CONVERGENT USE OF ADVANCED CAD/CAE/CAM CAPABILITIES FOR SUSTAINABLE INTEGRATED ENGINEERING

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ABSTRACT: The presented research approach is oriented toward the general problem of sustainable product development and more specifically, the idea of convergent use of advanced CAD/CAE/CAM capabilities is targeted as instrument to provide sustainable integrated engineering. A complex conceptual model for the convergent use of integrated engineering tools as strategy for sustainable product development is proposed and discussed in the paper. As case study, the paper subjects to discussion the problem of identifying, selecting, combining and aligning the best options to the needs, for the CAD/CAE/CAM/PDM activities within the process of product development for complex injection moulds designated to automotive industry. Finally, some adequate conclusions of the research approach are presented, oriented mainly in the direction of how a product developer should manage its integrated engineering activities.

KEY WORDS: sustainable product development, integrated engineering, CAD/CAE/CAM, technological convergence, injection mould.

1 INTRODUCTION. RESEARCH PROBLEM STATEMENT

Sustainable product development is nowadays a general problem concerning all the industrial productive companies, research and development institutes or technical academia.

Integrated Engineering and more specifically CAD activities effectiveness and efficiency have been identified as strategic instruments for Sustainable Product Development (Merticaru & Ripanu, 2013) and in this direction advanced CAD capabilities are necessary to be applied for integrating Flexible Engineering Design with Flexible Manufacturing (Merticaru et al., 2012), as long as Aberdeen's research (Boucher,·2012) sustains that advanced CAD capabilities promise design efficiency, but statistics show that companies should assume between six months and one year of expectation for experiencing the benefits of productivity improvements driven by the changes brought by the new implemented CAD tools.

Researches on the market have shown also that top product developers are expected to prove extended design and development capabilities and for that, they must put together, in the best way, adequate technical resources and well trained human resource, for being able to support all the phases of engineering design and product development and analysis (Bell Hel., 2014; Merticaru et al., 2014).

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2 RESEARCH IDEA

The above presented research approach is oriented toward the general problem of sustainable product development and more specifically, the idea of convergent use of advanced CAD/CAE/CAM capabilities is targeted as instrument to provide sustainable integrated engineering.

The research idea is based on the opportunity to bring together within one team, academia specialists and some graduated industrial engineers, also registered as students in master degree programs, well skilled in CAD/CAE/CAM activities, being employed in research and development or production companies and having to deal with the need of using a broad range of integrated engineering software solutions.

3 CONCEPTUAL MODEL FOR THE CONVERGENT USE OF INTEGRATED ENGINEERING TOOLS

Within the research approach, a complex conceptual model for the convergent use of integrated engineering tools as strategy for sustainable product development is further on proposed and discussed in the paper. The model is shown in Figure 1 and it was intended to help in identifying a set of criteria for providing convergence in engineering design and product development activities, as long as a previous research (Merticaru et al., 2014) have revealed that for providing convergence in CAD activities, there must be simultaneously acted upon personnel structure and qualification, upon physical and virtual infrastructure and not at last upon simplified operations management, because such an aim implies automation tools,

efficiency and agility and of course not only one approach but several. Within such a context, the option to implement a scalable HPC infrastructure and a clouding solution seems also to be of great interest.

From the detailed analysis of the presented model, there has resulted that for providing technological convergence in engineering design and product development activities, the problem of identifying, selecting, combining and aligning the best options to the needs, for the CAD/CAE/CAM/PDM activities within the process of product development has to been solved further on, within the considered research approach.

In such conditions, the research approach has been further on developed in the direction of testing the adequacy, effectiveness and efficiency of various integrated software solutions for some particular situations of engineering design and product development projects.

The way such tools respond to the demanded advanced capabilities of CAD, CAM, product data management and exchange, performance of finite element solvers for stress, fatigue, thermal and flow analysis has been mainly targeted.

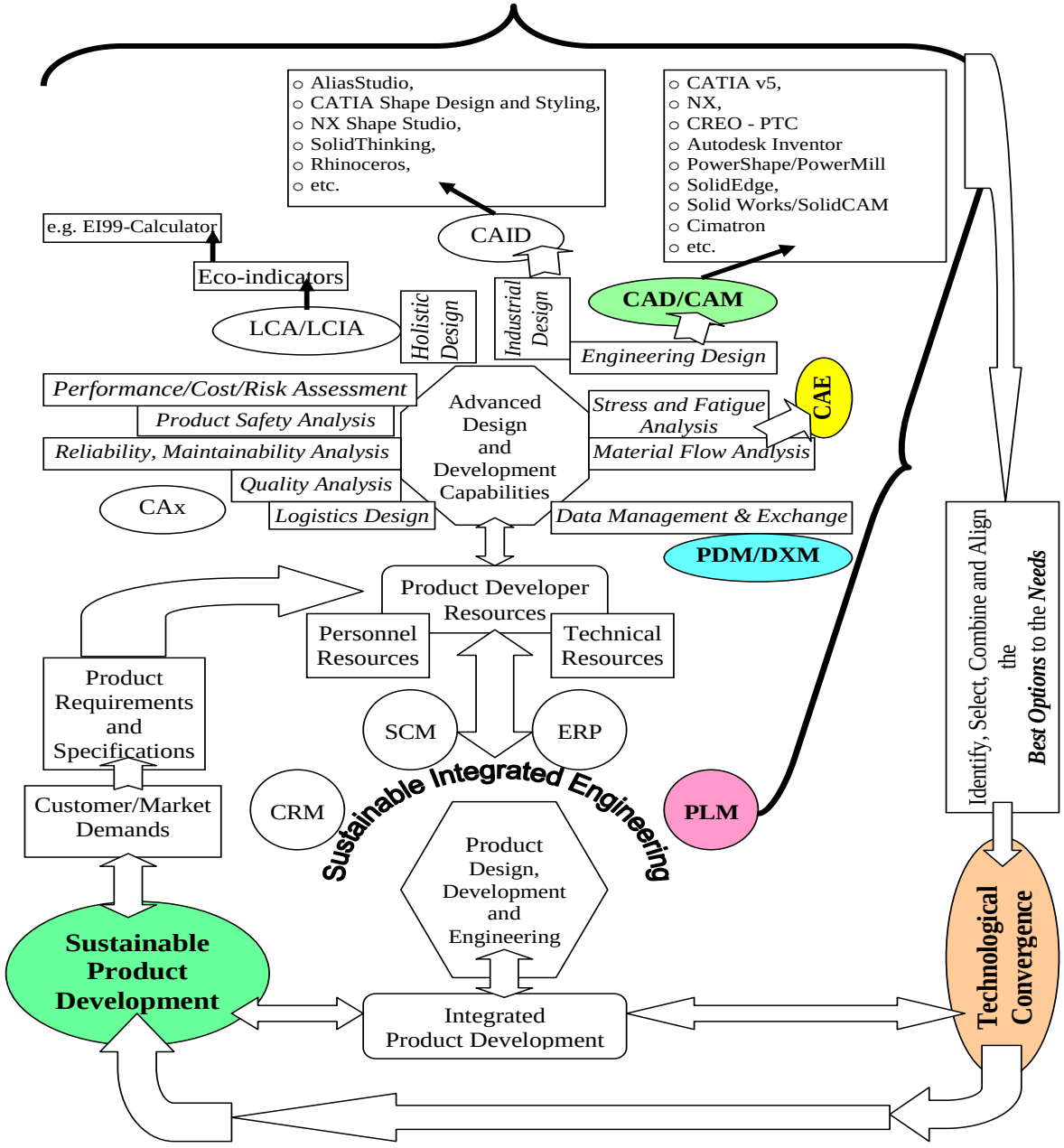

Figure 1. Model for the convergent use of integrated engineering tools as strategy for sustainable product development

4 CASE STUDY – COMPLEX INJECTION MOULDS ENGINEERING

As case study, the paper subjects to discussion the problem of identifying, selecting, combining and aligning the best options to the needs, for the CAD/CAE/CAM/PDM activities within the process of product development for complex injection moulds designated to automotive industry.

As a set of criteria for evaluating the adequacy, effectiveness and efficiency of various integrated software solutions, the following have been considered as being very important in the process of injection moulding:

- rejections elimination;
- quality improvement for the injected parts;
- design time diminishing;
- manufacturing time diminishing;
- manufacturing costs diminishing.

For trying to apply a holistic approach based on creative methods, within the early product design phase, TRIZ method was briefly experienced, by using as computerized tool, TriSolver professional software (TriSolver, 2014).

As CAD solutions, for building the complex 3D solid assembly models for injection moulds, SolidWorks and respectively Cimatron software solutions have been tested, as it is exemplified in Figure 2 and in Figure 3.

PDM Works from SolidWorks was experienced for the data management of complex products such as injection moulds.

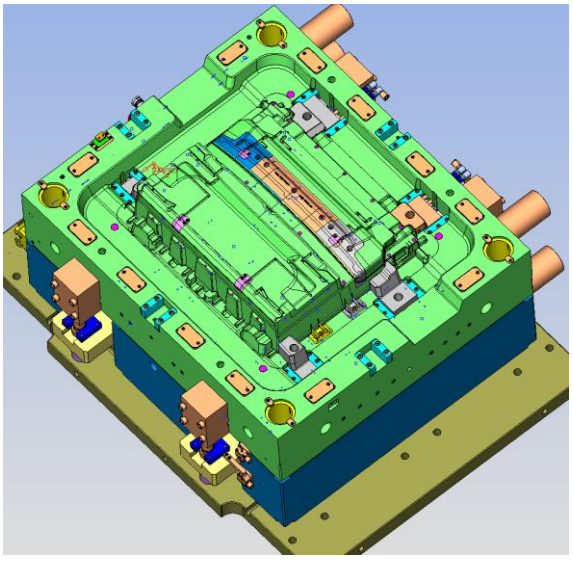

Figure 2. Partial model for a complex injection mold – SolidWorks application

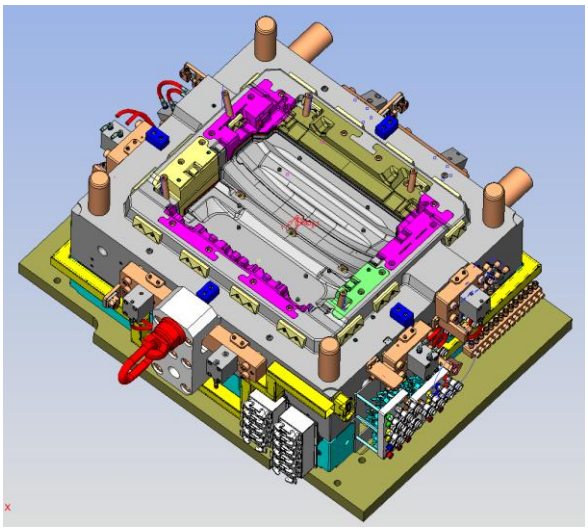

Figure 3. Complete CAD model for a complex injection mold – Cimatron application

Autodesk Simulation Moldflow Insight is exemplified in Figure 4 as a useful tool in performing correct engineering design of injection moulds. The presented example represents a simulation of injection molding process for the case of a part made of ABS as material family, with 17% Glass Fiber as filler, and for a mold temperature of 50°C, a melt temperature of 230°C, an injection time of 1.5 s and 99% of volumetric filling, as filling settings.

Moldflow from SolidWorks was also tested and experienced as a very useful tool which empowers the engineering designers to quickly check the manufacturability of plastic parts early in the design process and to create and simulate plastic flow through single cavity or multi-cavity molds.

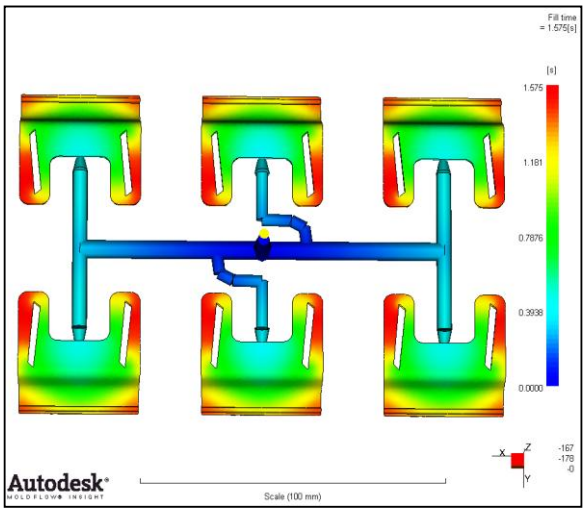

Figure 4. Injection molding process simulation – Autodesk Moldflow Insight application

After the elaboration of 3D models has been accomplished, and the CAE tests have been done, the technical documentation and drawings have been realized and sent for validation towards the project managers.

OpenDXM from Prostep represents a convenient solution for automated technical data exchange (Prostep AG, 2014). It includes capabilities for reliable, safe and facile technical data import and export, for data conversion, for input or output data checking etc. Practically, CAD management systems can be easily integrated as well as PDM systems, providing productivity and efficiency. PDM solutions from a large area of partners can be integrated, such as Dassault Systèmes PDM, Siemens PLM, SAP, PTC and Oracle. An example of experiencing OpenDXM for technical data exchange, within the presented research approach, is illustrated in Figure 5.

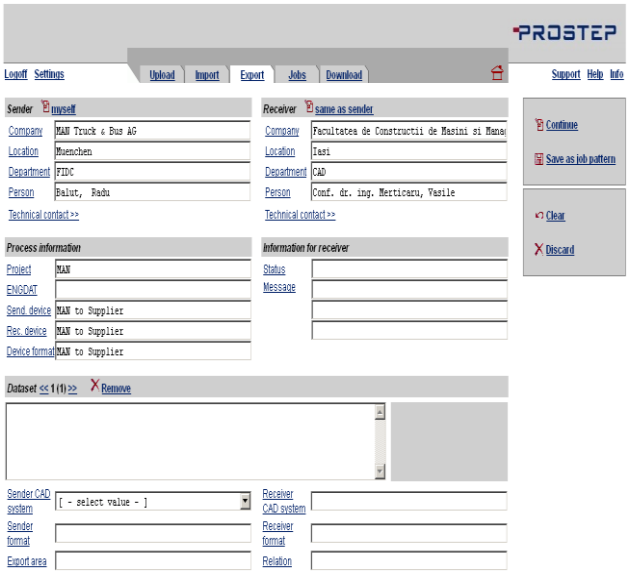

Figure 5. DXM application in Prostep OpenDXM

Once the engineering design projects have been validated and confirmed, 3D models have been imported in CAM applications and technological models have been elaborated. In Figure 6 there is exemplified a CAM model for injection mold part machining, respectively as PowerMill application.

CAM models and the advanced capabilities of CAM software solutions provide tools to analyze and optimize the machining methods, to select a way to position and orient the part in the most facile manner, both for the operator and for the operation itself and also tools for an efficient establishment of machining regimes and, of course not at last, for time consumption estimation.

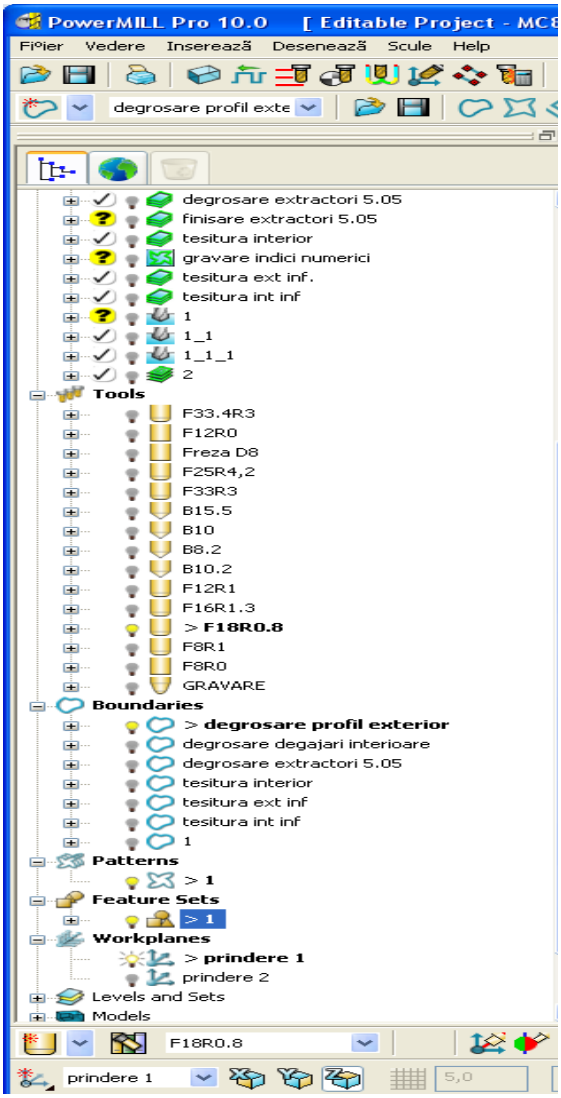

Figure 6. CAM model for injection mold machining – PowerMill application

As CAM solutions, for generating the CNC technologies for injection mold parts machining, there have been tested and experienced the following: PowerMill, Gibbs CAM, NX CAM, SolidCAM.

For example, within PowerMill applications, the following steps have been got through:

- part model import in STEP/IGES format;
- coordinate system positioning;
- blank definition and dimensioning;
- definition of tools and regime parameters;
- operation method definition;
- plane surfaces roughing and finishing;
- contour surfaces roughing and finishing;
- pocket surfaces roughing and finishing;
- holes roughing and finishing;
- engraving of numerical indexes.

Several machining methods have been experienced for injection mold parts machining within the CAM research approach, respectively: Offset AreaClear Model, Profile AreaClear Model, Helical Drilling, Optimised Constant Z Finishing, Offset Flat Finishing etc.

After defining the CAM models, post-processing has been performed, for each of them being selected the post-processor specific to the considered CNC machine. For example, SELCA.OPT, ANILAM.OPT have been experienced, the CNC G-code resulting in .sel format.

The main attribute of post-processor is to translate the tool paths in G-code program specific to the CNC machine. As method to develop a post-processor specific to the CNC machine interface, the user-development method is known. This method allows developing a post-processor by using programming interfaces like C++, Fortran. Implementation of such interfaces can be done in IMSPost, which is a macro program used for identifying tool paths from various software solutions like CATIA, Cimatron, SolidWorks etc.

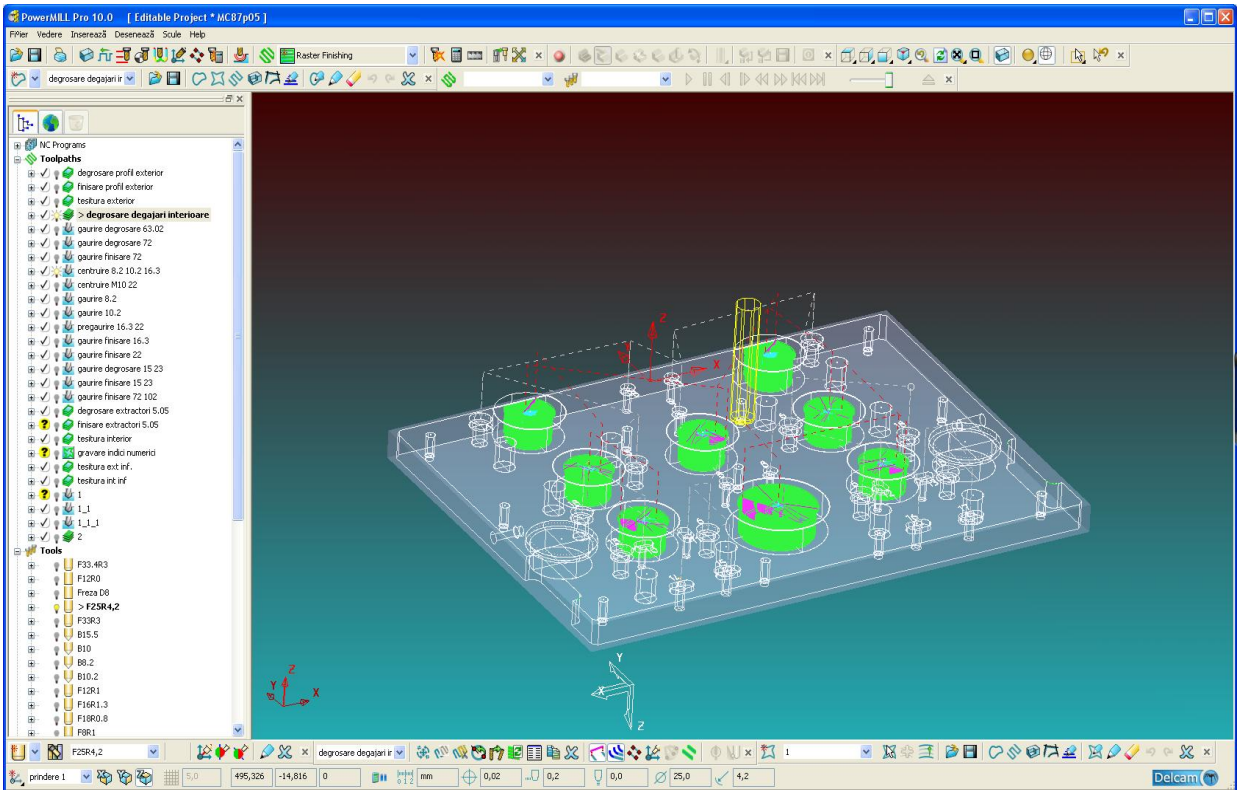

Figure 7. CAM simulation for a sequence of injection mold machining – PowerMill application

After the obtained CNC program has been post-processed, its correctness has been verified with the aid of dedicated software solutions like Plo3d and NCViewer.

Machining operations of the parts for complex injection moulds designated to automotive industry have been realized on CNC machining centers and before machining, the programs have been verified again by simulation directly on the machining center's CNC equipment, as it is exemplified in Figure 8, respectively for processing an injection mold part on a CNC machining center FAMUP MC120 EVOLUTION, the machine being shown in Figure 9, the exemplified machined part being shown in Figure 10.

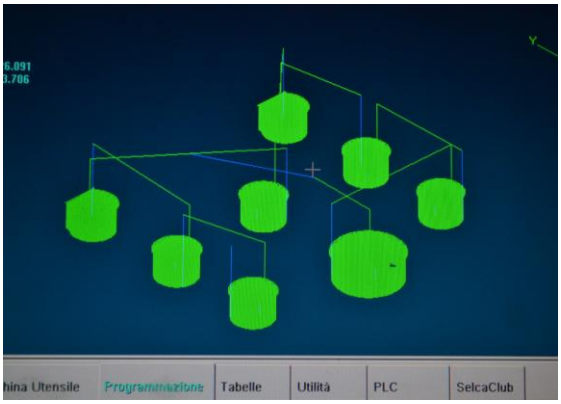

Figure 8. CNC simulation for injection mold machining –on FAMUP MC120 EVOLUTION

Figure 9. CNC machining center FAMUP MC120 EVOLUTION

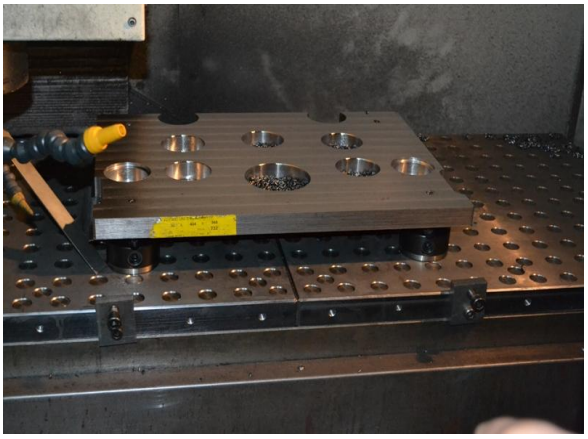

Figure 10. Injection mold part machined on FAMUP MC120 EVOLUTION

5 CONCLUSIONS

The research approach has targeted to establish a model of how a product developer should manage its integrated engineering activities, respectively to solve the problem of identifying, selecting, combining and aligning the best options to the needs, for the CAD/CAE/CAM/PDM activities within the process of product development.

A set of criteria for providing convergence in engineering design and product development activities has been established and investigated.

The engineering team involved in the research approach has experienced high developed skills in using a broad range of integrated engineering software solutions and has registered efficiency gains in terms of increasing with about 15% the productivity of engineering design and product development activities and project delivery time shortage.

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7 NOTATION

The following symbols are used in this paper:
CAD = Computer Aided Design
CAE = Computer Aided Engineering
CAM = Computer Aided Machining
DXM = Data Exchange Management
PDM = Product Data Management
PLM = Product Lifecycle Management
HPC = High Performance Computing;