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CONCURRENT ENGINEERING USING CATIA v5 FOR MOULD MANUFACTURING

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Abstract: *The paper presents the way the concurrent engineering concepts in CATIAv5 are used at conceiving, engineering, optimizing and manufacturing moulds in the automobile industry. 3D parametric modeling of the moulds, verification and optimization using the finite element method and the processing using numeric command machines-tools, are all interconnected activities through the informational flux using graphic and methodical databases.*

Key words: *CATIA, concurrent engineering, mould, FEM, CNC.*

1. GENERAL CONSIDERATIONS

The life cycle activities attached services organizing of the enterprise, the equipping with informational means and their connecting in a network leads to an integrated system of production (CIM-Computer Integrated Manufacturing), but it constitutes a linear structure, sequential which increases the duration of the cycle from the moment of the notification of the necessity till the delivery of the product. The simultaneous engineering brakes this linear and sequential organizing on specialized services in the product’s life cycle activities, generating multidisciplinary teams which work at the putting together of the project, following its main steps: the study, the conceiving, the making. All participants, regardless their specialization are regrouped around a common database which they create and exploit, continuously adding information to it, including information which comes from the product’s beneficiaries after the maintenance, preventive and corrective check, both during and after the guarantee period. Multidisciplinary teams work ensures the unity of solutions, avoids loops and terms prolonging, is reduces the manufacturing costs and increases quality. In simultaneous engineering, an activity can commence even if the previous is not over yet. This imposes the unstable databases operating, being able to verify the impact that other people’s work has over your own. For example, the method service can begin the industrialization study of a piece while it is being defined, which gives each of the team members the possibility to act in real time. So, a coherent informational system is absolutely necessary, at least in the developing stages of the product, to be able to use in all stages of the project the informational means, which ensure the permanent communication between specialists of different professions. In essence, concurrent, simultaneous or parallel engineering, represents, in an incipient phase, the ways of research for a maximum cutback of the life cycle, from defining till the effective launch of the product. On a secondary level its purpose is of solving the product related information problems, because as it was demonstrated earlier in this paper, engineers find it more gratifying to recreate the multitude of data, which has already, been studied, than to reuse already existing data. This duplication involves a great variety of pieces or subassemblies making the administration of stocks more difficult and burdening the maintenance pieces administration. The CATIA solution offered by IBM and Dassault Systems answers the demands mentioned earlier. It permits the integration of constructive design activities, technological design, devices design and executing, so realizing the decrease of the engineering cycle, the increase of quality and reduction of engineering and manufacturing costs. For the implementation of the CATIA application in concurrent engineering, a reorganization process of engineering activities is recommended, which will realize the passage from the sequential organization of the design activities to a unified structure at company level and to allow the adoption of a set of advanced design practices and the usage of a common database. CATIA comes in aid of the users with structure editing facilities, inspection, cinematic simulations, databases, modules and possibilities of definition, storing and reusing of engineering knowledge. CATIA offers a unique technological environment of design and preparation for manufacturing using the PLM concept (Product Lifecycle Management).

2. CONCURRENT ENGINEERING IN MOULD DESIGN AND MANUFACTURING

The recent research in concurrent engineering are directed towards the activities which have as main goal the conceiving of the product and its manufacturing process, activities wit the largest impact on global costs compared to the real cumulated expenses. The research will be subsequent extended over the life cycle activities assembly. The main goal is the development of methods and means to systematically integrate the conceiving process, constrained by the cost-term-quality compromise. Having these criteria as a start point, the methodology becomes concurrent, aiming at diversity, simultaneity and integration. Concurrent engineering stimulates an augmented informational flux, but the communication between services must also be assured.

One of the most dynamic fields of industry is the auto manufacturing. The preparation of the product for manu-

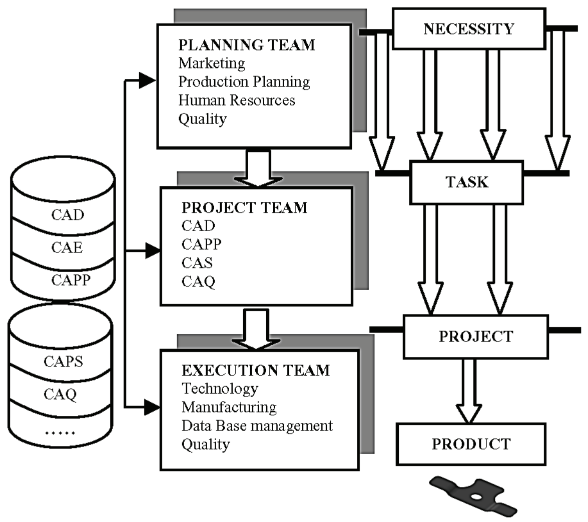

Fig. 1. Concurrent engineering in mould manufacturing.

facturing requires the engineering over a short period of time and at low costs of moulds and dies for the manufacturing of auto components.

The increase of productivity and engineering quality and at the same time reduction of costs can be realized using the method and means of aided design CAD/CAM/CAE using CATIA v5 and the concept of concurrent engineering (Fig. 1).

For the design of moulds and dies, the parametrical molding is used to generate a "generalized mould", mould which contains the main elements of any other mould and is connected to the standardized and normalized elements necessary for the making of any mould in the database, being this way able to design any mould using the initial design of "the generalized mould". "The generalized mould" is similar to "the generalized piece" from the group technology.

The flexibility of the design increases because at a new task of manufacturing based on "the generalized mould" one works only for the active elements (which are specific to each mark), the rest being used in the design only by modifying the geometrical parameters from the tables afferent to the constructive element. The checking of the CAE module design using the method of finite elements is the activity, which makes the design complete. After realizing the technology of manufacturing, the transfer to the CAM module is realized in which is developed the NC program of assisted processing of marks, in Fig 1.

3. THE COMPUTER AIDED PARAMETERIZED DESIGN OF MOULDS

CATIA v5 offers an unique technological environment for design and preparation for manufacturing. The CATIA v 5 application offers a homogenous interface in all of its applications, also defining the concept of PLM. For the implementation of the CATIA application in concurrent engineering, a reorganization process of engineering activities is recommended, which will realize the passage from the sequential organization of the design activities to a unified structure at company level and to allow the adoption of a set of advanced design practices and the usage of a common database.

CATIA comes in aid of the users with structure editing facilities, inspection, cinematic simulations, databases, modules and possibilities of definition, storing and reusing of engineering knowledge.

A series of functions benefit of expert systems capable to understand the designer's intention, to recommend solutions or to adopt optimal variants. One of the functions through which CATIA facilitates the implementation of concurrent engineering practices is the function of association.

Association between the 3D model and the 2D representation-technical design allows the designer-drawer to operate on the 3D model, but any ulterior alteration of the 3D model generates, on request, the actualization of the 2D representation. The main benefit in 3D molding of components' marks of the moulds is offered by CATIA v5 through which a parameterized molding of the products, method through which the quality and productivity of assisted design increases.

In Fig. 2 a mould design is realized through parameterized molding using CATIA v5.

The premises on creating a mould in the CAD module are: its integration in the CIM integrated system of production; connection with the other two modules through: informational system, the definition of the types of information used and the compatibility of information; the possibility of recognition of geometrical data (the geometric attributes of the product) by the CAPP module (the module which uses the data from CAD as in-data).

Punctual attempts have shown particular interest on form features in the preparation for manufacturing stage. In stead of using a product molding starting from conceivement, at the end of this stage form characteristics extraction algorithms can be applied to the supplied model.

With the help of calculated data this model can be expanded so it would come close to a product molding, to a high level structure, containing not only the structural description of the piece but also complementary data regarding certain areas, profitable especially for manufacturing.

The description of a form characteristic is tied to two aspects: its form (geometry, typology, category) and complementary data on its meaning or functioning, even if these last do not intervene in algorithms yet.

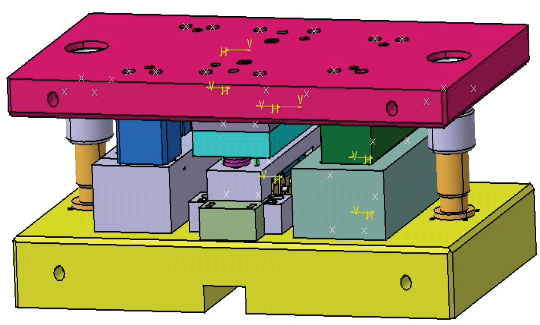

Fig. 2. The Computer Aided Parameterized Design of mould.

The study of form characteristic extracting subscribes to a larger picture of automatic understanding of a piece. The interest is so immediate, because the better this understanding is, the more possibilities of automatism, faster production, so more advantageous.

In our specific case, form characteristics and, in particular, detecting them before the manufacturing stages are:

- reducing, even canceling human intervention, till absolute necessity, to interpret the conceptual models and plates provided, and so decreasing the risk of errors;
- automatic selection of the tool;
- the calculation of the trajectory of the tool;
- the feature based parameterization of the manufacturing process;
- the analysis of the possibility of manufacturing;
- classification of tools and comparison of objects.

The graphic databases of standardized and normalized products, which communicate through CATIA v5, in the stages of design of moulds, is an important facility which leads to an increase of productivity and of design precision.

4. THE CONSTRUCTIVE AND FUNCTIONAL OPTIMIZATION OF MOULD COMPONENTS USING THE FINITE ELEMENTS METHOD

The molding of the product consists in the description of an object, not just geometrically, but also depending on a certain number of features, functional features, manufacturing features etc. So, product model contains:

- geometrical information, which can correspond to that which is being manipulated in solid models;
- technological data, for example manufacturing operations (drilling, threading, milling, lathering) which give more explicit data regarding the whole geometrical feature or just a part of it;
- precise data, which explain the manufacturing tolerances in order with the ideal feature;
- material data, which specify the type of material and its properties;
- administrative data, which make the maintenance of the material easier (references, providers, supply).

The CATIA v5 – Generative Assembly Structural Analysis product was designed as a useful extension of CATIA-Generative Part Structural Analysis allowing the study of mechanical behavior of the whole assembly. This product is totally included in the Generative Assembly Structural Analysis product and was conceived after the same "easy to learn" concepts, generating a powerful work instrument.

This module permits an optimization of the component parts of the 3D molded moulds using the finite element method. This module is useful for the constructive-optimization of the mould (Fig. 3), to be able to further develop the machines-tools mark manufacturing technology, using NC. Optimization takes into consideration both constructive and technological elements necessary in product manufacturing. Its effect is that of realizing optimal marks, from the constructive point of view, saving material and using a high technical process.

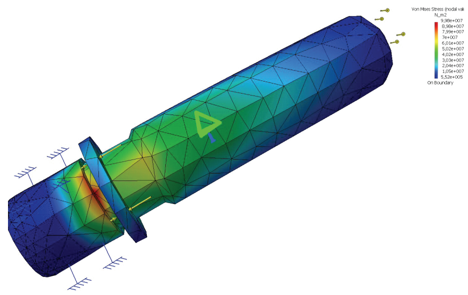

Fig. 3. FEM for a mould component.

Modified forms and dimensions (optimized) are saved in the graphic database. The drawings saved in the database are parameterized, so that at every alteration of the quotations during the optimization process, the execution drawing of that mark could be automatically realized. The database created is used both in the design-redesign phase and the conceivement of technological manufacturing processes phase, in Fig. 3.

5. THE PROGRAMMING OF THE CNC MACHINES-TOOLS MOULD MANUFACTURING

Computer Aided Process Planning (CAPP) makes the connection between constructive computer aided conception and aided manufacturing. In this module, the technological processes of manufacturing are conceived, and than, the data is transmitted to be processed with the purpose of product manufacturing.

Computer aided manufacturing (CAM), is the most complex module of the CIM system, its integration directly affecting the quality and manufacturing flexibility. The weight of the CAM activities in the integrated system of production is to be remarked. The CAM module includes procedures of automatic generation of numeric commanded machines-tools running instructions, based on the geometrical model of the executed piece.

CATIA v5 is the program that allows the making of NC manufacturing programs necessary to the numeric command machines-tools, using the NC Manufacturing module. The structure of data represented in this module is represented in Fig. 4.

CATIA v5 allows, through the NC Manufacturing module integration, the making of some NC programs for computer aided manufacturing of moulds on milling machines with NC 3 axes and 5 axes, through the Prismatic Machining module, as well as milling complex surfaces on manufacturing centers with NC in 5 axes, using the Surface Machining module, Fig. 5 representing

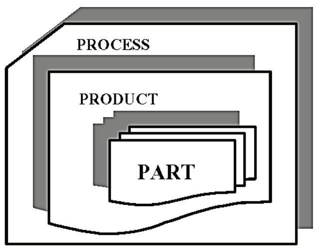

Fig. 4. The structure of CATIA process file.

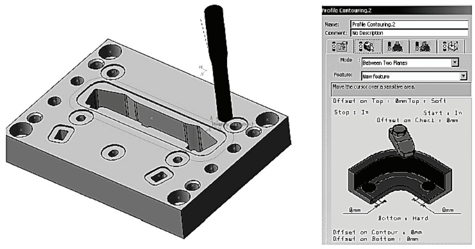

Fig. 5. CNC programming.

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$$ Manufacturing Program.1
$$ prelucare suprafete
$$*CATIA0
PARTNO PART TO BE MACHINED
COOLNT/ON
CUTCOM/OFF
PPRINT OPERATION NAME : Tool Change.1
$$ Start generation of : Tool Change.1
TLAXIS/ 0.000000, 0.000000, 1.000000
$$ TOOLCHANGEBEGINNING
RAPID
GOTO / 0.00000, 0.00000, 100.00000
CUTTER/ 30.000000, 0.000000, 15.000000,
0.000000, 0.000000,$
   0.000000, 50.000000
TOOLNO/3, 30.000000
TPRINT/T2 End Mill D 30
LOADTL/3
$$ End of generation of : Tool Change.1
PPRINT OPERATION NAME : Facing.1
$$ Start generation of : Facing.1
LOADTL/3,1
TLAXIS/ 0.000000, 0.000000,-1.000000
FEDRAT/ 300.0000,MMPM
SPINDL/ 70.0000,RPM,CLW
GOTO / -15.00000, 0.00000, 1.00000
FEDRAT/ 1000.0000,MMPM
GOTO / 236.33650, 0.00000, 1.00000
GOTO / -15.00000, -14.71664, 1.00000
```

Fig. 6. APT file.

such a manufacturing for a relatively complex, from the geometrical form point of view, mould.

After these stages, using on-line transmissions, the NC program in APT or NC-Code language, Fig. 6, is being transmitted to the numeric command machine-tools' equipment and the mark of the mould is being manufactured.

By using CATIA v5's Surface Machining module, the precision, productivity and manufacturing programming with direct effect on the manufacturing costs increase.

The increase of the manufacturing flexibility implies new combinations of information related to the usage of resources which should highlight the analogies in the structure of production assignments and the structure of production capacity, as well.

Flexibilities is the quality of a technological system to get used to different production assignments from the point of view of form and dimensions of the product on the one hand and the technological operations that must be done for its production on the other hand.

6. CONCLUSIONS

Nowadays economical averages are in the middle of global restructuring, restructuring characterized by the rapid evolution of opening markets regarding product diversification and time of response at the market's demand, by spectacular technological evolution of production means, by the evolution of products as materials, technology, complexity, by the decrease of products' life cycle and by a tough global competition determined by the fact that, on the global market, usually, the offer is higher than the demand.

The mentioned characteristics impose the necessity of passing from the old model of production, characterized by large and mass production, to production in medium and small series, in lots that are repeated after variable periods of times. This can be made possible only by passing to flexible production, to the concept of Concurrent Engineering. The paper presents a part of the research and preoccupation of the collective of the "Computer Aided Technological Processes" regarding the conceivement and manufacturing of moulds in the auto field in the context of a modern production system.

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