STRUCTURE OF PRODUCTS AND IMPLEMENTATION OF CAD MODELS IN PRODUCT DATA MANAGEMENT SYSTEM

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Abstract: Products suffer changes along the lifecycle time and the data management starting with the stage of conception and up to the disposal imposes systems PDM/PLM for data management. Configuration of the databases of those systems is based on the product model structure. An analysis of the structure of the products used for sheet metal parts processing and some proposals for the implementation of the projects within a PDM/PLM system are included in the paper. The paper presents a methodology for the development of product model and for the management of product versions with a PLM system. Using a family of stamping devices for processing sheet metal parts, having dimensions accordingly to the demands of beneficiaries, new versions are obtained, corresponding to the sheet metal parts to be realized. The management of the components and of the multiple product versions imposes the implementation of systems PDM/PLM for data management for the stages of lifecycle.
Key words: Structure of product, CAD, PDM, PLM.

1. INTRODUCTION

The structure of the technical data which characterize a product leads to a model of the product, defined by product components, product structure and relationships between product components, included in the database and also their belonging to sub-assemblies and to product assembly.

Different kind of components existing within product components, respectively original components, re-used ones or modified ones, and also different kind of models existing for each product component, respectively technological models, testing models etc., lead to very heterogenous technical data, which must be organized in easy to access and to control databases (Musca et al., 2009), (Galis, 2008), Andreadis (2009).

Development of a product needs getting through some sequences, each of them being realized after a scheme containing the releasing, development, validation and finishing of the sequence. For products realized without computer-aided data management, the development sequences are realized successively, with interruptions or mistakes and with repetitions.

Validation supposes getting through some complex procedures of calculation, simulation, practical behavioral verifying, which lead to modifications and returns in the process of product development, with repetitions of some sequences and with occurrences of some significant modifications related to the initial version. Computer-aided design and the use of PDM/PLM systems allow keeping of realized versions.

The concept of *Product Lifecycle Management* (PLM) represents a philosophy based on the data, models and procedures necessary for an efficient performing of product development providing data management, both of the older ones and of the new created ones, related to the product. Those data constitutes models characterized by CAD, CAM, PDF files, Word documents, instructions of processing and verifying, instructions for use, specifications etc. PDM (*Product Data Management)* systems are organized to avoid losing, substituting or damaging technical data. For a product to be defined for its entire lifecycle, a PLM system provides data organizing and preserving the history of process of model development.

In conclusion, a PLM system offers the correct definition of product and the history of its evolution, starting from the establishment of specifications, from the necessity and opportunity of product development and up to the product disposal finished with recovery, recycling and reuse of materials which have compounded the product (Grieves, M., 2006), (Musca et al., 2008), (Musca et al., 2009).

More than that, there must be considered some research statistical data, announced by specialists, which show that up to 90% of the overall design activities are based on variants of previous existing designs, (Abramovici & Meimann, 2008). In this sense, a system of product information management, respectively a PDM or betterly a PLM solution, brings important advantages in the collaborative activities related to the new product development, respectively in the activities of registering, capturing,

organizing and controlling all the technical information, including functional requirements, geometry, specifications, characteristics and, not at last, manufacturing processes, mainly by creating a unique vault of product information which is accessible throughout the entire lifecycle of the product (Ausura & Deck, 2003), (Evans, 2002), (GeometricGlobal, 2008), (Salelkar, 2008), (Singh, 1995), (Usher et al., 2005).
The efficiency of the management of technical data along all the stages of the product lifecycle, by using PLM systems, comes from the attribute of easiness of data searching, retrieving and accessing, in all stages, respectively in designing, in manufacturing, in selling, in use and service, in disposal or reuse etc. (Musca et al., 2009), (Iosip, 2008).

2. THE CONCEPT OF PRODUCT MODEL

In the development of some projects it is economically to be used also previously designed or manufactured elements, for which the method of conception, of manufacturing or of validation is known. For those projects, it is useful to know the solutions familiar to the departments of conception or manufacturing and their use with minimal modifications, imposed by the requests of the moment (Merticaru et al., 2009),(Musca et al., 2009).
Our work targets two aspects:

- efficient generation and management of product versions or variants;
- identification of methods and criteria for establishing the optimal version or variant.

The model or the project of a product is characterized by:

- component elements or sub-models;
- sub-assemblies composed by component elements, between which there are defined relations of positioning, setting, locking of certain mobility degrees.

The product model is represented by:

- general assembly composed by subassemblies and component elements;
- models for validation and for testing the working conditions or the technologies for practical realization;
- models of realization or manufacturing;
- models of presentation, marketing and selling.

An important representation of the product model is its presentation form, which must have some qualities:

- to be suggestive and accessible for those it is addressed to;
- to be easy transferable between groups of users or beneficiaries;
- to be correlated, in the sense that a modification in a representation form to be automatically transferred upon the other representation forms.

CAD representation of the models is the most frequent because it is obtained at the product model's engineering design and the other forms of the model derive from it. This representation form contains (Musca et al., 2008):

- Representation of the component elements, characterized by:
  - solid model;
  - solid model's breakdown, meaning the entities and their relationships.
- Representation of sub-assemblies or assemblies, which contains:
  - representation of the solid model of assembly;
  - relationships of the components in the solid representation model of the assembly components.
- Plane representation, respecting the rules of the engineering drawing, which contain:
  - representation of the components characterized by views, sections, details, dimensioning, tolerances, technical conditions;
  - Representation of assemblies characterized by views, sections, overall or mounting dimensioning and also by the bill of materials which defines the structure of the assembly or of the product.

2.1. Types of product models

PDM systems, for technical data management, are developed on a structure of database type, which objects are the informatic models and their components, developed by the conception teams (Grieves, M., 2006), (Musca et al., 2009). In this stage, for the present work, several product models have been developed, grouped as following:

- product for manufacturing, without guiding elements;
- products for sheet metal parts manufacturing, with guiding elements.

In the database of the PLM system there have been introduced those CAD product models. For those models, modifications of product structure have been realized by modifying the dimensions of the components and of the design principles.
There have been designed variants for stamping devices without guiding elements, with two guiding elements, with four guiding elements, function of the requests imposed by the accuracy of the part designed and manufactured and for each product variant, product families have been generated.
The product models stored in the database are useful for the development of a product. There can be saved a lot of work by reusing the previously designed components. This can be easily achieved with *TeamCenter*, taking into account its advanced capacity of searching, retrieving, configuring and re-

configuring the products. With *TeamCenter*, data is not lost, being available for using in other projects.
A CAD model for a product may have the form as in Figure 1, being characterized by the *product components*, represented in 3D, in the right window, the product structure function of the components (left-upper window) and the relationships between the components (left-lower window).
The structure by components for a product has the form shown in Figure 2.

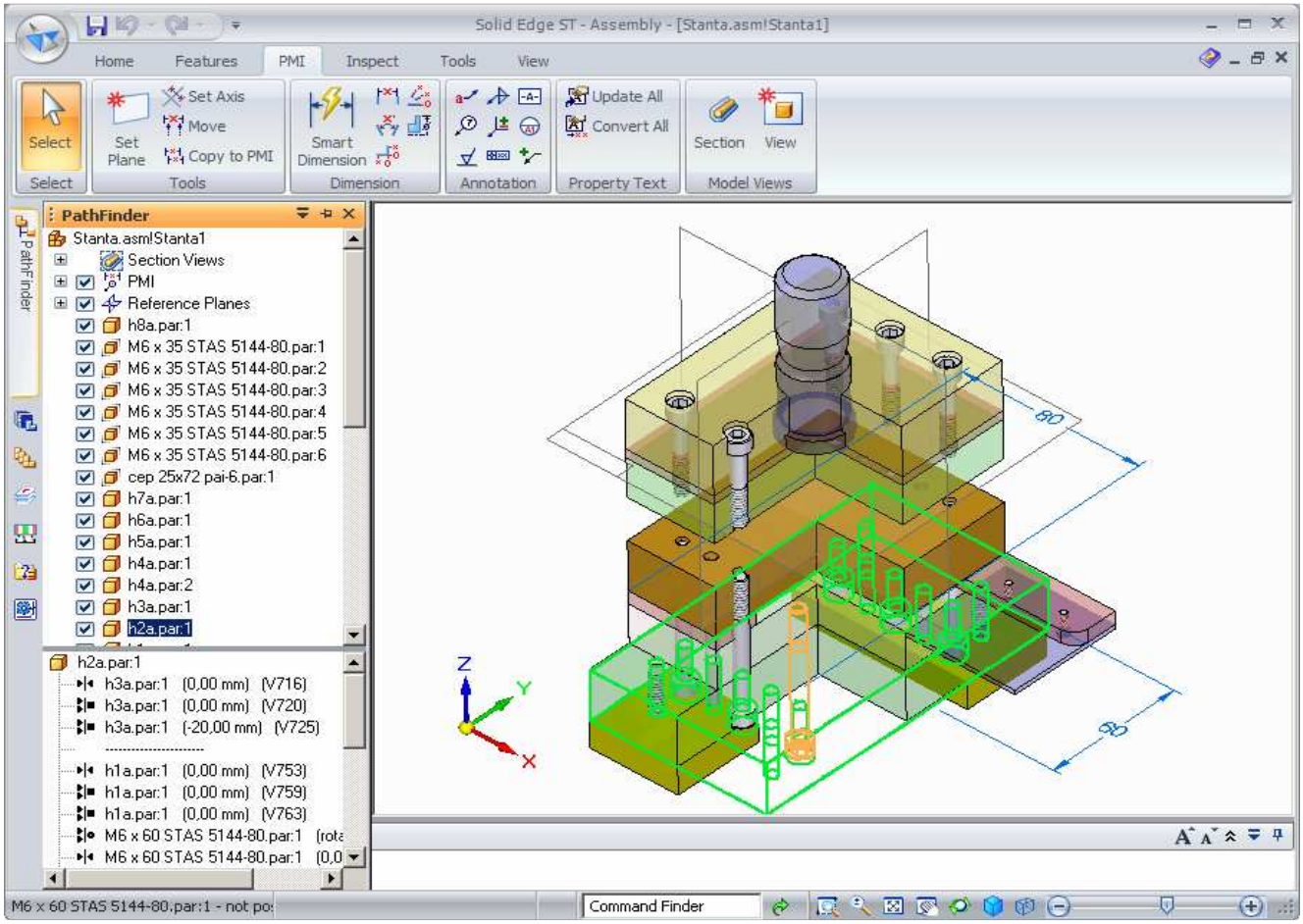


Fig. 1. Representation of the product model

Bill of Materials For Stanta.asm!Stanta1

Level	Docum. Number	Revision	Title	Quant.	Mass	Project
1	100.009	A	Material Support	1	0.078 kg	Parameterized stamping device
1	100.002	A	Support plate	2	0.629 kg	Parameterized stamping device
1	100.001	A	Base plate	1	1.947 kg	Parameterized stamping device
1	STAS	A	M6 x 60 STAS 5144-80	6	0.005 kg	Standardized part
1	STAS	A	M3 X 8 STAS 3954-69	4	0.002 kg	Standardized part
1	STAS	A	M6 x 25 STAS 5144-80	4	0.003 kg	Standardized part
1	STAS	A	Pin B5x65 STAS 1599-80	4	0.000 kg	Standardized part
1	100.003	A	Active plate	1	1.101 kg	Parameterized stamping device
1	100.010	A	Dowel	1	0.006 kg	Parameterized stamping device
1	STAS	A	M6 x 35 STAS 5144-80	6	0.004 kg	Standardized part
1	100.008	A	Upper plate	1	1.303 kg	Parameterized stamping device
1	100.007	A	Pressure plate	1	0.247 kg	Parameterized stamping device
1	100.004	A	Slide bar	2	0.234 kg	Parameterized stamping device
1	100.005	A	Guiding plate	1	1.407 kg	Parameterized stamping device
1	100.006	A	Port-punch plate	1	1.112 kg	Parameterized stamping device

Fig. 2. Primary structure of the product, defined by bill of materials

2.2. Families of models

A family of parts is characterized by a *parent part* and more *children parts* having a structure of entities close to the parent part but with different dimensions. Links between the parent part and the parts from the family are preserved and its modification leads to the corresponding modification of the elements of family. Following the same reasoning, using parts belonging to families of parts, families of assemblies are generated.

Within such a family, the members have the same structure, but their dimensions can differ. So, when selecting a certain member of the family, the corresponding members of the parts families are accessed but the number and the relationships between the component parts of the product are the same as for the parent product.

The use of product families is necessary when a product is designed and realized and the consumer demands claims different dimensioned types.

The design effort for realizing a project as part of a family is reduced in comparison to that necessary for the new product conception and the necessary steps are the following:

- it is finished the already realized product model;
- it is defined the parent model based on the realized model;
- using this model as basis, the first model of the family is generated, by operating the modifications imposed by dimensions, configuration, materials;
- using the models of representation of the parent, similar forms are obtained also for the member of the family.

2.3. Models of product variants type

Product variants provide preservation of conception and manufacturing knowledge with important economical effects. Most of the times, a modification of a component provide important work economy.

Modification of materials, of color of presentation, of surface covering and curing may have favorable effects.

Improving the machining technology provides economical advantages, even if there are necessary efforts for modifying and adapting some constitutive elements of some parts from the product structure.

The demands of the beneficiaries or of the suppliers often impose modifications of products structure, starting from the simple modification of shape and dimensions of some components and up to structural modifications of the products.

In the most frequent situations, the most recent version or variant is the operational one, its existence being justified by some of the above mentioned criteria.

The consequences of this state of facts are multiple, having negative effects. Among them, there can be mentioned:

- the existence of a large number of variants, difficult to manage at the level of digital model;
- the appearance of an important number of variants for certain components, without the justification of their existence or without knowing, most of the times, the cause of their generation;
- large number of files belonging to the digital product models;
- difficulties in establishing the relationships of the components of product variants with the systems of economical management of the companies.

The advantages and the aim of the generation of product variants are the following:

- preservation of knowledge at the level f products development and conception;
- there can be applied elements obtained within a process of products normalization, defining internal norms, product norms, components norms etc.
- the development of some models of products components.
- the data management for the evolution of product model, being accessible all the model variants, their evolution and knowing the causes which have led to the respective variant.

3. MANAGEMENT OF THE PRODUCT STRUCTURE

PLM (Product Lifecycle Management) is a concept which embeds all the stages from a product lifecycle, concept covered in practice by specialized software solutions such as: CAD, CAM, CAE, PDM etc.

The relationship between those solutions has in its center the products type PDM (Product Data Management) which realizes the link between data generated in different stages of product lifecycle. In other words, a PDM product represents the basis of the implementation of the PLM concept, but a PDM system cannot be confounded with a product of „document manager” type.

A PLM system is designated for the management of information in the evolution of a product starting from its conceptualization, design data detailing, manufacturing, distribution, maintenance and up to disposal and recycling.

An important function for the PDM system is those to control/generate new product structures, starting from a known structure. With the aid of a known structure, there can be analyzed, modified, built and generated other product structures. Once built, the *Product Structure* can be combined with functionalities of dynamic generation such as the revisions filtering rules, which decide which components and revisions are applicable for that product.

The computer-aided design of products allows generation of an important number of variants. The generation of a variant of product or assembly makes

possible, by modifications of some components, to obtain some new variants, sometimes better or demanded by beneficiaries.

As it resulted from the previous chapter, the generation of some variants of product assemblies can be realized in several ways:

a) using PSE (Product Structure Editor), with which aid, starting from an assembly, new variants are obtained, by modifying some component elements;
b) by generating families of assemblies based on a parent product assembly which transmits its characteristics to the members of the family;
c) by using the same assemblies or sub-assemblies, but placed in different configurations in the product structure (for e.g. the components piston, pin, piston rings, rod, stub, connecting elements, represent such an assembly, within an engine with several cylinders).

CAD software solutions provide the management of changes and of revisions for the product variants and also for relationships of modified components. Their embedding in PDM/PLM systems allows the introduction of product structure in *TeamCenter*, the elaboration of interrogations for the selection of a product variant, the generation of a new variant based on the selected variant.

The components and the materials can be classified, organized and anteceded by attributes. This sustains the standardization by identification of similar components or materials, by elimination of excess and by establishing a list of preferred parts.

The establishment of classes and sub-classes with attributes allows to a engineering designer to search and select a material or a wanted material or to assembly with minimum effort, avoiding in this way to specify again an existing or a similar component or material.

Realization of those sub-assemblies in the design stage is important but supposes knowing some specialty elements such as:

- the functional role of the components which must be grouped for optimizing the functioning conditions;
- mounting technology and its importance upon the product's qualities;
- the constraints imposed by positioning and mobility degrees of the components of assembly.

CAD software solutions used for realizing the projects provide dynamic generation of the products structure.

Generation of the optimal solution for the product structure is realized in the steps presented right as following:

- the product components are designed;
- the relationships between those components (spatial positioning and relationships on the mobility degrees) are defined;
- groups or sub-assemblies optimizing the product structure are defined.

At the present time, the authors focus their efforts in the direction to configure the environment of product data management, by establishing the rules for product development and to obtain the product model based on which multiple variants can be obtained in order to identify the optimal variant (Merticaru et al., 2009), (Musca et al., 2008). The necessary steps are:

- defining the structure of the processes attached to the stages of product development;
- establishing the sub-processes, the activities and the rules of validation for each activity, sub-process, process after the rule – activity start - activity development – activity validation – registration of the result of activity.
- generation of the product model;
- to parameterize the product model by the following methods:
  - establishment of the types of parameters by identifying their range of variation;
  - typifying the values of parameters for reducing the number of generated variants;
  - generation of the product variants corresponding to the considered process;
  - optimization of the process by identifying the optimal variant based on criteria which for the product development processes can be:
    - productivity of the process of conception and manufacturing (time of realization or the number of sub-processes and activities);
    - quality of the processes and of products using criteria like: quantity of material, costs of materials, types of blank, quantity of resulted waste, material recovery after product use and disposal;
    - cost of the product or of the necessary work.

The design of the product variants is realized:

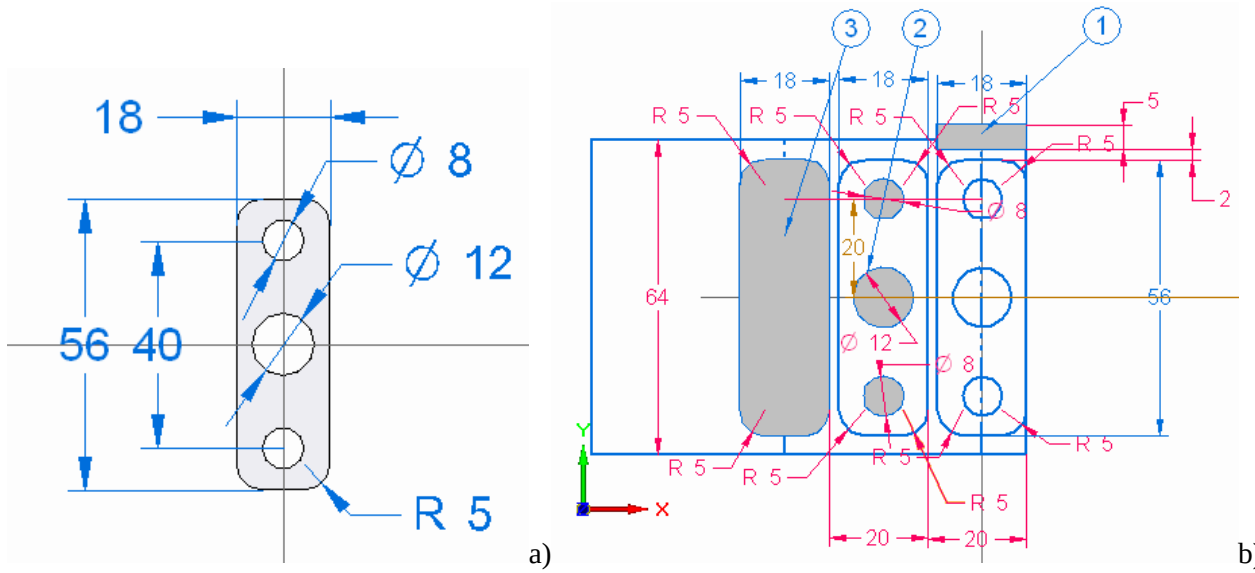
1. With modification of some characteristics of product components (color, material, heat treatment, coverings and protections etc.), without modification of product structure;
2. With modification of product structure which supposes modification of dimensions, loadings, treatments, technologies etc.)

For the realized and previously presented model, there is generated a variant allowing the machining of part from Figure 3.

The overtaking of working sketch and its transposing in the machining plan, represent the following step. Cutting all the elements which intersect the working profile allow the realization of the active elements, of the elements for material guidance and elimination, obtaining a new variant of the fixed package,

corresponding to the previous machining scheme. Using the same working scheme, the working punches are generated for the mobile package. The command *Create Part In-Place* is used for overtaking the geometry of the working sketch and for the generation of the punches having, for the closed stamping device, the length situated between the inferior face of the pressure plate and a plane parallel to the superior face of the active plate, situated at 2 mm under that.

The product from Figure 4 is obtained by following the above presented algorithm.



a) b)

Fig. 3. Realized part *(a)* and the working scheme *(b)*

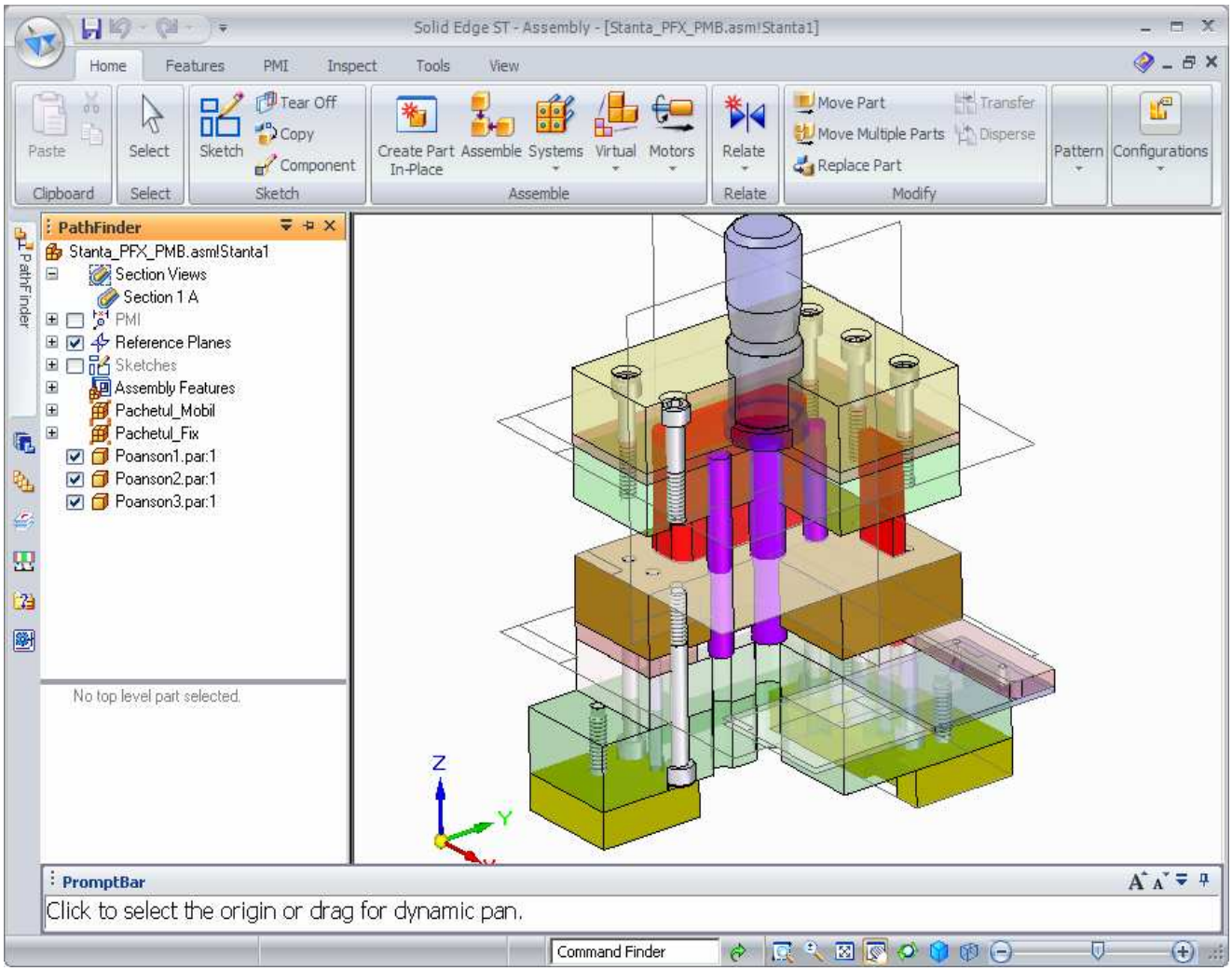


Fig. 4. Product variant corresponding to the imposed working scheme

After getting through the example of generation of a product variant, some conclusions can be formulated, as following:

- Any variant of a project can represent the starting element for obtaining a new variant for the respective project;
- The new variant of the project may contain elements of the parent variant, new elements or modified elements of that;
- Technical data management for the project variants is necessary and provides substantial time savings and saving of design and manufacturing costs.
- The modified components of the components from the parent variant become members of the families of components.
- There are necessary specialized procedures for updating the properties of the modified components (code, mass, material).

An important function for the PDM system is those to control/generate new product structures, starting from a known structure. With the aid of a known structure, there can be analyzed, modified, built and generated other product structures.

Once built, the *Product Structure* can be combined with functionalities of dynamic generation such as the revisions filtering rules, which decide which components and revisions are applicable for that product.

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4. CONCLUSIONS

The management of technical data referring to a product uses the digital model composed by a multitude of files, having different formats and significances.

The product model has a dynamic character, the initial variant being permanently improved in all the stages of the lifecycle: design, manufacturing, use and recovery of components or of materials at the product disposal, being composed by a multitude of new variants or revisions which empower the model with new aspects improving its quality, machinability, costs.

The management of data corresponding to the model characterized by multiple variants and representation forms imposes the generation of some PDM systems for the stage of conception and of PLM systems for the entire product lifecycle.

The paper presents the main product models, enclosing in:

- model of family type, for which a parent model transmits its main characteristics to the members of the family;
- model of variant type, when a certain variant is modified, improved and becomes a revision of the model or a new variant.

The advantages of the generation of product variants are:

- preservation of the knowledge at the level of products conception and development;
- there can be applied elements obtained within a process of normalization of products, defining internal norms, product norms, components norms etc.
- the development of some models of products components.
- data management for the evolution of product model, being accessible all the model variants, their evolution and knowing the causes which have led to the respective variant.

The paper presents a way for obtaining a variant of stamping device, product use in sheet metal processing, starting from the part to be realized with that stamping device.

Using that methodology, the design of a product used in sheet metal processing is effective and efficient and can be realized in the following steps:

- the technology for realizing the sheet metal part demanded by customers is established;
- the working scheme and the location of the working elements on the sheet metal stripe is established;
- the product which can contain the adopted working scheme is selected among the

families of products already existing in the database of the PLM system;
- the working scheme is transferred in the selected product and, based on it, the product variant providing the part manufacturing is generated;
- the new product variant is managed with the PLM system.

The authors use the concept of product structure and its adopting at the product variants models. A model of assembly or product type is characterized by its structure which contains the component elements, the relationships between them and their grouping on functional or technological criteria.

The structures can contain only component elements, between which there are defined relationships of spatial positioning and of overtaking the mobility degrees. Grouping some components in sub-assemblies, the structure becomes one of superior level, easy to use in design, manufacturing, assembling, use and service.

The authors present the results obtained in the management of products structure and in the implementation of a PDM system. The way of building, modifying and comparing the product structures is presented. The way of obtaining products variants and the management of those variants with a PDM system based on *TeamCenter* is implemented.

There is paid attention to the management of modifications, revisions and to the way of projects and of their variants accessing with *TeamCenter*.

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