Graphic Results of Applying CAD Tools to Design Automotive Braking Systems

GOANTA ADRIAN MIHAI, GHELASE DANIELA, DASCHIEVICI LUIZA,
Engineering Faculty of Braila
“Dunarea de Jos” University of Galati
Calea Calarasilor, no. 29, 810017, Braila
Romania
Goanta.Adrian@ugal.ro

Abstract: In this paper the author tried to show the application and some results obtained in computer aided design of subassemblies of automotive braking systems. The working environment chosen was an integrated design platform that allowed obtaining multiple results in a single file. Even if the resulting file gives the designer the possibility to obtain integrated results from different stages of design, special emphasis was put on the stage of parametric geometric modelling. Results and conclusions of the work was exemplified by a particular case i.e. calliper brake mechanism.

Key-Words: - CAD, PDM, PLM

1 Introduction to CAD and generalities about car braking systems

The present situation is quite varied due to the fact that besides the traditional work on the drawing board and paper sheet, the computer drawing methods have been increasingly used, which proved efficient with small production capacity and an average complexity works. In the traditional version there are some major drawbacks related to the impossibility of archiving in electronic format, cumbersome copying, limited graphic layout, etc. The second variant mentioned above features some significant advantages [2]: fast convenient archiving, flawless graphics, fast multiplication, possibility of transfer via e-mail that is why at this moment it has the largest spreading area in our country. If we look back to the 1990s, we find a significant qualitative leap because most designers have directed efforts to both computer-aided design, as a result of realizing the benefits of that working method, and to the decrease in the costs of the associated equipment. Also it should be taken into account the decrease in the purchase price of the design software solutions along with the creation of certain discounts, which made the users of the “stolen (broken)” variants to work legally. As a result some firms, even if they have not launched the best software products on the market, managed to remain in the users' preferences range as a result of having applied a very clever marketing policy, and managed to successfully combine the policy of letting themselves intentionally stolen in the first phase, until the user became addicted to that product, and in the second phase to compel the user to purchase the latest version on the market. Also the policy of the software companies to market software versions able to work on older computers that is with poorer hardware configuration than the software being launched caused users to focus on such design solutions which, not in the least, proved to be much cheaper than the complex design solutions offered by some manufacturers. However [3], it must be said that there is at this point a number of users working in large financially powerful firms using complex design solutions containing modules of CAD, CAE, CAM and PDM type. These complex solutions provide users a multiple-parameterized-type 3D geometric modelling, analysis and research in the field of virtual simulation on the behaviour of the designed item and manufacturing simulation. Last but not least they allow for the management of the related documentation throughout the life product.

1.1 Purpose of the Braking System

Valuing the safety performance of speed and acceleration of a vehicle depends, to a decisive extent, on its braking ability. The more efficient the braking system, the higher the average travel speeds and the vehicle operational indices . Also, good braking qualities ensure avoidance of accidents which may occur even at relatively low speeds due to unexpected obstacles. Road accident statistics
show clearly the importance of efficient braking systems in eliminating the dramatic consequences of inadequate operation of other parts of the vehicle. Vehicle speed reduction can be achieved by forces opposing the movement. Because some forward resistance has poor effects and resistance to acceleration, when braking, becomes an active power, there is the apparent need for the vehicle to be equipped with devices able to generate forces opposite to movement. These forces are called braking forces; they must have values large enough and that can be adjusted by the driver as necessary. Braking forces are created by braking mechanisms included in the vehicle braking system.

1.2 Terms And Functional Conditions
Imposed To Brake System
Braking devices, the same as those of slowdown, must meet certain functional and structural conditions in order to ensure good vehicle braking capabilities to highlight the speed and acceleration performance safely. Vehicle braking devices must meet the following conditions:

- be capable of some imposed decelerations;
- to ensure vehicle stability during braking;
- to ensure progressive braking without shocks;
- to provide proper distribution of braking effort across the bridge;
- the driver does not require too much effort to drive;
- conservation of the vehicle braking qualities in all working conditions encountered in service;
- to provide heat removal which arises during braking;
- to have high reliability;
- to provide safe operation in all working conditions;
- clearance adjustment be less carried out and easy or even automatically;
- to get quickly in service;
- braking should not be influenced by road bumps and the steering wheel blocking;
- to allow vehicle immobilization on the slope, if idle for longer times;
- not allow oil and impurities to enter the friction surfaces;
- braking force to act in both directions of the vehicle motion;
- braking performed only by the driver
- be designed, constructed and installed so as to withstand corrosion and aging
- not be possible simultaneous operation of the brake and acceleration pedals

- to have quiet operation;
- to have a simple and inexpensive construction.

1.3 Purpose of the hydraulic transmission
Hydraulic braking devices are currently the most widely spread systems in cars. They are found in all cars, and small capacity trucks and buses and in most medium capacity buses and trucks, and some tractors. With all the advantages provided by hydraulic transmission, due to inability to achieve a high transmission ratio, the force applied by the driver on the pedal does not always ensure sufficient braking effectiveness. For this reason, the use of hydraulic transmission imperatively calls for a servomechanism. Using a servomechanism is also required with cars having the lower total weight if they are provided with disc brakes. With cars having total mass exceeding 10,000 kg hydraulic transmission, even when equipped with servomechanisms, is used less frequently. To maintain the stability and maneuverability of the vehicle during braking to a stop minimum space, it was introduced on an international scale the bridge braking -forces distribution diagram in terms of compatibility for the constructive and operational elements of the car. Achieving these conditions, regulated by STAS 11960-89, is also mandatory for the vehicle dynamics resizing, representing the criteria for assessing the vehicle capacity of braking. Regulations relating to braking capacity, valid in our country, pay special attention to the effectiveness of the brakes based on the braking area. Prescriptions are provided regarding the structural characteristics of the brakes, braking performance and test methods for each category (cars and trailers are classified in categories M, N, O). Table 1 provides the braking performance of the motor vehicles of categories M and N. Assessment and comparing the braking ability of the are based on the maximum absolute (a_{max}) or relative (d_{rel}) deceleration, the braking time (t_{b}) and minimum braking area (S_{f}), depending on the initial speed of the vehicle. To determine the parameters above the literature presents analytical calculation relations. The relations presented refer to a vehicle where distribution of braking forces is ideal, respectively relative decelerations achieved by each bridge have equal values. As this actually happens only in special cases, the construction of brakes includes brake adjusting devices depending on the dynamic/or static load.
3 Theoretical Considerations of Geometric Modelling

The main idea of this article consists in imposing dimensional and geometric restrictions on each item in order to create, by changing the sizes, families of parts that should meet the geometrical typology while being characterized by different sizes. Thus the technological documentation for several dimensional variants of the same geometric model which defines a family of parts can be obtained in a very short time. The scope of this design method is very wide, i.e. it can be applied from furniture design to areas of maximum complexity, obviously within the performance limits of the IT equipment and hardware used. The basic principle of the parametric modelling [4] is the step by step incorporation of a 2D sketch into a solid model in the following sequence [1]:

1. Creating a 2D sketch usually representing a basic feature of base sketch.
2. Using the command Create Sketch, the sketch is transformed into a parametric profile (Single Profile or Profile).
3. Implementation of constraints and parametric profile dimensions (fully constraint). Figure 1 represents the fully dimensioned and constrained sketch for the flange fitted on the pump body.
4. Creating the base solid entity (part) by extrusion (Extrude) revolution (Revolve), movement acc to a travel path (Sweep), symmetry (Mirror) or overlapping (Loft).
5. Generation of additional geometric components with the related sizes in order to complete the complex geometry of the item model. In this respect the sequence of operations 1-4 is repeated.
6. Complete the part model (changes in size or shape) by adding simple holes, threaded holes, blunt edges, connections, grooves, etc.

![Fig. 1. The profile sketch fully dimensioned and geometrically constrained](image)

In the initial phase of modelling, the basic feature of the part has not fixed dimensions yet. Most conventional CAD systems require, however, from the start, accurate dimensions and locations of the part entities. By parametric modelling, the NX7 program offers the possibility of modelling and changing the shape throughout the development of the project. The initial sketch reflects the approximate basic feature of the part being designed, and does not require accurate sizes and geometric shapes. The NX7 provides the possibility of completing the sketch by transforming it into a parametric profile on which the necessary changes can be subsequently and automatically applied.
4.3D Model Visualization Tools
Mention must be made that all these graphic results are obtained by option True Shading Editor from the View pull down over the path View/ Visualization which provides realistic images containing light and shadows and also reflections of the metal, glass, plastics, etc. type. Figure 2 illustrates the access path to this command.

As shown in the figure above there is plenty of choices and settings of the stage lights, shadows, visual effects, materials and textures that leads to a high quality image. Setting details of the materials are shown in Figure 3, where at the bottom it is apparent specific settings as reflections or background colour resulting in highly realistic quality photo images. To obtain images rendered [5] by a render, other commands are activated which however consume very large hardware for equally high graphical results.

5. Graphic results obtained in the hydraulic braking system design
Strictly applying the above steps to generate each piece as part of the assemblies and subassemblies in the automotive industry, files of type *.prt are obtained leading automatically to the execution drawings. The purpose of all computer aided design activities is to reach, by three-dimensional geometric models created and used to simulate the actual behaviour by finite element software, programming of the numerically controlled machine tools and cutting simulation. Also a latest trend occurring in the country lies in the ability to manage the entire documentation throughout the product life. All these goals can be implemented in a variety of software packages to be found on the market, each with advantages and disadvantages. For example we present the results obtained for a brake pump and the calliper braking system.

Thus creating sketch after sketch and applying three-dimensional generation commands such as Extrude, Revolve, Variation Sweep, Emboss, Draft, Draft Body, Edge Blend, Blend It, Bend Software, Chamfer, Shell Hole Emboss, Body Trim, Divide Faces, and Instance Feature each item is obtained
separately. Below are presented (Figures 4, 5, 6, 7) some of the items constituting the braking pump assembly of a car.

We also present, without going into details of drafting and 3D modelling, parts of the brake calliper assembly - Figures 8, 9, 10.

As to how to view it, it must be said that choosing...
the landmark but mostly the modelled assembly, makes it possible to visualize the geometric details on the opposite side of the part/assembly designed. The mirror image is separated from the real one by a plane marked by a grid suggesting surface reflection. The mesh grid can be suppressed in settings or may be omitted in representation, by choosing a certain viewing angle which prevents her appearance on the screen.

- Ensures products are constantly aligned with their strategic intent.
- Standardizes, automates and streamlines repeatable design processes.
- Improves development productivity through the use of embedded knowledge.
- Captures and manages design rules to balance conflicting requirements and ensure compliance.
- Eliminates costly physical prototyping by simulating and validating products and processes across multiple product development stages.
- Enables cross-discipline teams to deliver faster iterations by using common data and models.
- Speeds up development by using simulation to deliver critical product performance information earlier in the development cycle.

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Fig. 10 Assembly with calliper brake

6. Conclusions
Besides great graphics due to using graphics tools of the type CAD in automotive design, the following benefits must be underlined:
- Eliminates data translation costs for cross-discipline activities.
- Reduces maintenance, support and training costs.
- Minimizes time and cost impact of product changes that affect multiple disciplines.
- Leverages knowledge captured from experienced engineers, as well as industry best practices.
- Breaks down barriers to cross-discipline collaboration.

References: