COMPUTATIONAL METHOD USING F.E.M. FOR OPTIMIZED BOWL CONFIGURATION

ZICHIL, V., PINTILIE, GH., SAVIN, C., JUDELE, A.

Abstract: Development costs and turnaround times can be significantly reduced by using a combination of computational and experimental methods. That is why, simulation methods have become an indispensable tool in the Diesel engines development process. The hardest part in this process is the model conception. The authors had created the model using a specialized soft "SolidEdge", the analysis being developed using Finite Element Method due to the COSMOS/M soft. In addition to the F.E.M., simulation methods are increasing in significance. Numerical methods are also becoming increasingly important as a tool for the development of combustion system applications. These methods provide a better understanding of the processes occurring inside an engine, allowing to perform dedicated fine-tuning of the various processes and to investigate the impact this has on performance, efficiency and emissions.

Keywords: finite element method, particle tracking, steady-state flow field, air/fuel ratio

1. INTRODUCTION

To define combustion system parameters, suitable boundary conditions as well as performance and emission requirements have to be done. Cycle simulation is the chosen method to compute the parameters relating the intake and exhaust system, the configuration of the turbocharger and the exhaust back-pressure. The method models the entire intake and exhaust system as a one-dimensional pipe system and takes dynamic gas effects as well as the momentum and heat exchange at the walls into account [6]. For the turbocharged Diesel engine, compressor and turbine characteristic maps provided by the manufacturers [2] are incorporated into the simulation, as the figure 1 shows.

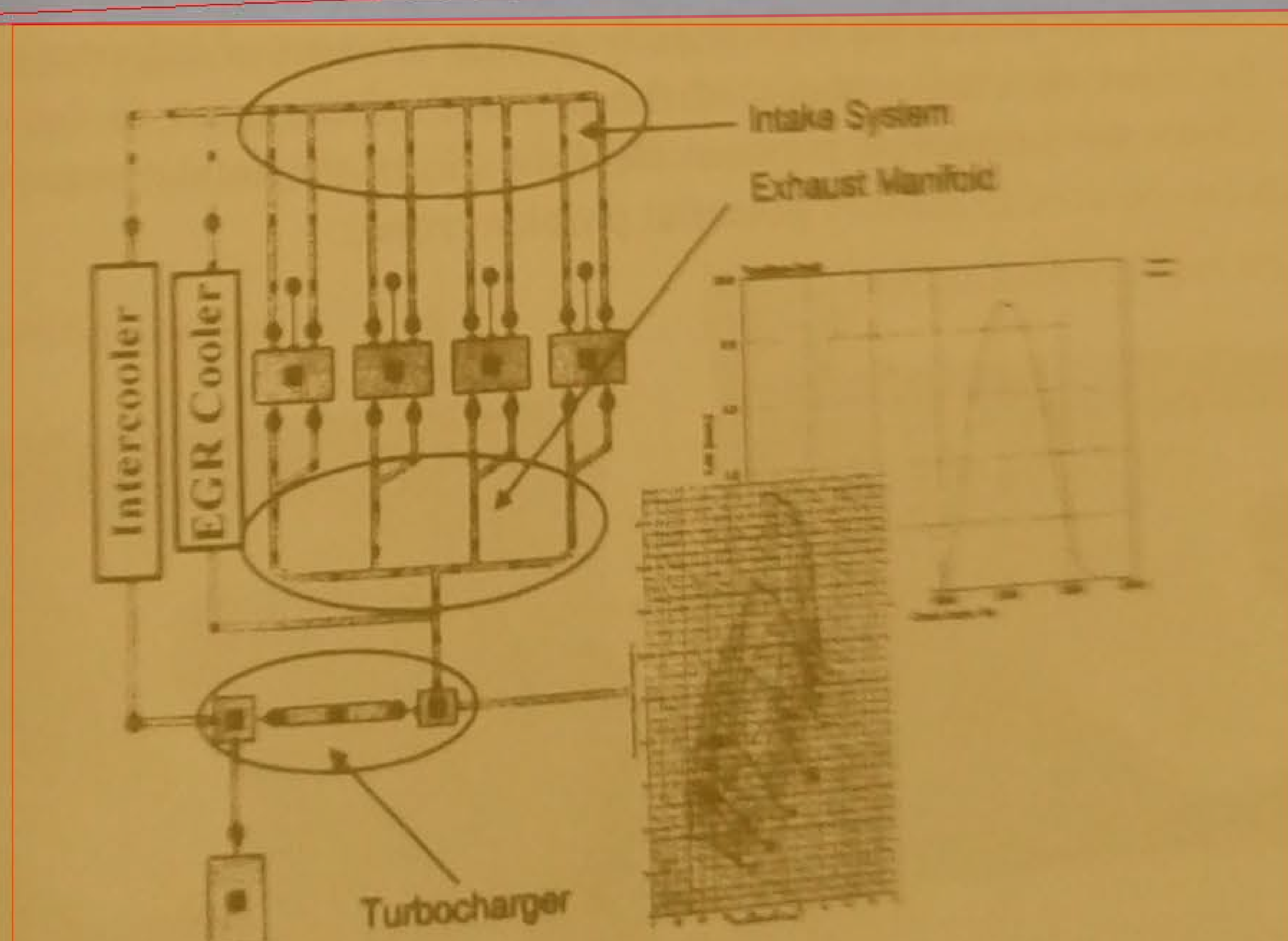

Figure 1.

2. OPTIMIZATION OF AIR/FUEL MOTION

The design of the intake ports determines the nature of the large scale air movements in the sy the level of combustion air swirl at the moment of fuel injection. Swirl motion is induced engines by appropriate shaping of the ports. In addition to this, the ports must be optimi regard to flow behavior. Traditionally, intake and exhaust ports are developed using flow M.E.F. methods can be used to simulate both the flow bench experiments in the form of sta computations and the transient processes occurring inside the engine. Figure 2.a, depicts typ patterns of two traditional concepts of the turbo charged direct injection Diesel engine and 2.b, the mesh used for thermal analysis in such a Diesel engine cylinder.

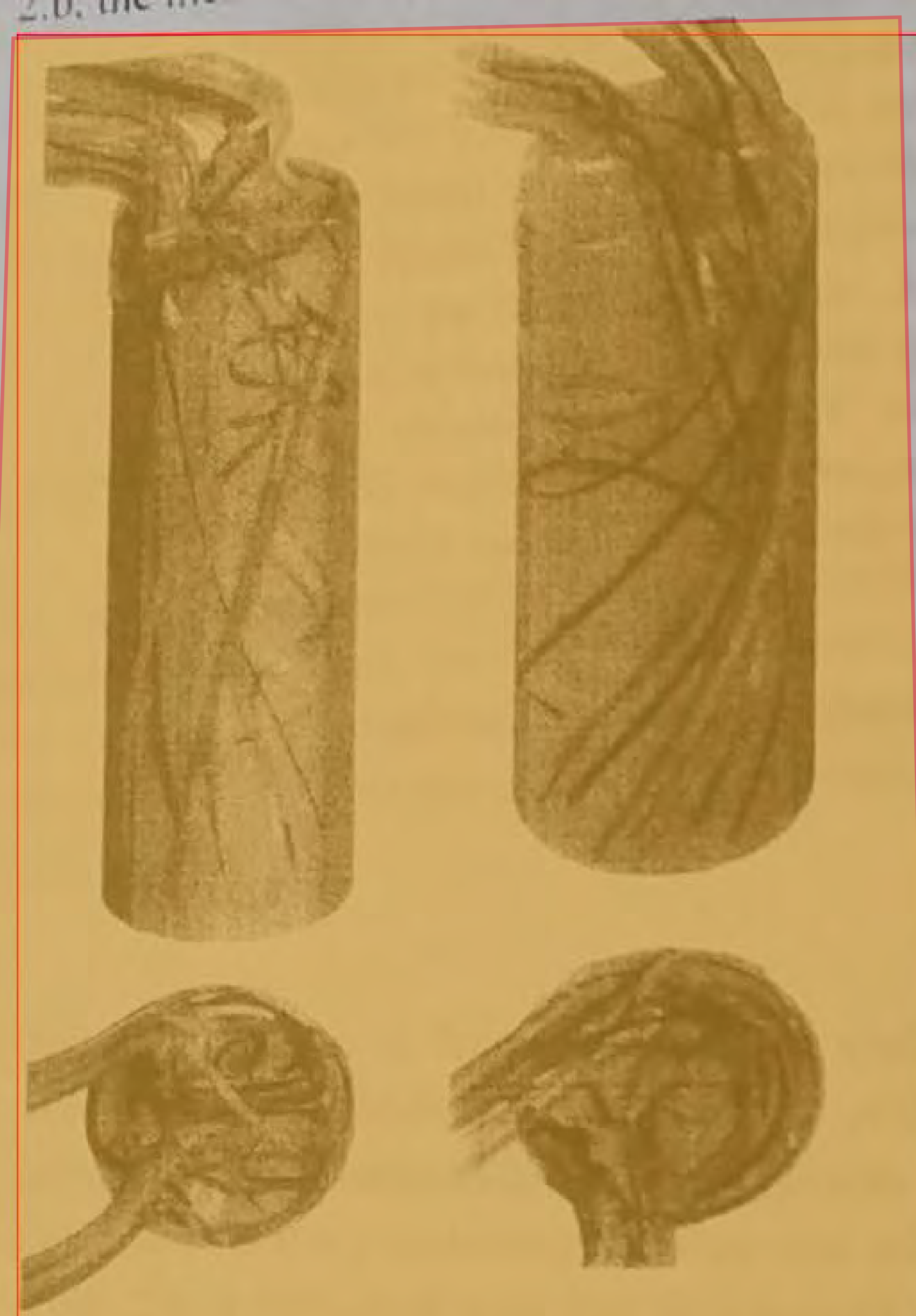

Figure 2,a

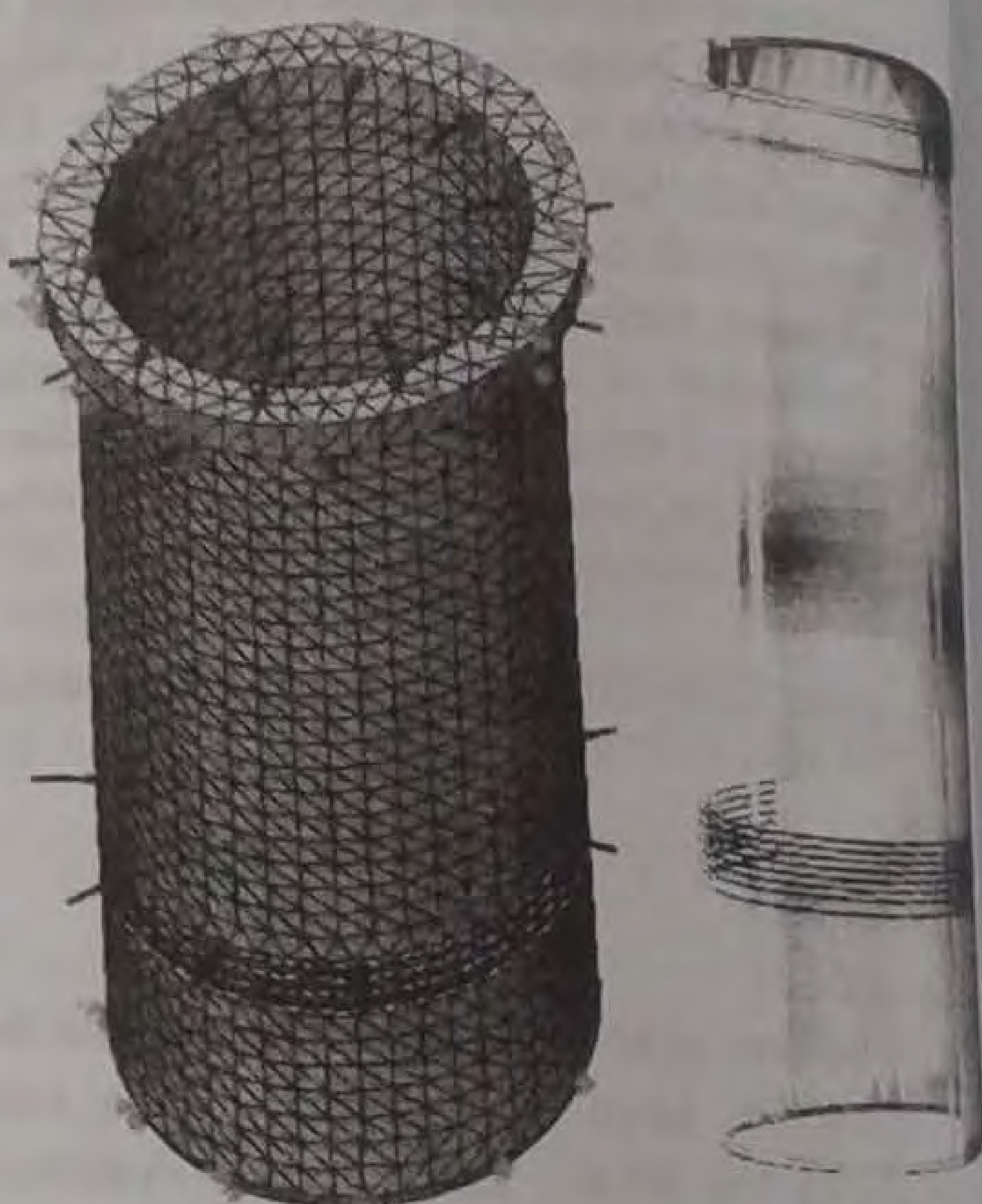

Figure 2,b

The advantage of simulations is that the significantly greater amount of information contained results permits a far more detailed analysis of the physical phenomena to be carried out. example, figure 3 shows the interaction between the flows from the intake manifold and provi visualization which can be used to identify potential problem zones.

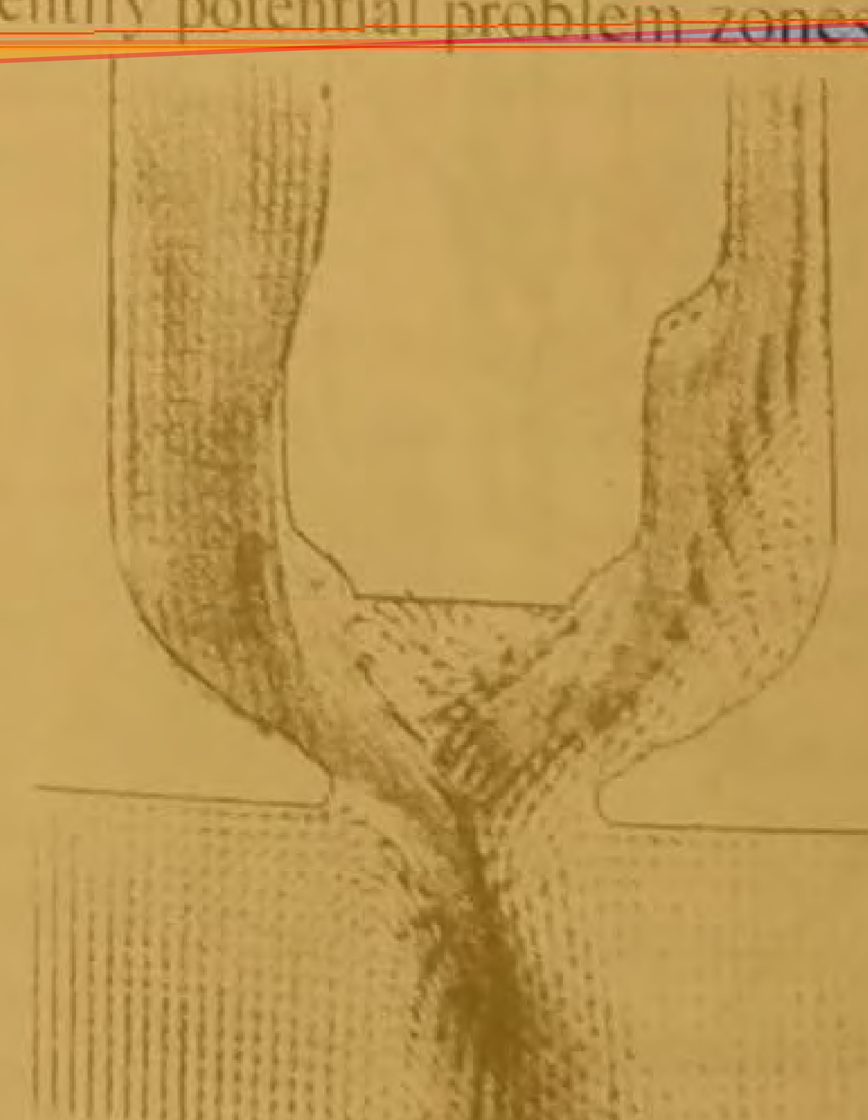

Figure 3

Additionally, unsteady-state flow simulation provides information about charge motion in the cylinder during the development process. This is the only method which can deliver sufficiently accurate information about the flow conditions at the start of the injection process [3].

DEVELOPMENT OF THE COMBUSTION SYSTEM

The performance and emission characteristics of the Diesel engine depend on the geometry of the combustion chamber and the definition of fuel-injection parameters as well as the previous described charge motion design. A numerical tool incorporated into the development process, as well as the [illegible] program, gives the opportunity for the optimization of the combustion and injection processes and diagnosis of test bench results are playing an increasingly important role. It is now possible to closely model the complex interactions between highly turbulent flow processes as well as the interactions between multi-phase flow and combustion processes (figure 4).

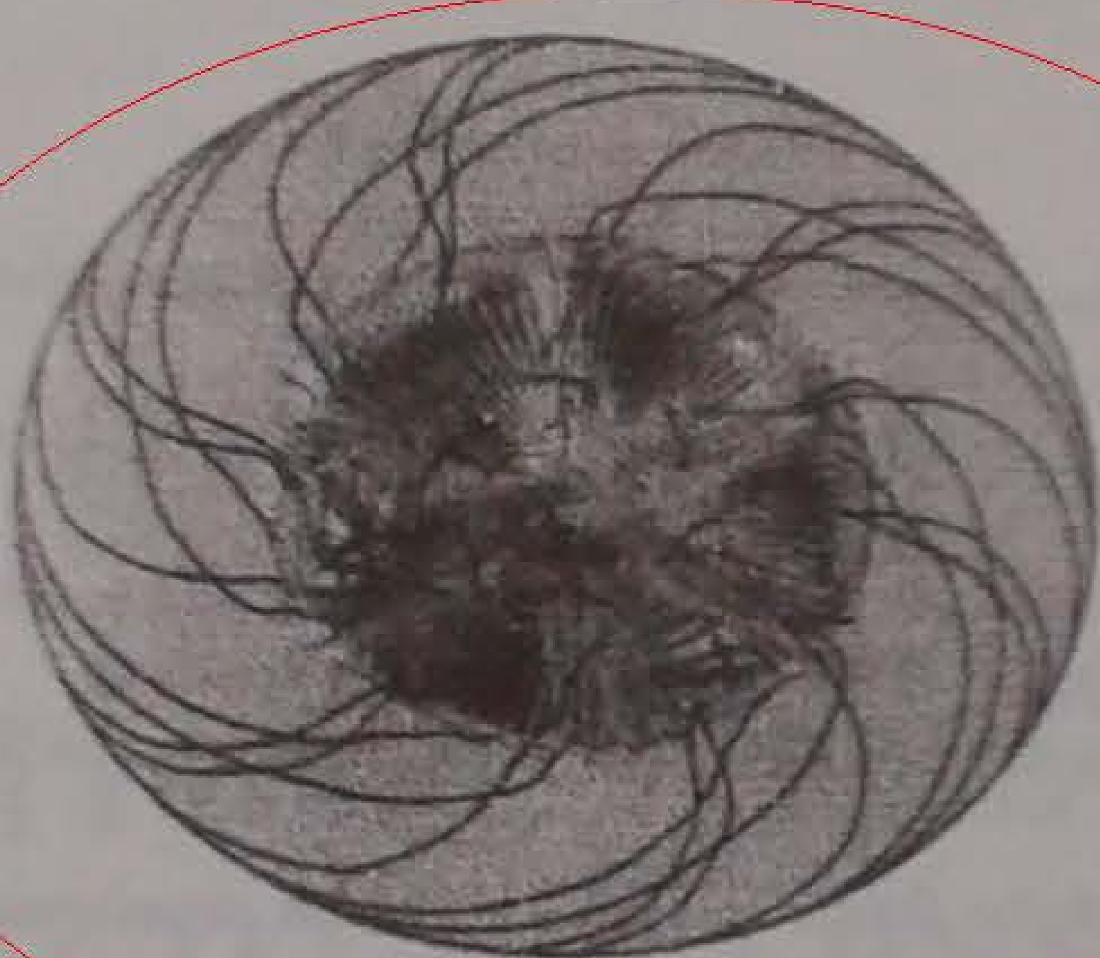

Figure 4.

The results of the simulation can be used to develop an understanding of the system and to describe the physical processes with the aid of qualitative and quantitative metrics which are not dependent on model parameters. Using a visualization to show the distribution of computed results is the easiest method for this. In figure 5, the distribution of stoichiometric air/fuel ratio for two different bowl configurations can be seen. The blue areas represent regions where the air/fuel mixture is lean whilst the red areas indicate regions where the mixture is rich. The stoichiometric air/fuel ratio occurs at the line separating the blue and red regions. An improvement in the distribution of fuel in the bowl can be seen for the case of the optimized bowl [7]. This indicates an improvement in air utilization.

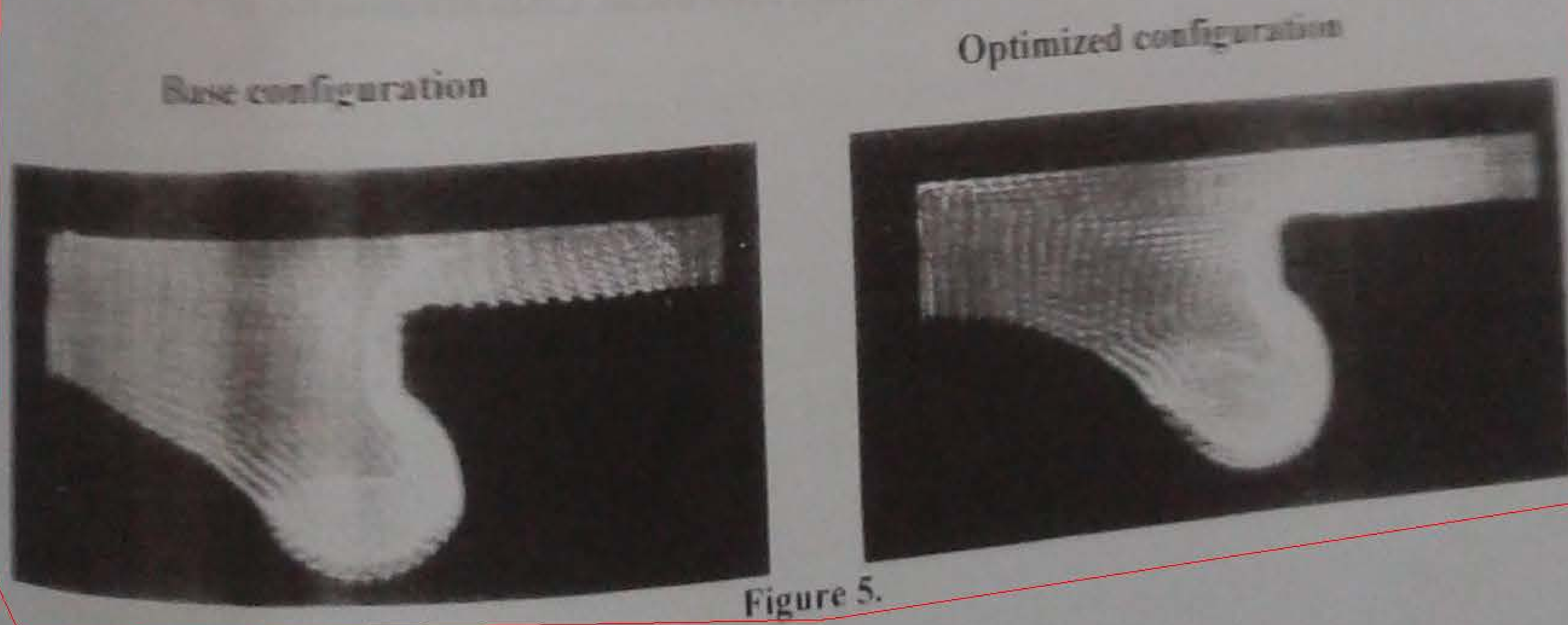

Figure 5.

4. CONCLUSIONS

The aggregate is a representation of the basic engine and includes all of the components relevan the combustion system, such as the piston bowl, cylinder head and fuel-injection system. Combus system parameters are defined under full-load boundary conditions [8], [9]. Optimized opera points are determined which adhere to predefined particulate, peak pressure and exhaust tempera boundary conditions. If the engine is charged externally, the results of the cycle simulation can directly used.

In the future, the use of modern optimization methods (neural networks, design-of-experiment genetic algorithms) will play an increasing role in the Diesel combustion system development proc [4], [5]. It will certainly not be possible to develop combustion systems without recourse experimental methods. However, quality requirements and short development times will not feasible without the inclusion of numerical simulation methods.

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***Valentin Zichil**, University of Bacau, Engineering Faculty, 5500-Bacau, Calea Marasesti No. 157;*
***Gheorghe Pintilie**, University of Bacau, Engineering Faculty, 5500-Bacau, Calea Marasesti No. 157;*
***Carmen Savin**, University of Bacau, Engineering Faculty, 5500-Bacau, Calea Marasesti No. 157;*
***Adrian Judele**, University of Bacau, Engineering Faculty, 5500-Bacau, Calea Marasesti No. 157;*