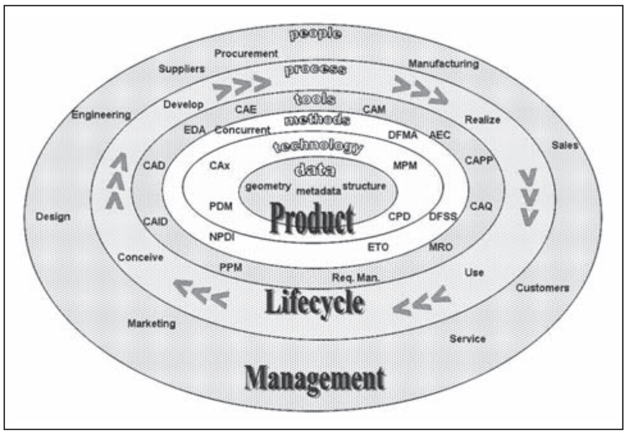

Figure 1 CAx tools in the context of product lifecycle management [7]

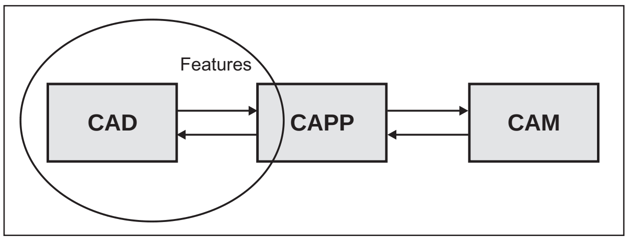

Figure 2 Links in the integrated CAD/CAPP/CAM systems [8, 9]

MODEL OF INTEGRATED CAPP SYSTEM

Model of this systems is based on the general settings for specialized integrated CAPP systems, using general purpose software. This setting are:

- System allows 3D modelling and production of 2D drawings for the manufactured parts and their casting blanks,
- System allows casting process simulation of blanks based on 3D models and known manufacturing parameters,
- System allows geometric and technological recognition of manufactured parts, as well as selection of standard manufacturing processes in given conditions,
- System allows automated process planning for given part as well as generation of NC programs for manufacturing operations, including process simulation.

An specialized and integrated CAPP system based upon these settins was developed. It is shown in Figure. 3. It was designed for automated process planning of internal combustion engine's piston assembly parts manufacturing. Assembly parts include pistons, cylinder liners, ribbed cylinders, etc.

This system is vario-generativ integrated CAPP system. Model of this system, encompasses three basic modules:

- Parts and casting blanks modelling, CAD module,
- Casting process simulation, and
- Manufacturing process planning, CAPP/CAM module.

In the CAPP integrated system, module for parts and blanks modelling is one of the most important elements. This also applies to the module for casting process simulation of blanks.

DESIGN OF CASTING BLANKS

The first module allows determination of the typical part or blank group. This is usually preceeded by parts geometric recognition. If a corresponding typical part cannot be found, modelling is done instead of group determination.

Every type of a part and a blank has corresponding 3D model with parameters. These models are designed in CAD module. In Figures 4, 5 and 6 are shown 3D models of casting blank for some piston-cylinder assembly parts.

Working conditions of the piston-cylinder assembly parts, as well as conditions which come out from dy-

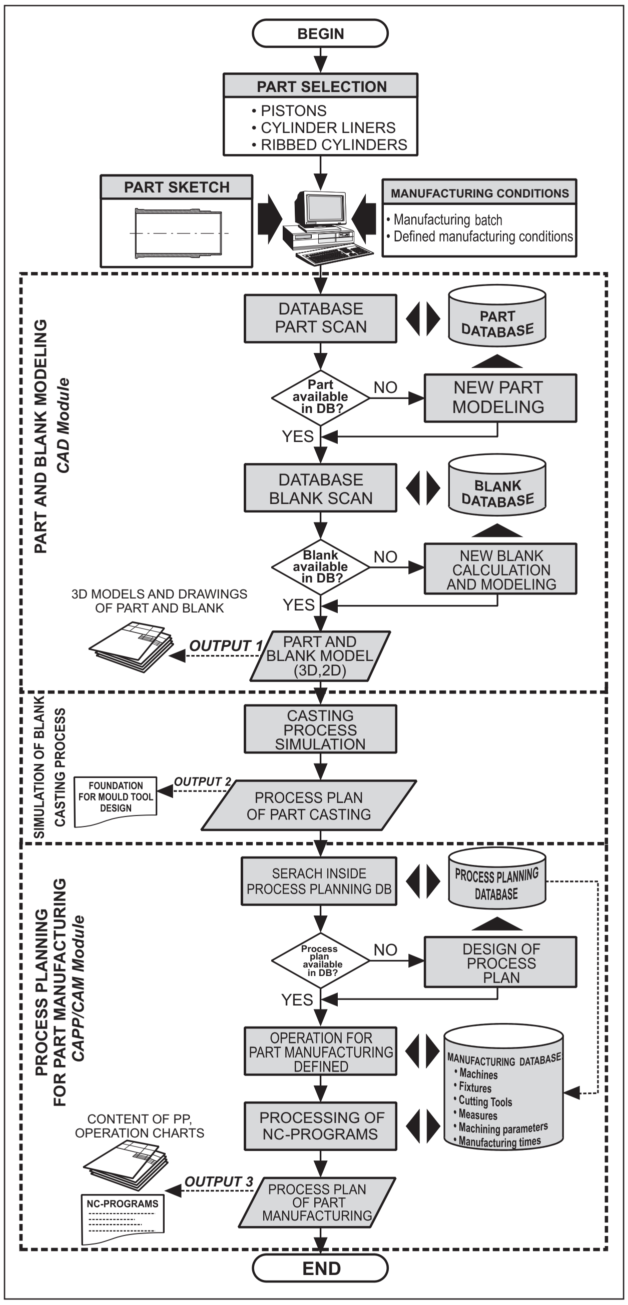

Figure 3 Integrated CAPP system's algorythm [11, 12]

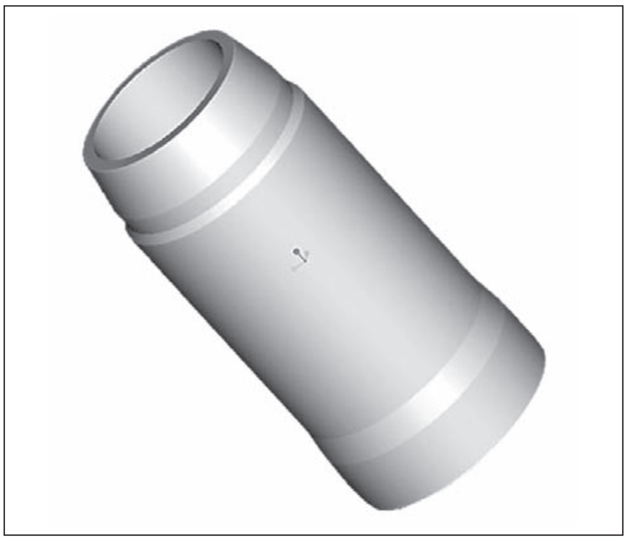

Figure 4 Group casting blank of cylinder liners

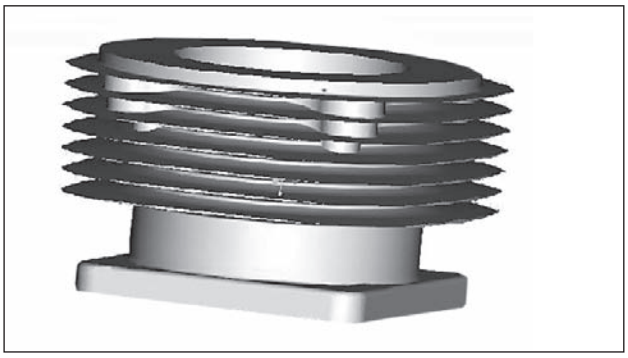

Figure 5 Ribbed cylinder – casting blank

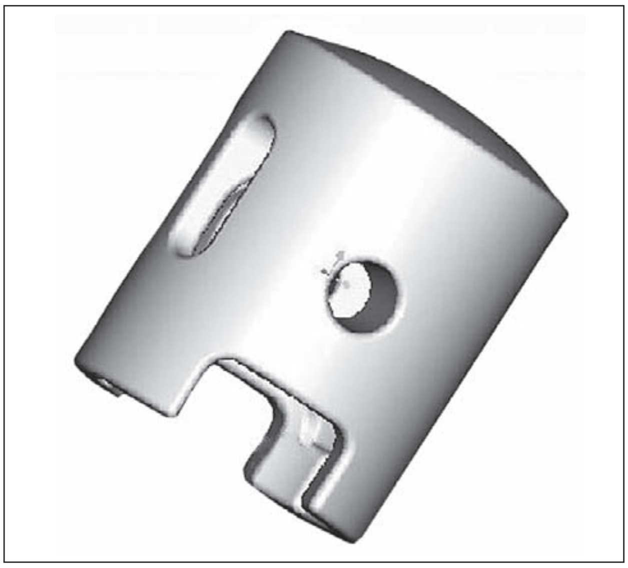

Figure 6 Piston – casting blank

namics of the motor mechanism put higher requirements for some parts materials: good mechanical properties at higher temperatures, high resistance to wear, good sliding properties, small specific weight, homogenity, good machineability etc. Due to this material used for casting this parts must have high mechanical, physical and other properties [13, 14].

Materials for casting the cylinder liners are special low alloyed and alloyed gray casting which meet the standards of the most eminent motor manufacturers. Observed production system casts them centrifugally on the multi-position machine or on the particular machines for casting. Heat treatment is performed after casting in order to remove strains occured within the process of casting.

Materials for casting the ribber cylinder are special modified casting CSL-1 to manufacturer local standards which fit to eminent motor manufacturer standards. Pistons are casting from specially chosen alloys of aluminium and silicon of eutectic and overeutectic composition, by die casting.

For cylinder liners, eleven different types of groups were defined (Figure 7). For ribbed cylinders and pistons corresponding blanks are being modelled on a one-by-one basis.

Blank precision for ribbed cylinders and pistons definition encompasses determination of blank dimension by adding or subtracting dimension additions for parts' manufacturing. Programme determins this blank dimensions by using developed knowledge database and given parts' dimension.

Blank precizion for the cylinder liner is made on the basis of the developed knowledge base. Knowledge base allows it to on the basis of a given type of liner and its dimensions determine the appropriate type of group blanks with specified dimensions.

In Figure 8 an example of cylinder liner Ø98,48 PERKINS KS which belongs to the type SVDI is presented with its dimensions.

Blank dimensions for observed cylinder liner Ø98,48 PERKINS KS, type IV are presented in Figure 9, Figure 10 show a 3D model of the blank of this cylinder liner.

Defined 3D blank model with other given parameters allows simulation of casting manufacturing process with the use of appropriate software (programmes). 3D part models and their blanks, with manufacturing conditions allow automated manufacturing process planning of the piston-cylinder assembly parts in the proposed CAPP system [11, 12].

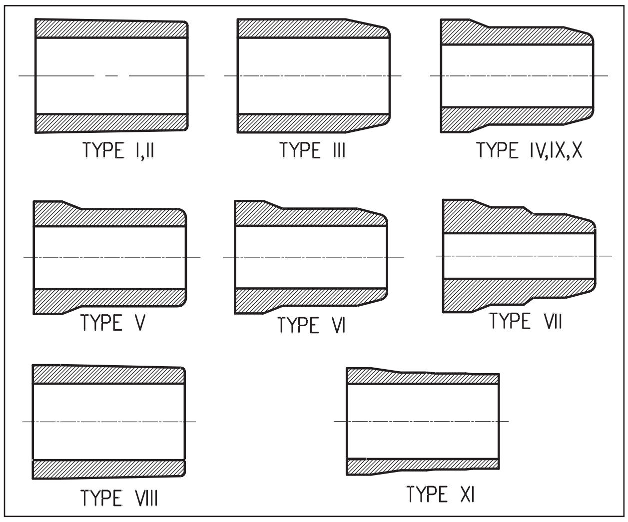

Figure 7 Types of group cylinder liner blanks

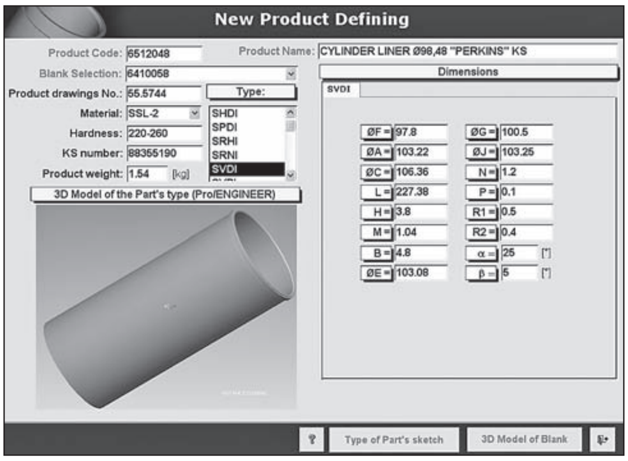

Figure 8 Dimensions and general product information definition

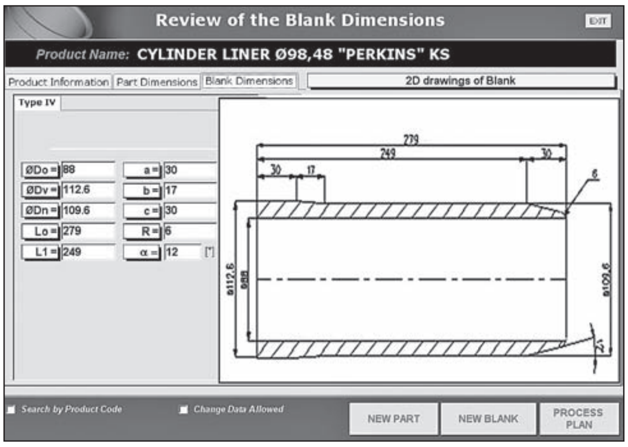

Figure 9 Cylinder liner detailed casting blank drawing

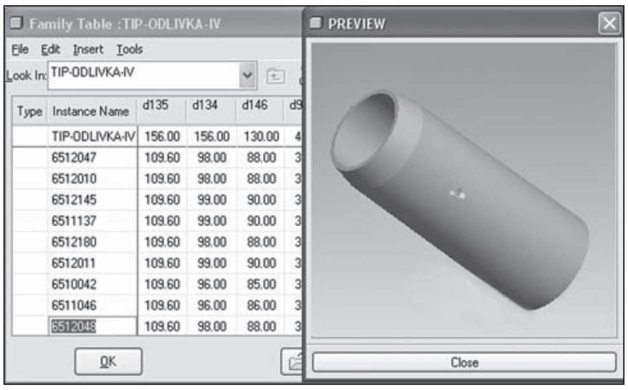

Figure 10 3D model of observed cylinder liner blank

CONCLUSIONS

Specialized and integrated CAPP system, that was developed by using general use software allow automated product design and manufacturing process planning in a given manufacturing system. This manufacturing system is specialized for production of large series parts of piston-cylinder assembly of internal combustion engines.

Developed CAPP system provides part and casting blank modelling which in turn provides basic inputs for simulation of the casting process and manufacturing process planning observed parts.

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