George GHERGHINA, Dragos TUTUNEA, Dragos POPA

EVOLUTION IN TECHNICAL DRAWING FOR MECHANICAL PRODUCTS

Abstract: *Hand drawing and representation of various images engraved in stones or physical models built to scale come from the beginning of the human kind. The history of civilization presents many forms of representations based on the human imaginations. Nowadays the engineers create a technique to draw and design ideas by rules in ISO standards. If at the beginning of the last century the creation of industrial technical drawings was realized by crayon with very original results, in present, the computer aided three-dimensional design is widespread and introduced in digital mock-up processes. The integrated 3D-CAD design is used since the early automotive development processes. This paper presents the use of 3D modeling and analysis of automotive components to reduce cost and time in the concept phase of development.*

Key words: *computer graphics, technical drawing, digital mock-up, digital design.*

1. INTRODUCTION

Drawing has an old history since the birth of humankind; people began to draw pictures on cave walls from 30,000 to 10,000 B.C in France and Spain. Like other skills drawing has developed and change from designs scratched on the surfaces of primitive tools to walls of temples and tombs (ancient Egyptians) and decorated pottery vases (ancient Greeks). In the middle Ages drawings and painting was used for illustrations of Bibles scenes. In the Renaissance, the production of drawings increased especially due to the decoration of public buildings and palaces and the use of pen and ink on cheap paper. The control and precision of drawings were improved in the Baroque period by using superior forms and use of new materials. The 1800's started with the development of pencils which became the favorite tools of artists. Also academic training was used in the development of many currents like cubism, abstract expressionism, fauvism and postmodernism. The development of CAD/CAM started in 1957 with Hanratty which develop a program called PRONTO (Program for Numerical Tooling Operations) which have a graphical user interface. In the 1960s other companies develop other programs such as Applicon, Computervision and Evans & Sutherland. In the 1970s Ken Versprille with NURBS started 3D modeling with the basics of 3D curve. In the same period PADL (Part and Assembly Description Language) was developed by Alan Grayer and others as the first solid modeler. In the 1980s with UNIX workstations, all CAD programs started to be used in the field au automotive and other industries. But the introduction of the IBM computer in 1981 started the large-scale adoption of CAD programs (in 1983 the Autodesk released AutoCAD). AutoCAD was the first program affordable with results in industry but was largely 2D. In 1987 with the release of Pro/ENGINEER a fully CAD program based of solid geometry was developed. In the 1990s the computers were capable for computations required by these programs. In 1995 was released SolidWorks the first CAD program for Windows platform. The later years saw the release of several programs such as Siemens PLM, Solid Edge, Inventor, and others. The evolutions of drawing have passed through changes promoted by various tools available on the market. The application of the new technologies improves and exceeds the customer´s expectation [1]. One area were programs evolve is the geometric modeling since the earlier programs use two dimensional data. The initial transition was done by wireframe geometry with points in space and lines which connect these points. Nowadays surface modeling technology used in automotive and aircraft industries reduce time and costs. Design engineers do today analysis that years before was done only by professionals; the software is more reliable and only problem is the increasingly complexity of the projects which generate a large amount of data [2].

The digital mock-up system (DMU) a tool to build a virtual mock-up in the design stage is used extensively during design and manufacturing processes. DMU can perform simulation such as dynamics, kinematics, strength, thermodynamics etc. The virtual prototype of a piece can be seen as digital mock-up (DMU) which is composed by 3D models which integrate the mechanical structure of a system [3]. Comparing different studies the fallowing steps can be realized to reduce time design [4]:

- - reutilization of existing CAD models and geometry.
- - enhance collaboration between designers.
- - improve the quality of CAD models.

In another study Danesi et al. [5] reported that a CAD model becomes a digital mock-up (DMU) at the center of communication and interaction between all parts of the project. From a company point of view, the application of more parameterized CAD models should increase his efficiency and productivity. Companies have to work with different original equipment manufacturers (OEMs) that use various CAD platforms. In this context, many researches within the simulation community use the principle of Functional Mock-up and the main target is to combine the ideas of the digital mock-up processes with functional aspects [6]. This study can be used in CAD education at university level to highlight the importance of digital mock-up in manufacturing industries (Fig.1).

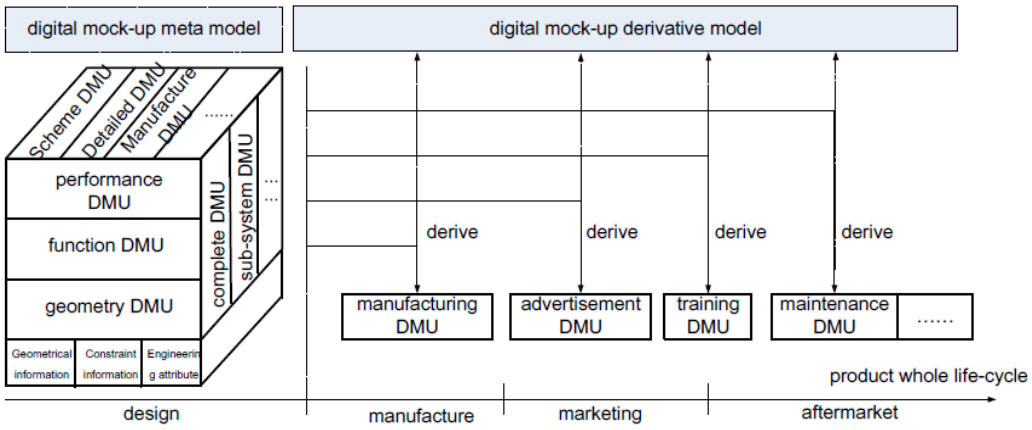

Fig. 1 Relations between all kinds of digital mock-up [6]

2. HAND DRAWING OR COMPUTER DRAWING

The development of computer aided design tools in the recent years convinced the designers and engineers that the end of hand drawing is very close. If we analyze the programs of the schools over the world we notice that hand drawing is still at the curriculum. The debate continues in present since the drawing is the simplest way to visualize an object. The drawing is the direct relation between hand and brain and is a language for engineers. The hand drawing must be used because even takes time is a way to acquire new knowledge. The computer can be a help in many processes and should be used for repetitive tasks and for operations that needs lots of changes. The manual drawing can be used for rapid sketching and for fast communications of concepts and ideas. If for computer drawing is need it of a specialized training, hand drawing is a basic need. Both computer and manual drawing are means to achieve the same goal. In the design processes we can use a hybrid of manual drawing and computer drawing [7].

3. ADVANTAGES OF USING CAD SOFTWARE

CAD tools are used today to ease of execute designs with greater accuracy and precision. The use of CAD software requires only basic knowledge in computers and a few principles of drafting and methods used in traditional technical drawing. The use of CAD programs is conditioned by the time and cost involved in manually drawings. Visualization is one of the benefits of CAD software bringing ideas and concepts in 3D forms. The following advantages of computer aided design tools are:
- the time of design is reduced with the possibility to modify drafts;
- reduce the costs of errors because doesn't require physic support (paper, pencil) every time when a revision in need it;
- can produce outputs faster than other methods because all the tools are incorporated in the software;
- reduce the manufacturing time due to the efficiency of design in computers;
- the documentation is easier to store and reproduce because all records are electronically;
- the three dimensional view provide better visualization with different textures and colors;
- CAM uses CAD information's to control machineries with numerical command;
- allow the simulation of design works as mechanically moving parts [9].

4. THE AUTOMOTIVE PARTS CONCEPT PHASE

In the automotive industry the development process uses computer aided design tools at each steps of creation, design, modeling and optimization. In a continuous competition by automotive producers to reduce the cost and time of production new strategies have to be implemented since the early stage of conception by using network based data and information transfer. A connection between all the engineers involved such as, component designers, safety and crash departments, ergonomic specialists and all the parties to realize an effective data transfer. In Fig. 2 are presented the principal phases in the development of automotive parts. During initial design of a part an optimal interaction is need it between styling process and technical engineers to improve the pre-development process.

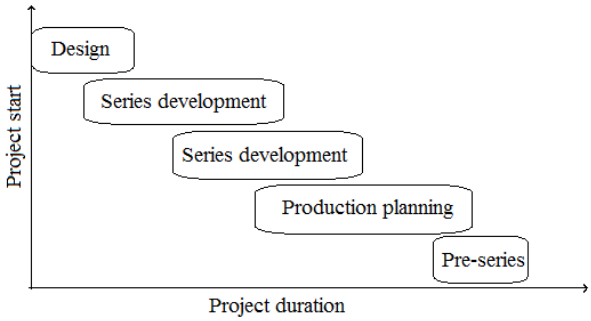

Fig. 2 Steps of an automotive development process [8]

For quick determination of solid geometry, 3D scanning technology can be used. When we discuss about 3D, we must to talk about real-world coordinates in three-dimensional environment [11]. In geometrics, these

coordinates are represented as points on the X, Y, and Z-axis in Cartesian coordinates.

The third dimension gives 3D systems (as 3D scanners) an important advantage because can create virtual environments in our computers. The difference between 2D based scanners and 3D based systems does not make them incompatible. Almost of 3D scanners combine these methods and techniques. For example, there are 3D scanners that can produce coloured 3D models by overlapping planar coloured maps onto a 3D model [11].

The result of a 3D scanner is to create a point cloud of geometric shapes from the surface of the real object. These point clouds can be used to obtain the shape of the subject using reconstruction virtual tools.

The 3D Scanner device works with a software, in our case, the software is Geomagic for Solidworks with the main software window.

Current 3D scanning technique allows the scan of a piece, import into a modeling program, analyzing and optimizing construction and rapid prototyping. These steps allow obtaining better products, cheaper and faster to satisfy the current competitive market.

The all process can be planned to ensure that products can be manufactured. The product decisions should be take on the base of digital models. The planning process is brought forward from the PMU (physical mock-up) step to the DMU (digital mock-up) Fig.3.

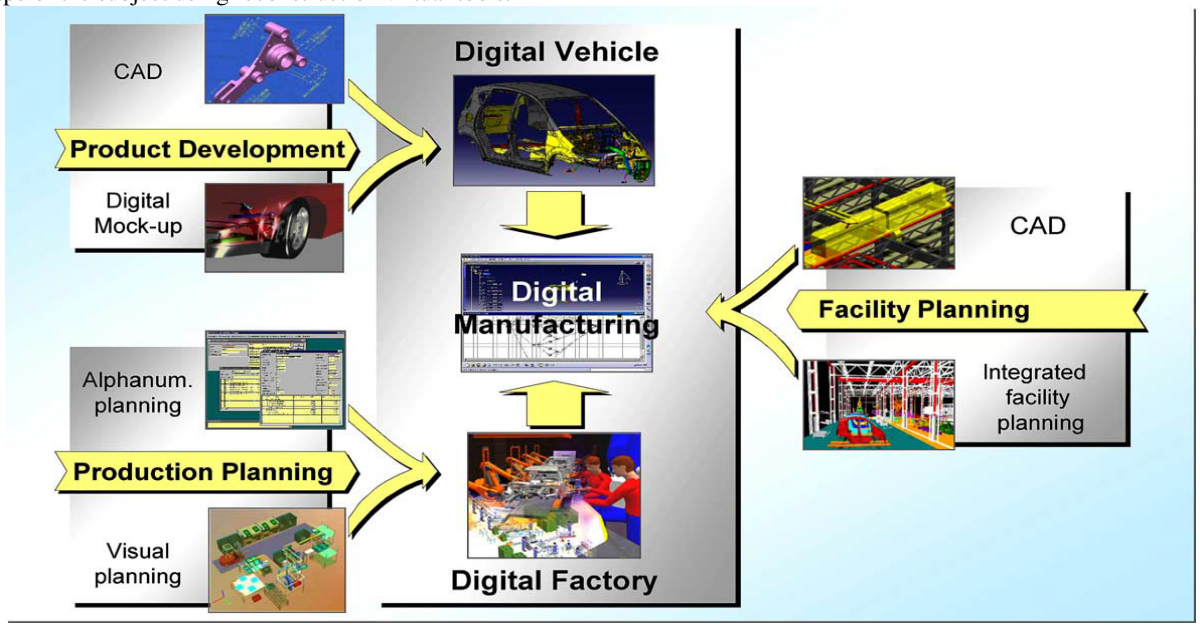

Fig. 3 Digital manufacturing links product development, production planning and facility planning [10]

5. DESIGN AND MODLLING OF AN INJECTOR

CAD programs allow to design and build 3D models of automotive parts. The authors design an auto injector for D115 engine and simulate the injection pressure in the combustion chamber. In Fig. 4…14 are presented the main components of the injector. The 3D program used for the design is SolidWorks version 2014.

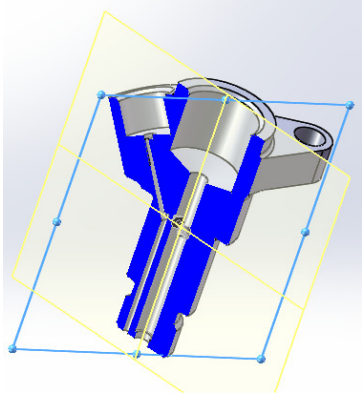

Fig. 4 Injector body section

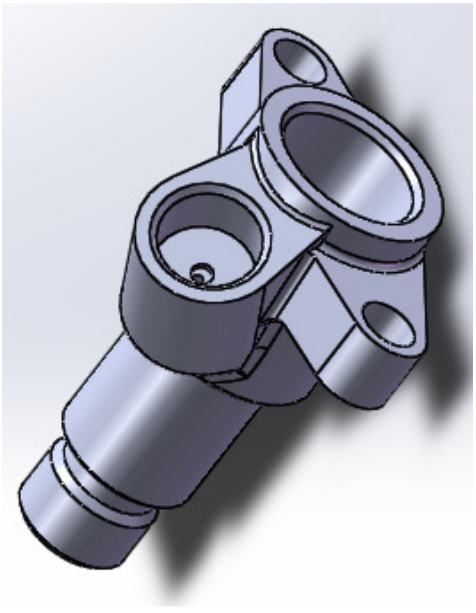

Fig. 5 Injector body

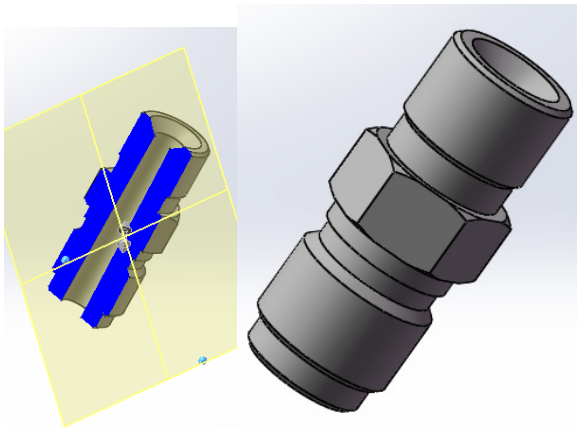

Fig. 6 Connection of injector

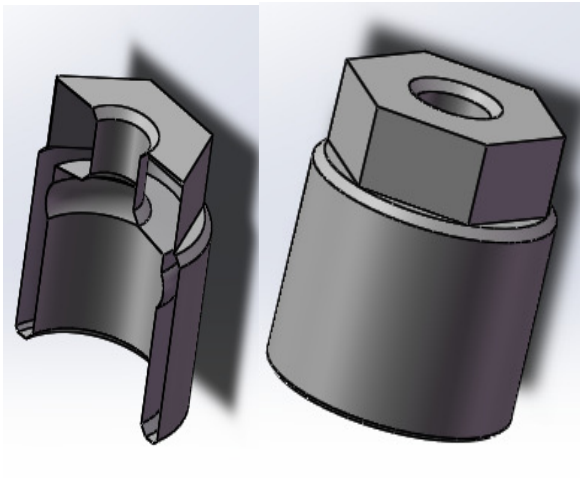

Fig. 8 Arc adjustment nut

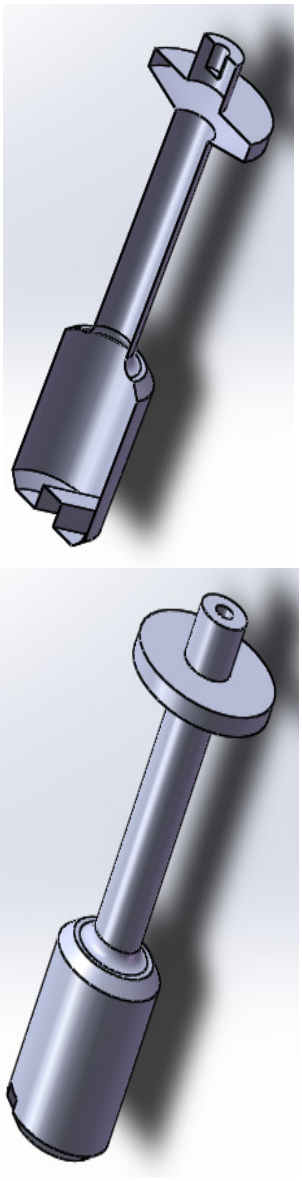

Fig. 7 Screw for adjustment of the arc tension

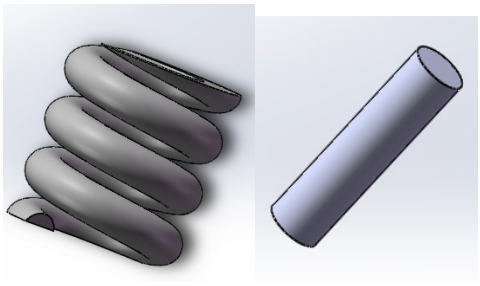

Fig. 9 Arc and shift guide

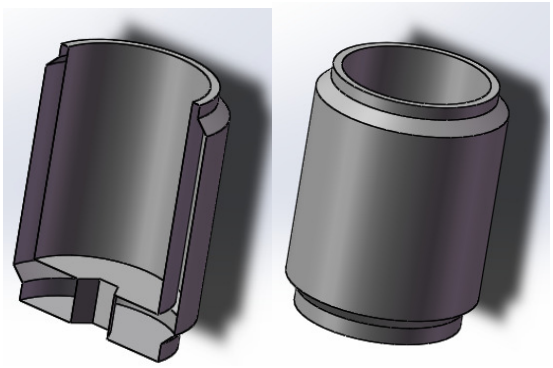

Fig. 10 Arc guide nut

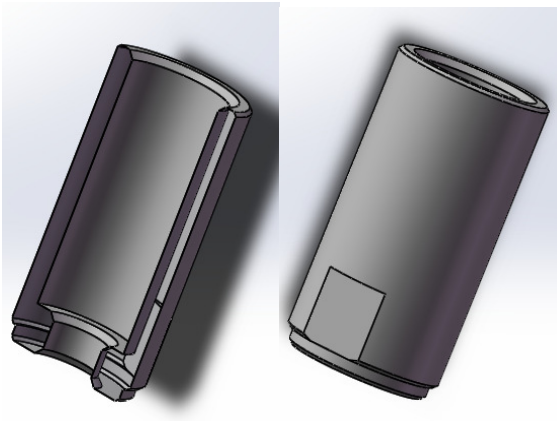

Fig. 11 Nut port nozzle

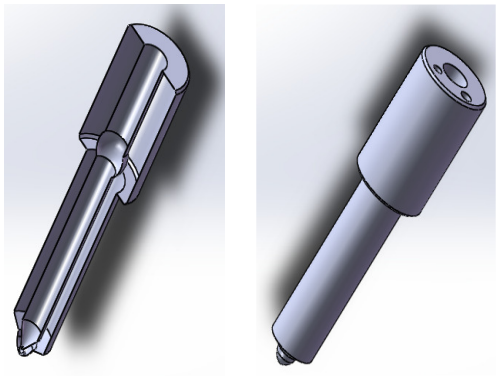

Fig. 12 The body of nozzle

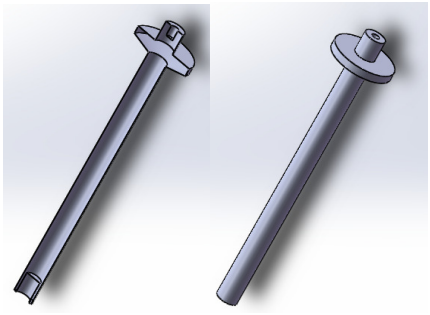

Fig. 13 Rod of injector

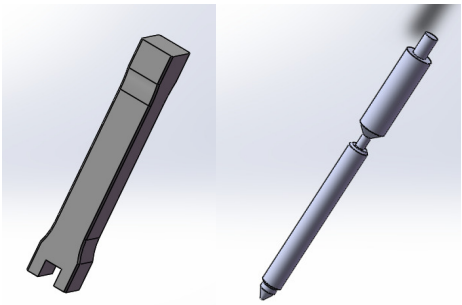

Fig. 14 Nozzle control and shaft of injector

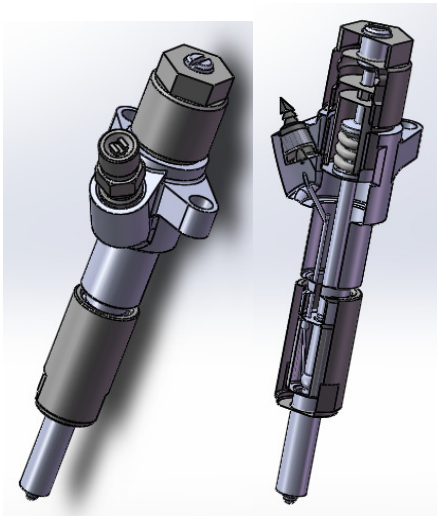

Fig. 15 Final model of the injector **A**

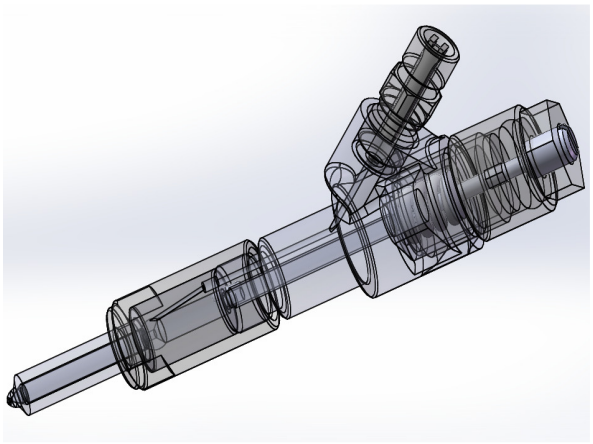

Fig. 16 Final model of the injector **B**

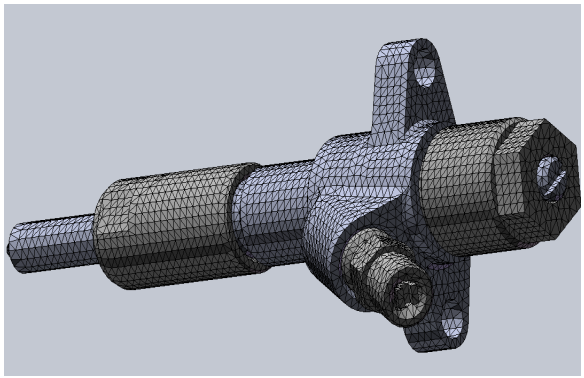

Fig. 17 Mesh with finite elements

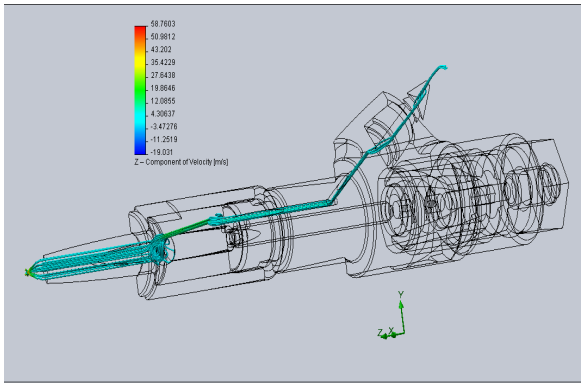

Fig. 18 The flow of fuel inside the injector

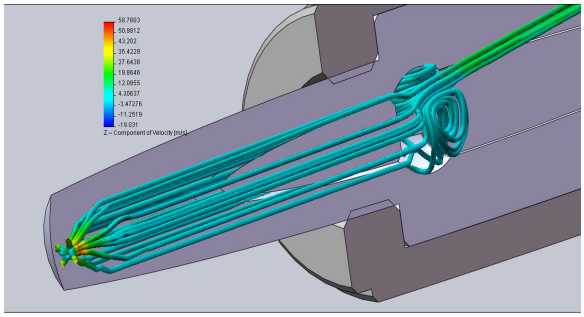

Fig. 19 The spray of fuel in the combustion chamber

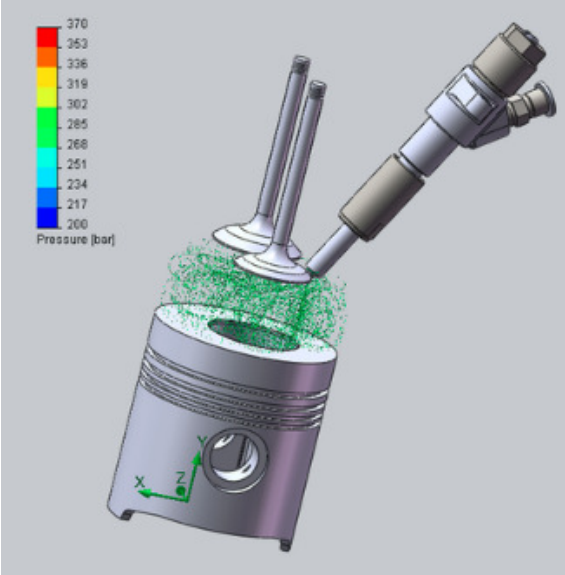

Fig. 20 Simulation of injection in D115 engine

. In Fig. 17…20 are presented some aspects of MEF analysis.

6. CONCLUSION

The presented 3D-CAD method can reduce significantly the time for design and modeling in the early automotive development processes. This method allows the visualization of different components assembly at different steps reducing errors in the design.

Hand drawing and computer drawing can be combined together to realize various automotive parts. Current 3D scanning technique allows the scan of a piece, import into a modeling program, analyzing and optimizing construction and rapid prototyping. These steps allow obtaining better products, cheaper and faster to satisfy the current competitive market.

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