USE "VIRTUAL LABORATORY" IN RESEARCH AND TEACHING AUTOMOBILE TECHNOLOGY

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Abstract: *Hanoi University of Business and Technology is investing in the construction of a laboratory and a car practice. Along with the real experiments on cars and engines, in the future university will intend to apply dynamic simulation (CFD) to set up "virtual lab", serving for research and teaching of this branch.*

This paper presents a brief overview of the virtual laboratory in car design research; analyzes typical simulation methods and introduces some results that have been applied in the medical field.

Keywords: *Computational Fluid Dynamics (CFD); virtual lab; fluid mechanics.*

1. Overview of "Virtual Lab"

The history of formation and development of science in the world is always associated with two branches of experimental science and scientific experiment. The purpose of empirical science is to find laws of nature, theorems, and laws by conducting a series of experiments that are repeated many times. Since ancient times, many principles and laws have formed by real experiments in mechanics. For example there are the law of Archimedes and the principle of leverage of the scientist Archimedes (284-212 BC), Pascal's principle of Pascal scientist (1623-1662), the principle of unpredictable physics of Galilei scientist (1564-1642), the laws of universal gravitation and the friction force of Newtonian scientist (1642-1727) and many other inventions in physics in general and mechanics in particular have been drawn from experimental science.

Meanwhile, with the development of scienceandtechnology,thefieldofscientific experiments is responsible for verifying the principles, theorems, laws of physics, mechanics by demonstration experiments in laboratories and in practice. At the same time, through scientific experiments valuable experiences were summarized in order to the design and manufacture of technology products for human use. In addition, through experiments conducted in practice, lecturers in university can help learners better understand the nature of the laws that have been summarized into principles, laws, formulas. .

To be able to conduct a series of practical experiments with large volume, long time and high level of complexity, it is necessary to equip laboratories with large scale, complex structures and very high costs. The rapid development of computer science and technology has allowed scientists to approach how to verify the theory by using "virtual laboratories". It is a science based on dynamic simulation (CFD) in order to make qualitative (and sometimes quantitative) predictions of physical processes occurring in nature by 3 means (see figure 1): mathematical

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models (partial differential equations), numerical methods (discrete ways and solving techniques) and finally software tools (calculation tools, preprocessing and postprocessing) [1], [3].

In the field of engineering and technology simulation techniques based on mechanical and numerical analytics have enabled scientists and engineers to perform "digital experiments" (that is, simulations on computers) in a "virtual lab".

The computational dynamics method (CFD) in hydromechanical mechanics is a tool to simulate the interaction between the moving fluid and the objects submerged in it, enabling architects to design and build safe environment and living space. At the same time, there is an effective tool for vehicle designers (waterway, road, and aviation) to complete hydrodynamic characteristics in the fastest, most efficient and most affordable way.

Although the results obtained from the "virtual laboratory" still depend on many foctors like the initial and the boundary conditions to solve mechanical problems, the methods of approving complex mechanical functions and the degree of error caused by computers and simulation, its contribution to experimental science has been and will be a major concern of advanced countries in the world in the era of technology 4.0. The comparative figures below are proof of the superiority of "virtual laboratories" (see table 1).

With the development of computer science, virtual experiments to verify the laws of fluid mechanics have been built completely from the beginning to the modern period. Typical methods applied in fluid mechanics are Finite volume method (about 80%), Boundary element method and other method (about 20%) with the support of 3D simulation software.

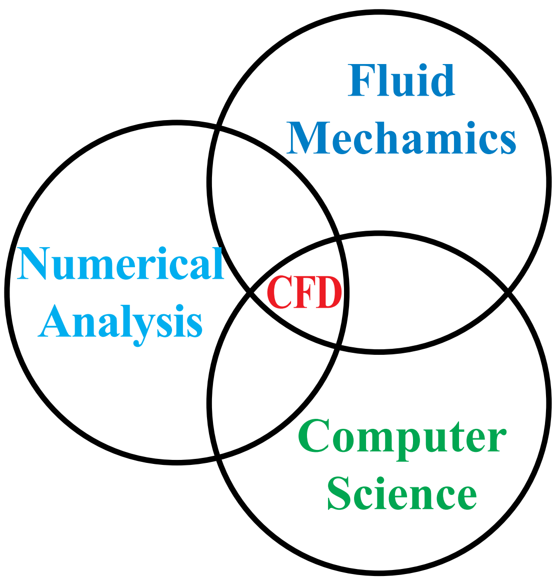

Figure 1. Diagram depicting CFD simulation

Table 1. **Comparison of real and virtual experiments**

Real experiments	Simulation (virtual experiments)
Quantitative description of the typical properties of flow using measurement means:	Quantitative prediction of the typical properties of the flow using specialized software:
• For a number of experiments at a time	• Given all the quantities required by the problem
• With a limited number of measurements and instantaneous timing	• With a high-level solution in space and time
• For application of an experimental model	• For many models of change
• Limited to a number of problems and execution conditions	• For many problems
• Sources of error: measurement errors, flow disturbances due to interaction with the test wall	• Sources of error: simulation, discrete, repetition, computer errors
• Big cost, slow	• Cheaper, faster
• Only conducted in a continuous process	• Can be done in parallel
• Test objectives are single	• Test objectives are for a variety of purposes
• Experimental equipment is difficult to move	• Computer can be portable, easy to use and modify
• Safety is not high and depends on many factors	• Safety is very high and depends on few factors

To illustrate the applications of "virtual laboratories" the article presents a number of results that have been published by researches in the world and in the world in the automotive sector as well as the applicability to the medical industry for research and teaching of Hanoi University of Business and Technology now and in the future.

2. "Virtual laboratory" in the field of automobile technology [1], [2]

2.1. Simulation of optimal automobile shape design

In order to the design and manufacture or improvement of modern cars, especially sports cars, virtual experiments have been used to simulate velocity and pressure fields of the airflow acting on the exterior of the car. The simulation results can be used to test the vehicle's technical features and help finalize the design of cars in terms of aerodynamics, creating faster and more fuel efficient vehicles (see Figure 2).). Fro 3D images we can observe the velocity and pressure distribution of the air on the outer surface of the car and assess the areas of drag and lift. On that basic we can adjust the shape of the car body to achieve an optimal plan of car drag.

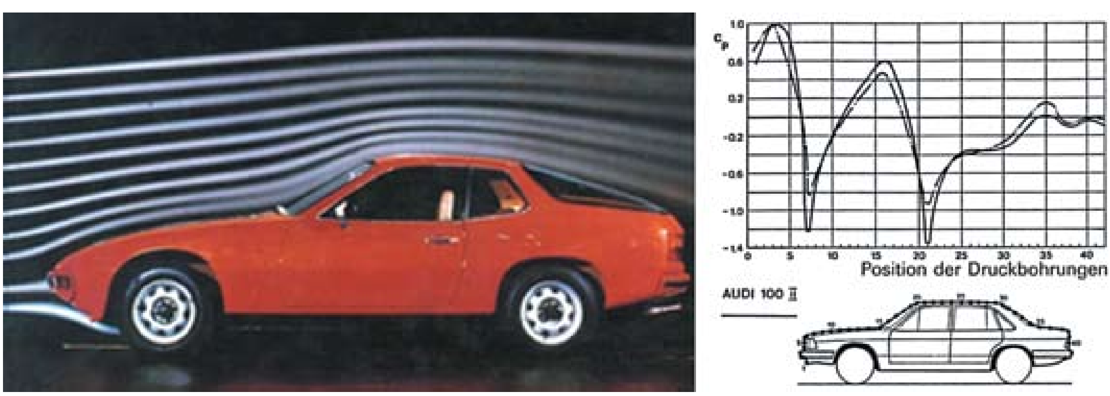

Figure 2. Aerodynamical Simulation of a car

2.2. Simulation of hydraulic brakes in cars

Simulation images 3D in a car can visually visualize system components, hydraulic transmission in brake mode and brake release mode. The simulation results are used to calculate the design of the hydraulic brake system in cars and serve the operation, maintenance and repair of this system (see Figure 3).

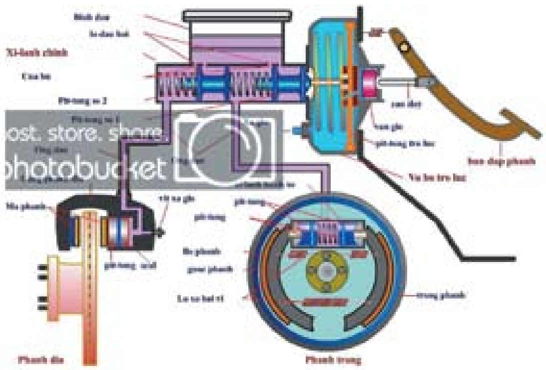

Figure 3. Simulation of hydraulic braking system in a car

2.3. Simulation of power steering system in cars

The power steering system is also simulated by 3D images to replace the actual system of the same type. The simulation process is carried out from the stage of steering wheel, driving high pressure oil pressure into the plunger to push the gear bar in the direction of rotation of the steering wheel. The value of pressure difference on the plunger can determine the optimum steering force of the driver on the steering wheel (see Figure 4).

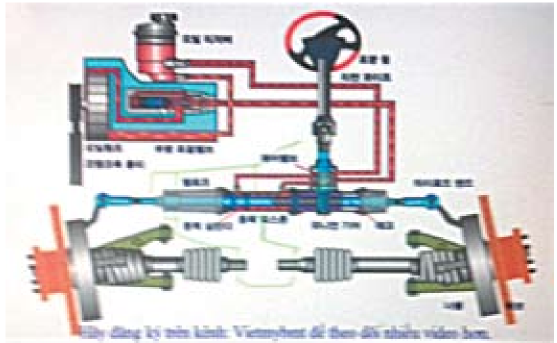

Figure 4. Simulation of the car power steering system

2.4. Simulation of car suspension

The car suspension is the most important and also the most complicated transmission system in a car because it relates to the motion of the car. Describing by drawing or motionless models is often difficult and relatively confusing. 3D simulation can visually describe the operation of the suspension system when the car is moving. Using specialized calculation software (carsim, matlab, ..) identifies the optimal properties of the elements, evaluates the advantages and disadvantages of the car suspension options and recommendations. It is useful information for manufacturers as well as users. Figure 5 and Figure 6 describe the results of the simulation of the 2 suspension plans by spring and by electronic-air system.

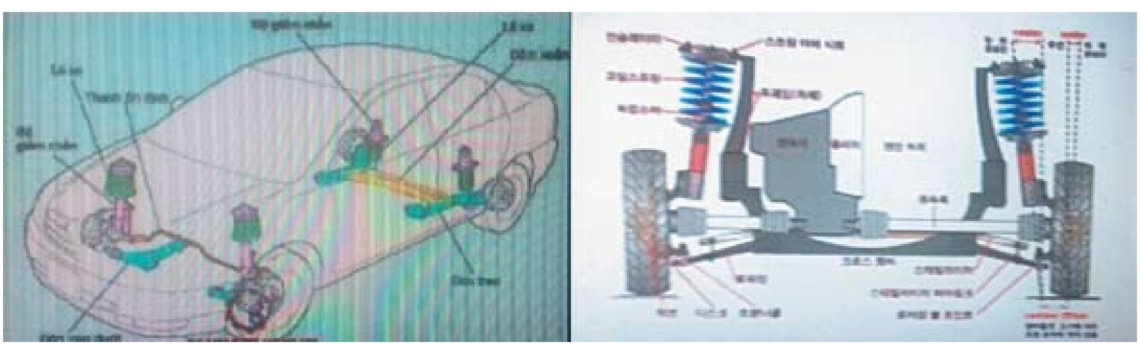

Figure 5. Simulation of the spring suspension

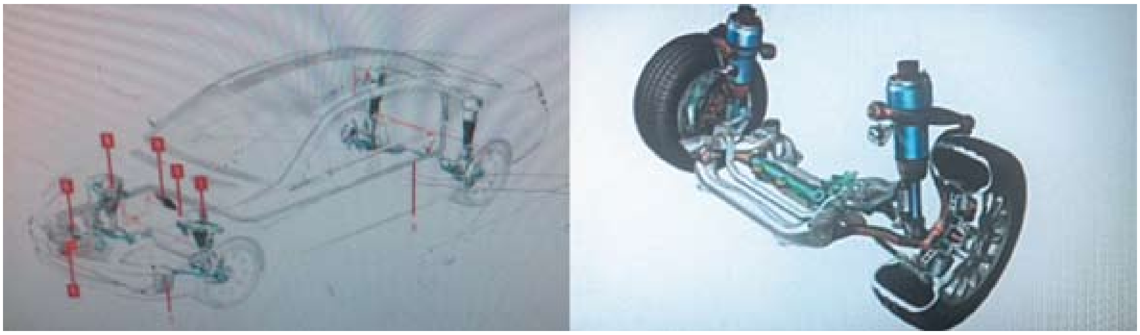

Figure 6. Simulation of electronic-air suspension

2.5. Thermodynamic simulation of car engines

Thermodynamic simulation of a car engine gives us an idea of the mechanism of thermodynamic effect in the engine on critical position to heat. Thereby evaluating the degree of heat resistance of engine details. The results of engine heat simulation can serve the preliminary design and selection of materials for manufacturing automotive engines (see Figure 7).

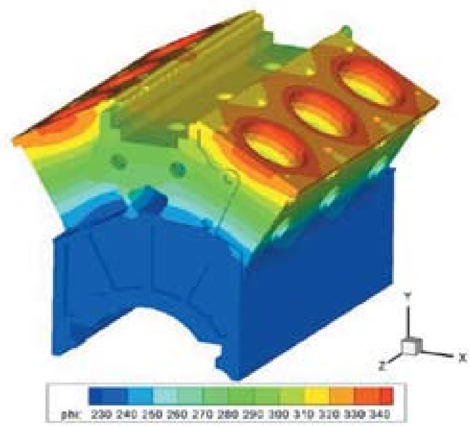

Figure 7. Simulation results of internal combustion engine heat

3. The ability to use virtual experiments in the medical field [4], [5]

The human body consists of the most complete, difficult and sophisticated systems compared to common mechanical machine. In particular, the operating mechanism of blood in the human body is similar to the hydraulic transmission in machines and can also cause unpredictable damage.

Previously, in order to successfully perform surgeries, especially those involving the human blood circulatory system, doctors had to conduct medical experiments on animals or on large real models, which do not fully reflect the similarities with details on the human body.

Today physicians and medical experts today collaborate with fluid dynamics experts to conduct virtual experiments on computers before operations of real surgeries on people, avoiding possible risks. Some virtual experiments can be used to simulate cerebral vascular circulation before and after stents (see Figure 8) or simulate blood circulation in the aorta to find ways to fix circulation velocity, blood pressure and shear stress acting on artery walls (see Figure 9). However, to conduct medical surgery on the human body, the health facilities also need more sophisticated machines, equipment and modern medical technology and supportive robots to increase the level of reliability and possibility of success in surgery.

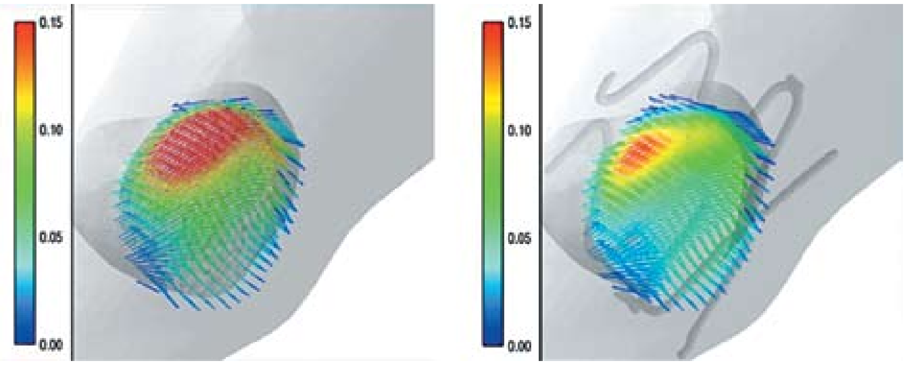

Figure 8. Simulations of cerebral vascular circulation without stents (a) and after stenting (b)

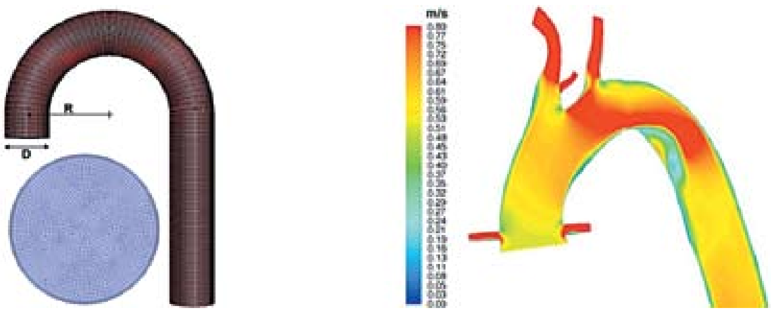

Figure 9. Geometric model (a) and simulation result of blood velocity field in the aorta (b)

4. Conclusion

The application of CFD methods creating virtual laboratories has practical significance in scientific and technological research and teaching of car technology and in a number of other related industries in the industrial age 4.0. Research and teaching institutions need to invest in both technology and human resources. Approaching and gradually applying virtual simulation simulation to solve suitable practical problems and deploying in teaching fluid mechanics and researching in car technology if fully invested .

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SỬ DỤNG "PHÒNG THÍ NGHIỆM ẢO" TRONG NGHIÊN CỨU VÀ GIẢNG DẠY NGÀNH CÔNG NGHỆ Ô TÔ

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Trường Đại học Kinh doanh và Công nghệ Hà Nội đang đầu tư xây dựng Phòng Thí nghiệm và Thực hành về ô tô. Cùng với các thí nghiệm thực trên ô tô và động cơ, trong tương lai trường định hướng ứng dụng mô phỏng động lực học (CFD) để thiết lập "Phòng Thí nghiệm ảo", phục vụ nghiên cứu, giảng dạy. Bài viết trình bày sơ lược về Phòng Thí nghiệm ảo trong nghiên cứu thiết kế ô tô; phân tích các phương pháp mô phỏng điển hình và giới thiệu một số kết quả đã được ứng dụng trong ngành Công nghệ ô tô và khả năng sử dụng trong lĩnh vực y khoa. Ngoài ngành công nghệ ô tô, phương pháp CFD ứng dụng mô phỏng trong Phòng Thí nghiệm cũng có ý nghĩa thiết thực trong nghiên cứu khoa học và giảng dạy ở một số ngành khác, như y học, cơ học lỏng chất khí, v.v…

Từ khóa: Động lực học tính toán chất lưu (CFD); phòng thí nghiệm ảo; cơ học thủy khí.

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