USING CAD INSTRUMENTS FOR COLLABORATIVE PRODUCT DEVELOPMENT IN PLM ENVIRONMENT

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Abstract: The paper presents an application of collaborative product development using CAD instruments into a PLM environment. The principles of collaborative product development in the PLM environment are described in the paper, together with the presentation of a collaborative network developed for implementing a PLM solution. A case study is described in the paper, referring to the CAD activities developed for an assembly product for railway industry, made of aluminum alloys and designed to be assembled by welding operations.

1. INTRODUCTION. PROBLEM STATEMENT

In the nowadays context of the European Union economy, there are well known the necessities of the economic agents for conceiving, designing and producing qualitative, economical and aesthetical products. In these conditions, the specialists from manufacturing industry and from the research centers from universities can assume time consuming tasks such as execution of drawings and technical documentation, conception of the products' aesthetics and ergonomics, simulation of the products behavior through FEM (Finite Element Method), generation and testing of the technologies for CNC machine-tools using the facilities of the CAM (Computer Aided Manufacturing) systems.

The authors propose and exemplify in the paper a way for developing new products in a collaborative manner, by using CAD (Computer Aided Design) instruments into a PLM (Product Lifecycle Management) environment. In this sense, the realization of a collaborative network composed by technical universities and productive enterprises is nominated. The purpose of the mentioned network is the generation of projects and new products using the concepts of CAD/CAM/CAE and data management at the network's level by using PDM/PLM systems.

2. PRINCIPLES OF COLLABORATIVE PRODUCT DEVELOPMENT IN PLM ENVIRONMENT

As it is already well known, PLM concept refers to the management of the lifecycle of products, processes and services from the very beginning to the final point or, as it is used to be said by the specialists, from "cradle to grave". PLM systems support the management of the products, processes and services from the initial concept, through the phases of design, launch, production and use to final disposal. An extended vision on PLM concept, considering all the phases in the product lifecycle, is presented in Fig. 1. PLM systems co-ordinate, in a collaborative manner, all the information about products and processes throughout the mentioned phases of the new product development, among the various participants, both internal and external to the CIE (Computer Integrated Enterprise), who must collaborate to bring the concept alive. The principle of PLM concept and systems is to maintain an information vault, possibly physically distributed, but always having a single logical index towards all the product, project and process information. So, the various factors and processes involved in the new product introduction, production, service and retirement use a single source of product information. The access to the mentioned vault's information is given orderly, PLM applications using for this workflow and authorization rules.

Some specialists consider that within PLM, as a set of application software that help the manufacturing engineering enterprises to develop, describe, manage and communicate information about their products for enabling the NPD (New Product Development) business process, there are four primary areas [1]: PPM (Product and Portfolio Management), CAD, MPM (Manufacturing Planning) and PDM (Product Data Management).

An extended vision identifies the following PLM sub-systems, developed at the present time [4]: CAD, CAM, EDA (Electronic Design Automation), TDM (Technical Document Management), DMU (Digital Mock Up), VMU (Virtual Product Mock Up), CAE (Mechanical Computer Aided Engineering), MRO (Maintenance, Repair and Operations), CAPE (Computer Aided Production Engineering), Project and Program Management Systems, Release Authorization and Engineering Change Control Systems. Nowadays, the vast majority of PLM expenditure is developed on CAD/CAM systems.

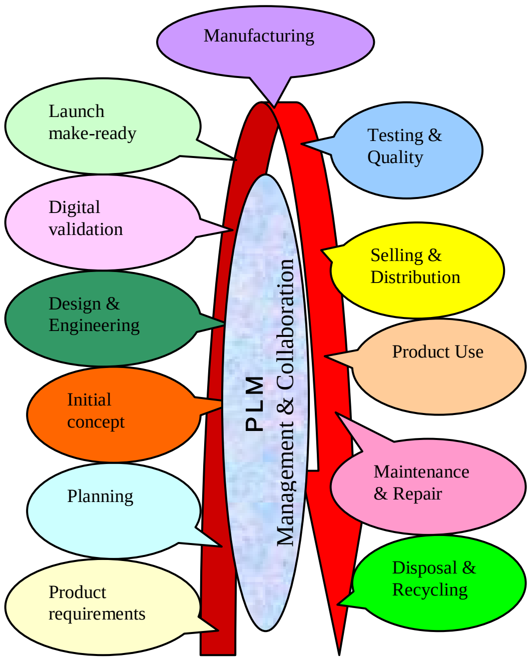


Fig. 1. Extended vision on PLM concept

The main advantages brought by a system of information management, respectively by a PLM solution in the new product development are: the time for realizing a new product (Time to market) is reduced; the productivity of the design/calculation process is improved; the design and manufacturing accuracy is improved; an innovative content of the products is determined; data security is provided; a better control upon changes is provided.

In the environment of PLM, cPD (Collaborative Product Development) begins the first phase of the new product's lifecycle [5] and, as initial stage, it is an approach which intend capturing, organizing, co-ordinating and controlling all the information related to the new product development, including all the functional requirements, geometry, specifications, characteristics and manufacturing processes, for providing a shared common view upon the development of the product to accomplish the requirements and for creating a unique vault of product information accessible throughout the product entire lifecycle.

In PLM, in the case of client orientated product development, the client specifies, more or less, the following aspects: requirements; functionality; specifications; product's characteristics.

This situation allow a large range of activities for the product developer, at one end of this range being situated the manufacturer, who gets completely defined the product geometry, specifications and characteristics, sometimes even with the technological process specifications included. At the other end of this range, the client simply transmits the requirements to the product developer, who becomes responsible for transforming them into geometry, specifications and characteristics. Sometimes, the above mentioned situations determine the development of subsystems in which the product developer becomes client of his suppliers. In this informational environment acts the functionality of CRM (Client Relationship Management) systems.

Also related to the client relationship management, we mention here that a principle in Collaborative Product Development (cPD) from PLM, considers the use of PLM for developing the marketing collaterals. Especially in the entrepreneurial orientated product development, the scope of the marketing is to attract the buyers' attention toward the product. This involves better marketing collaterals. Without PLM, the marketing collaterals will be in trouble when various changes occur. The benefit brought by PLM in this direction has two sources: the costs are reduced because marketing area does not need to re-create already existing product information; the marketing material is more accurate.

3. ABOUT A COLLABORATIVE NETWORK DEVELOPED FOR IMPLEMENTING A PLM SOLUTION

There are well-known the multitude of problems that occur in implementing some PLM solutions. There is intended to nominate here some efforts existing in the Laboratory of Computer-Aided Design from the Technical University "Gh. Asachi" of Iasi [7] for developing a collaborative network for the implementation of an PLM solution in order to create conditions for a better collaboration between the research teams of specialists from universities and economic agents for solving the problems identified in the computer aided conception, starting with the constructive design CAD, design and ergonomics of the product, cinematic simulation of the product in the design phase, simulation of the functioning behavior using FEA, conception of the manufacturing technology CAM.

The development of the PLM system is realized as collaborative activity between the partners. The partners use a network for the design data management (PDM), gathering competences and reducing the times for realizing the design orders. An increase of the research and development competitiveness is estimated by stimulation of partnerships in the area of computer aided design and manufacturing, materialized in projects of products and technologies, using data management PDM for the whole products life-time PLM, for solving the complex problems that occur in specialists' forming and in the implementation of the CAD/CAM/CAE concepts in PDM/PLM. The formative – collaborative aspect of the mentioned network provides the increase of the competitiveness and of the creativity and development of the organizational culture inside the design-research institutions but also in the area of education of the students, of engineers and researchers. The realization of the conception projects uses CAD software from the family Siemens-UGS. The components of the projects are realized by the partners and then they are assembled, using a web network and software for technical data management, which provide the information change between the partners, the identification and administration of the changes and corrections in the project. The realization of the phase of project development is conceived as a collaborative activity, where the partners develop the project components, contribute to the finishing of the product aspect and to the presentation shape, assure the use of FEA software for simulation of the products functioning conditions. After the analysis of the problems generated by the computer aided conception from the constructive point of view (CAD), from the technological point of view (CAM), of the simulation of products behavior (CAE-FEA), there will be implemented PDM/PLM solutions for type projects.

In the Laboratory of Computer-Aided Design from the Technical University "Gh. Asachi" of Iasi, there exist concernments for developing a PLM solution, applicable in the economic environment specific to the Romanian industry. For implementing such a solution into a network formed by researchers belonging to some universities and specialists from manufacturing enterprises, certain stages are necessary, within them outstanding the following: the knowledge acquirement and the development of skills for using CAD systems; to know the concept of data management and to establish some procedures for implementation at the level of functional areas into an industrial enterprise; establishment of the soft and hard structure of the system used for data management; the training of the staff involved in the activity of products' conceive, design and manufacturing.

The research team from the above mentioned laboratory have passed through the above mentioned stages, both for their own team and for their industrial partners. After the training of several groups of participants in the PLM programme, groups belonging to the partners, there have been observed that a vital direction for the success of the approach is to form new specialists in the areas of interest, respectively firstly CAD and CAM and secondly in Computer-Aided Engineering (CAE) or data management for the Product Lifecycle. The best results have been obtained with teams formed by researchers from universities and students.

At the level of a PLM network, functional within an environment heterogeneous as education and preoccupations, one of the main requirements is to form a motivated and efficient virtual team. The premises of forming a team, efficient in work in the virtual environment, base on: adequate level of knowledge for accomplishing the tasks for the main stages of the product lifecycle, CAD, CAM, relationships with the suppliers and customers; motivation of the team working by co-interesting and counsellorship in the domain of PDM/PLM. There have been found that partial accomplishment of some premises is not sufficient; so the financial co-interesting of the team members can be inefficient if the motivation of the team working does not exist. The accomplishment of this premise is difficult for the teams of the partners from industry, even if the presumed results are known and noteworthy. Even in the research environments or in the universities, some malfunctions can be found, caused, accordingly to the authors' opinion, by: insufficient number of persons with abilities in the CAD/CAM/CAE area; inefficient education of the specialists in this domains and of the students, as the work with a CAD system requires to go through a training stage that must be individually realized; differences between the team members regarding the knowledge level, which lead to difficulties in collaborative activity.

Considering the experience gathered in the CAD area in the laboratory from TU Gh. Asachi of Iasi, the implementation of the PLM solution started with the design of some elements necessary for the partners. For the design stage, there have been used *SolidEdge, v20*. Each working team, activating in the CAD stage of the product lifecycle, has a manager, an administrator of the computer network, designers, verifiers and drafters. *TeamCenter Express* was adopted as environment for the implementation of the PLM solution. The development of the design procedures was done with a team that realized the design of the components on the Laboratory's network, with the resources managed by the TcX system. The database assigned to the project is automatically realized, when saving each component of the project. These components represent parts, drafts, sub-assemblies and the final assembly. The access to the components of the project is possible with the aid of a component of the TcX system, Product Structure Editor. For this stage, there are realized the procedures for the management of the design data, procedures which can be appealed by the project manager. These procedures display the project's status and the activity of each member of the team. There are in course to be elaborated the work-flow procedures for computer-aided management of the assignment of the work tasks (design, verifying, drafting, sign-up). For the product structure, taken over from the bill of materials of the final assembly, there are designed procedures for data management, for the management of the design activities and for the work stages for product development.

4. EXAMPLE OF USING CAD INSTRUMENTS FOR COLLABORATIVE PRODUCT DEVELOPMENT

When the range of designed and manufactured products is very large, it is a good idea to form groups of similar products, mainly to facilitate the treatment of the product information. A bigger or a smaller aggregation among the products must be function of their relative weight in the group, as much regarding the quantity as the value, so for the begining, there must be established relationships between the products, with some indication about their importance.

Some of the aspects that are necessary to be known before proceeding to the new product development are:

• The type of product that we have to conceive, design and manufactured, including variations and characteristic.

• The quantity of each part that should be manufactured.

• The route or process, meaning the manufacturing operations, their sequence or the order in which are done the operations.

The group of products that has been chosen as subject of the case study for the collaborative product development is represented by the back headboard of a modern suburban train. The headboard is the assembly that represents the mechanical interface between the railway carriage's structure and the coupling elements. The coupling elements are the mechanical elements whose function is to provide the joint between railway carriages. For the coupling elements to be perfectly anchored to the carriage's structure, an intermediate structure, respectively the headboard, is needed, as it is shown in Fig. 2. The headboard occupies the whole extremity of the wing framework of the railway carriage. For a correct distribution of the mechanical efforts throughout the structure, the central part of the headboard is usually wider than the extreme ones. At the same time, this configuration allows a bigger central space that allows the anchorage of the coupling elements.

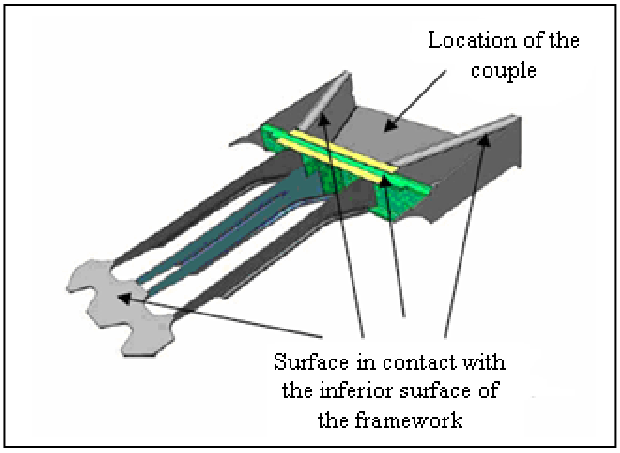


Fig. 2. The product subjected to design

In the case of the analyzed assembly product, we have a structure clearly break down in four subgroups, as it is sho... l profile that accomplishes the crossp... l direction of the vehicle, on which s... t coupling elements of the joint betwe... e two profiles (B), in shape of "U", ... y constitute the lateral walls of the p... e intends to allow the movements of ... e when this carry out a curve. In ... -reinforcement (C), their destination ... e headboard to the wing of the carria... s generated in the joint of the carriag... t close at the inferior part the place of t... ect these against impact of aggressive ... are

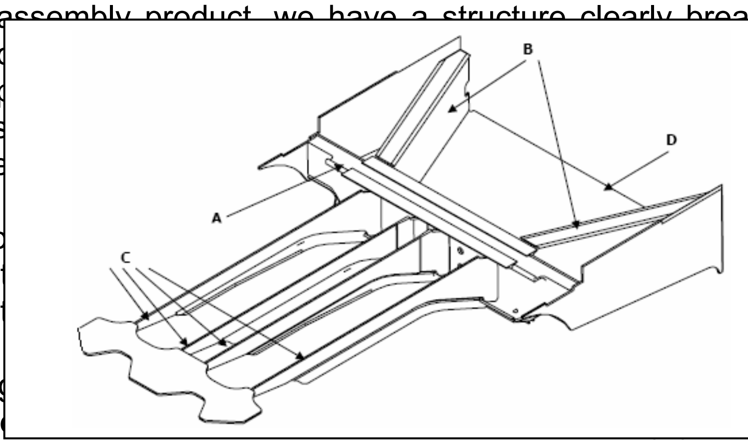


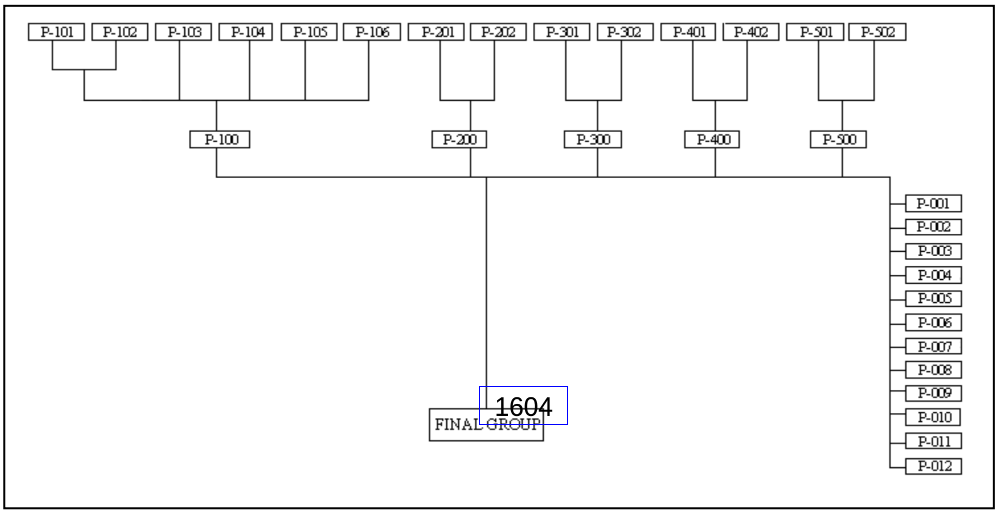
Fig. 3. Location of the four subgroups in the designed product

anchored to the structure of the headboard by screwed fasteners. The headboard is joined to the rest of the carriage structure by welding, if being of the same material. The shape of the headboard is designed to provide a bigger contact surface between the headboard and the carriage's wing, for maximizing the lengths of the weldments and in this way to guarantee a better joint between both structures. In some cases, the headboards are designed to carry out a function of collapsible structure, in order to absorb the energy generated in a crash, in the eventuality of an accident. The designed headboard is formed of 26 parts, presented in table 1.

Table 1. Bill of materials for the designed product

Piece number	Code	Denomination	Quantity for group
1	P - 101	Crosspiece	1
2	P - 102	Central badge	1
3	P - 103	Sheet left	1
4	P - 104	Sheet right	1
5	P - 105	Folding left	1
6	P - 106	Folding right	1
7	P - 201	Reinforce external left	1
8	P - 202	Nerve external left	1
9	P - 301	Reinforce external right	1
10	P - 302	Nerve external right	1
11	P - 401	Reinforce right intern	1
12	P - 402	Nerve right intern	1
13	P - 501	Reinforce internal left	1
14	P - 502	Nerve left intern	1
15	P - 001	Right pontoon	1
16	P - 002	Left pontoon	1
17	P - 003	Nerve right	1
18	P - 004	Nerve left	1
19	P - 005	Plate	2
20	P - 006	Profile of support	2
21	P - 007	Plate of support	1
22	P - 008	Rest	2
23	P - 009	Rest back	1
24	P - 010	Rest body	3
25	P - 011	Plates of closing end	1
26	P - 012	Plates of closing interior	1

In Fig. 4, the assembling scheme for the studied product is shown.



In Fig. 5, the location of the component parts in the studied assembly is shown.

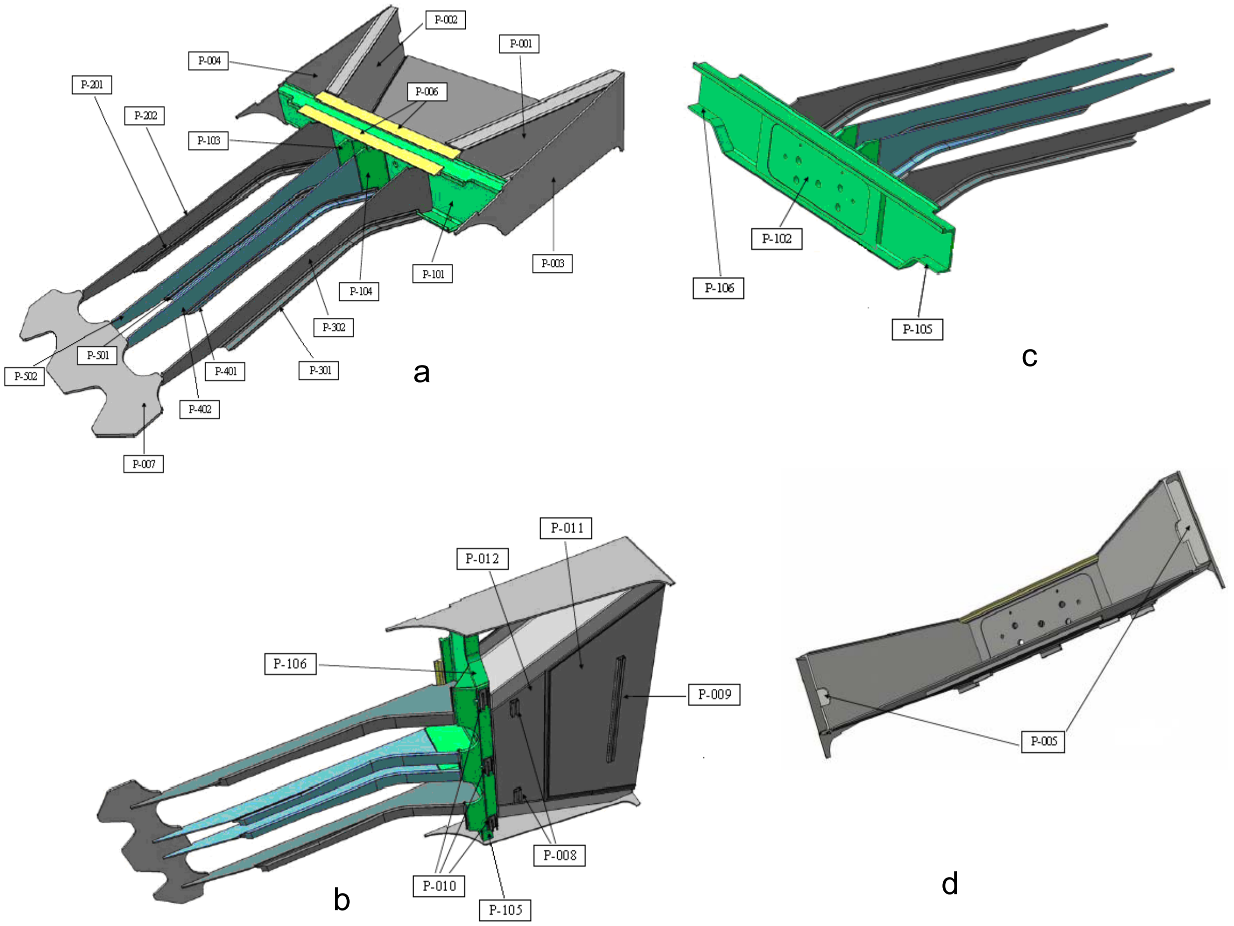


Fig. 5. The location of the parts in the headboard assembly

a ***- downward view;*** b ***- upward view;***

c ***- Location of the "Central badge"and "Foldings left and right" in the front side of the product***

d ***- Location of the part "Plate" in the lateral view of the product***

The back headboard, as well as the rest of the components that constitute the structure of a railway vehicle, is manufactured starting from plates of medium or big thickness, cut at stipulated dimensions and then joined by welding. In the case of aluminum structures, one of the big advantages is the possibility of using profiled bars extruded in cold conditions. The aluminum profiles give the possibility to build a structure more optimized in relation to the mechanical efforts the structure is subjected to.

The reason that has directed the decision towards the design of a product assembled by welding of big and medium aluminum structures has been represented by the increased impact and use that this material is having in diverse sectors of the industry, but with special emphasis in the European railway sectors. At the present time, about 80% of the orders that the administrations of the European railway sectors are launching, stipulate in the corresponding sheets of specifications the requirement that the structure must be manufactured in aluminum alloy. Lately, the aluminum has consolidated as a clear alternative to the steel in the production of boxes of railway vehicles. In the high-speed railway transportation segment, the aluminum is used in 100% of the cases. In tram and metropolitan transportation segments, the aluminum is located around 90%, while in regional and suburban train it descends around 60%. Anyway, also in the suburban trains, mainly when speaking of electric traction, the aluminum overcomes a lot over the steel in the orders of railway material during the last years.

For the above presented reasons, all the parts in the designed assembly were stipulated to be manufactured of Anticorodal-110, which is a medium strength aluminum alloy with Mg and Si, having good machinability, excellent corrosion resistance in inland atmosphere and excellent TIG/MAG weldability.

For the assembly product subjected to the case study, also the manufacturing technical documentation was elaborated, the above mentioned CAD instrument being used in this stage for elaborating the technological schemes for parts positioning and the details working schemes for each welding phase and operation in the assembling process route.

In Fig. 6, there is exemplified such a technological scheme for parts positioning for welding operations.

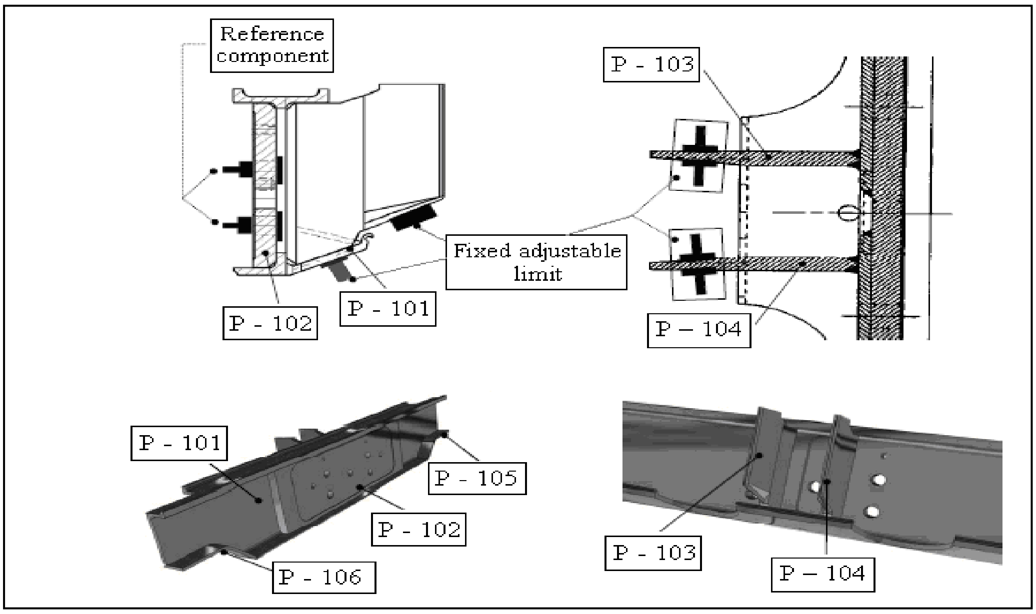
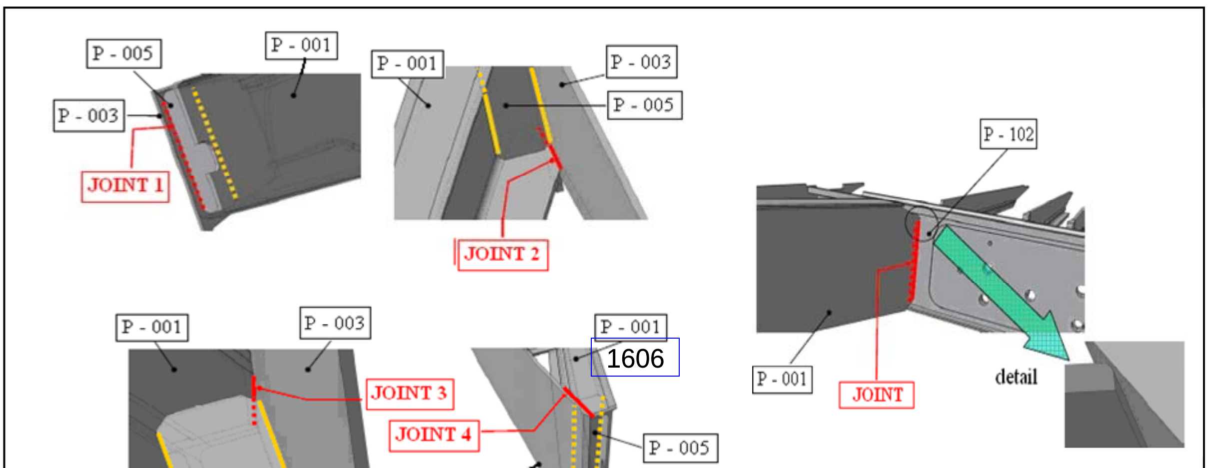


Fig. 6. Positioning technological scheme for welding operations

In Fig. 7, there are exemplified some technological detailed schemes for welding operations.



5. CONCLUSIONS

The paper presents an application of collaborative product development using CAD instruments into a PLM environment. The principles of collaborative product development in the PLM environment are described in the paper, together with the presentation of a collaborative network developed for implementing a PLM solution.

So the paper proposes a collaborative methodology for developing some type projects, specific to the machine manufacturing industry. A case study is described in the paper, referring to the CAD activities developed for an assembly product for railway industry, made of aluminum alloys and designed to be assembled by welding operations.

The development of some type projects consists in the realization, by the collaborative partners and using computer aided design software, of parts from the product, in making information exchange and in realizing assemblies by working on the network, in realization of the technical changes imposed by the product design (shapes, colors, presentation materials), in simulation of the loading conditions using FEM, in development of the numerical control programs for the complex parts in the project.

For each developed project, the databases specific to the implementation of the PDM/PLM procedures are generated and there is configured the data management system for the identification of the product structure, of the changes and variants of project-product that occur at different requirements of the beneficiaries. Project data management between the partners in the project and also between the departments of conception, design and manufacturing from the economic agents is realized at the level of a web network, administrated by a PDM/PLM system.

In the mentioned collaborative network, the economic agents, through the experience and knowing the competence area, contribute and collaborate to the projects development, providing for themselves a reserve of specialists among the master, doctoral and bachelor degrees students which develop their activity in the universities participating in the project.

In conclusion, this paper presents one solution for data management between the partners in the network and also between the departments of conception and manufacturing from the economic agents, administrated by a PDM/PLM system.

The presented case study refers to a product designated for the Spanish railway industry, but with adequate adapting it can be extrapolated for developing similar products for the Romanian railway industry.

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