Study of the operation of a solenoid injector used in a Common Rail Diesel Injection System (CRS)

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Abstract: **The main means of transport and implicitly travel is the car, one of the most modern things that technology gives to humanity. Internal combustion is the transformation of the chemical energy of a fuel (gasoline, diesel) into mechanical energy (with some losses). With the main role of introducing fuel into the combustion chamber of the cylinders, the injection system performs this task regardless of the engine speed at a given time, dosing exactly the amount of fuel needed to operate at optimal parameters.The AMESim environment allows the numerical simulation of car injectors for the dynamic analysis of their operation.The answers obtained in the study of an injector for different pressure levels, allow the analysis of the operation of the injector and of the elements in its structure in different phases of its operation.**

*Key-Words:***AMESim program; solenoid injector; diesel injection system;**

I INTRODUCTION

The transformation of the chemical energy of a fuel takes place after burning the fuel in the engine cylinders.From the point of view of ignition of the fuel mixture we distinguish two types of engines.
¬ SIE (spark ignition engines).
¬ CIE (compression ignition engines).
Any internal combustion engine is equipped with an injection system that ensures the introduction of the air-fuel mixture into the combustion chamber of the cylinders.There are several types of such systems, classified both according to performance or principle of operation and the engine for which they were designed, petrol or diesel.In general, the injection system for the diesel engine consists of a high pressure pump, a common ramp and several injectors.The injection system is responsible for introducing fuel into the combustion chamber at a very high pressure, by spraying.The direct injection system, through which diesel fuel is injected directly into the cylinder, is currently used on almost all modern diesel engines.Its main feature is given by the high pressure at which the fuel is introduced (sprayed) inside the cylinders.This is possible due to the construction of the injection pump, which uses a piston to create the high pressure required for injection (up to 2500 bar).Piston injection pumps were first used in 1930, the so-called in-line injection pumps.It was not until 40 years later that rotary pumps appeared and since 1997 the vast majority of diesel engines have been equipped with common rail injection pumps.Any injection equipment intended for internal combustion engines must be so designed as to ensure:
- compression of the fuel at sufficiently high pressures, necessary for its fine spraying;
- dosing the amount of fuel per cycle;
- controlled triggering of the injection;
- introducing the fuel into the engine cylinders or into the intake manifold and spraying it;
Common Rail Systems (CRS) are also recognized for their contribution to the ongoing efforts to increase the dynamic performance of engines, while gradually reducing fuel consumption.Although

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composed of a number of elements and sensors, common ramp injection systems are controlled very precisely with the help of the injection computer and the electronic engine control unit.

II MODELLINGAND SIMULATION OF THE OPERATION OF A SOLENOID INJECTOR USED IN A DIESEL COMMON RAIL SYSTEMS (CRS) INJECTION SYSTEM

Due to the large number of fields in which simulation is applied, as a method of investigating the behavior of technical systems, numerous programs have appeared and developed, the most used in the simulation of engineering systems are Simulink, Catia and AMESim.Due to the multiple possibilities offered for the elaboration of submodules with the help of interdisciplinary libraries, AMESim[1] was adopted as a fundamental design tool by reputable manufacturers of automatic systems: AEROSPATIAL, BOSCH, DAIMLER-CRIYSLER, GENERAL MOTORS, etc.Given the complexity of the design of a high-pressure solenoid injector, a model must be created that includes all the geometric details. By this methodology, it is possible to understand the influence of the different component parts of the injector.Figure 1 represents the AMESim sketch associated with a typical injector structure.

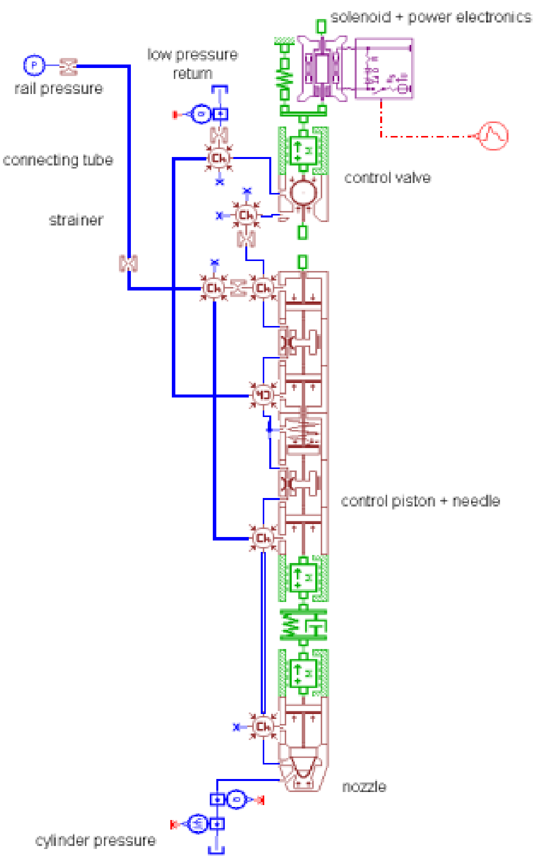

Fig.1.Injector model

In Fig.1.it can be seen that each component visible in the injector diagram has its equivalent in the AMESim model.In the AMESim environment some interesting details of the injector can be modelled such as:

-dynamics of the internal hydraulic network of the injector;

- solenoid valve of advanced injector actuator with power electronics;

-compressibility of the injector nozzle needle;

-specific model of injection nozzle with volume chamber. [2]

In order to have a complete understanding of the system, we can analyse the CRS supercomponents respectively at: common ramp, injector nozzle, linear magnetic transducer and low pressure pipe (return). We are observing the following variations of injection parameters for two pressures in the central rampfuel respectively 1000 bar (case 1) and 2000 bar (case 2). Following the simulation for the two cases, the following results are obtained:

1) injector nozzle:

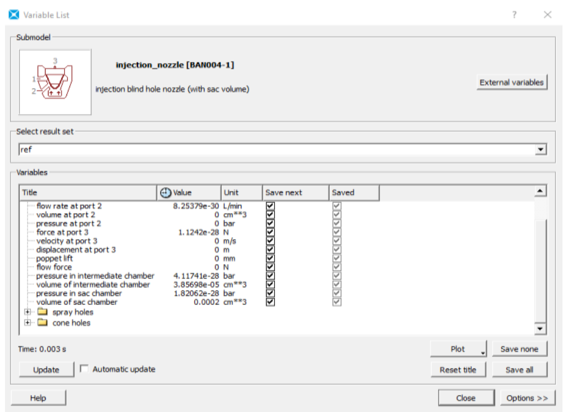

Fig.2.Injection parameters from the injector nozzle (case 1)

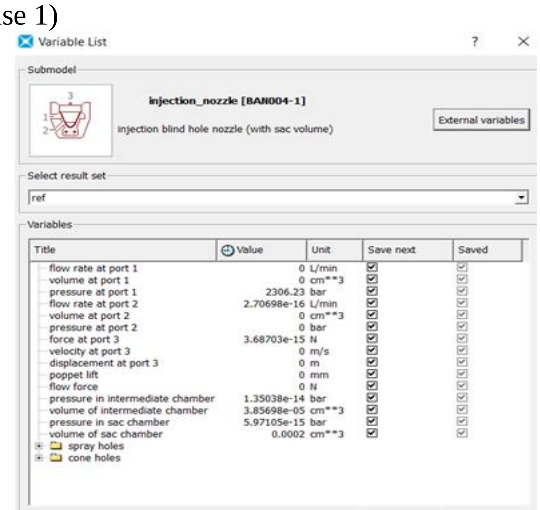

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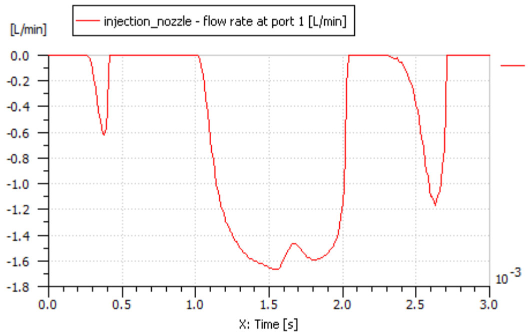
Fig.3.Injection parameters of the injector nozzle (case 2)

The variation of these parameters in the injector nozzle for the two cases is shown in the following graphs:



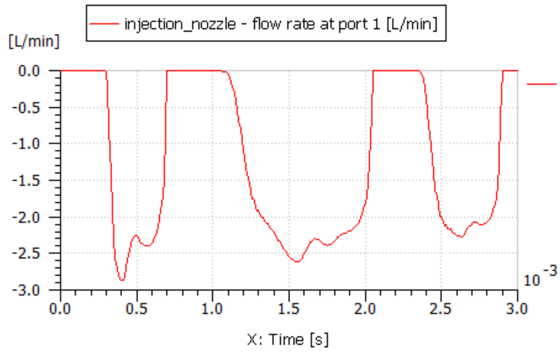


Fig.4. The evolution of the injected flow Fig.5. The evolution of the injected flow from port 1 of
the injector nozzle (case 2) from port 1 of the injector nozzle (case 1

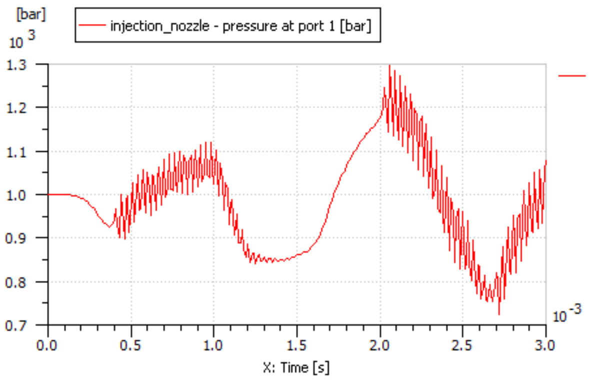


Fig.6. The evolution of the pressure in port 1 of the injector nozzle (case 1)

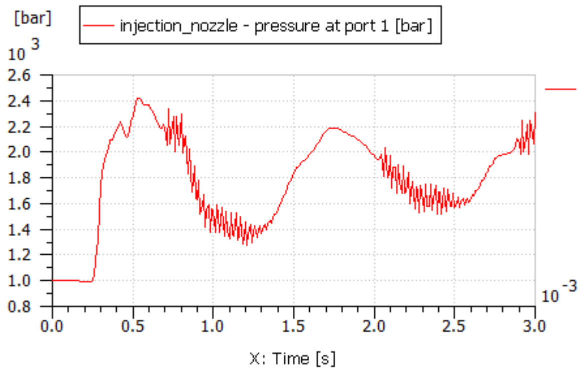


Fig.7. The evolution of the pressure in port 1 of the injector nozzle (case2)

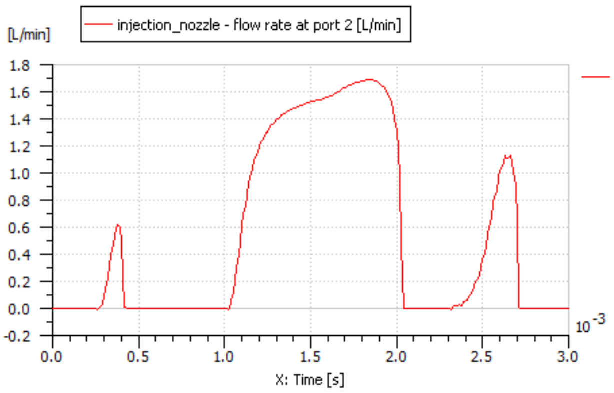


Fig.8. The evolution of the injected flow from port 2 of the injector nozzle (case 1)

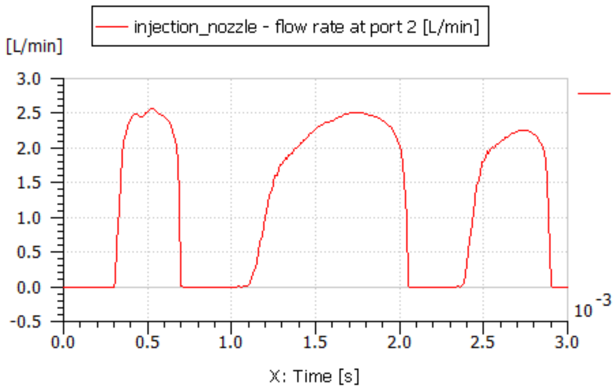


Fig.9. The evolution of the injected flow from port 2 of the injector nozzle (case 2)

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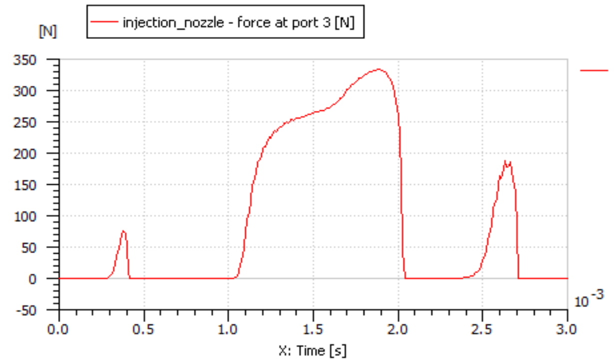


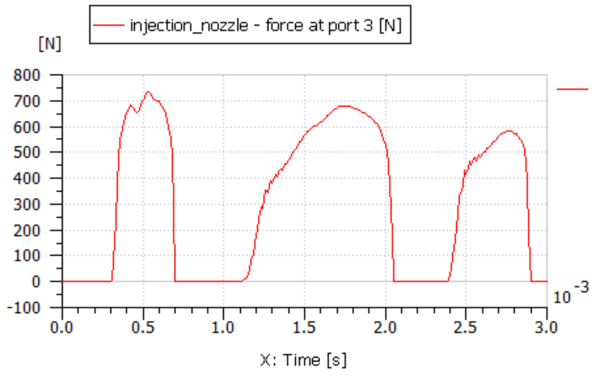
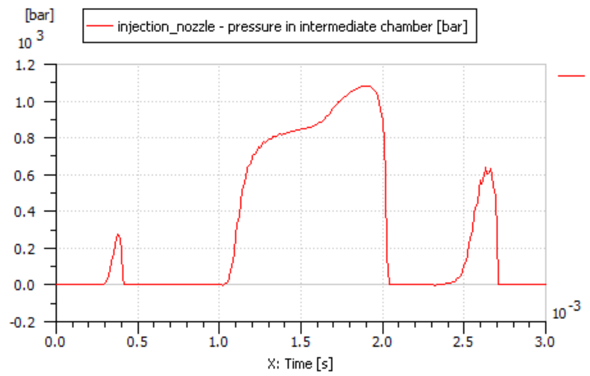


Fig.10. The evolution of the force in port 3Fig.11. The evolution of the force in port 3 of the of the injector nozzle (case 1)injector nozzle (case 2)



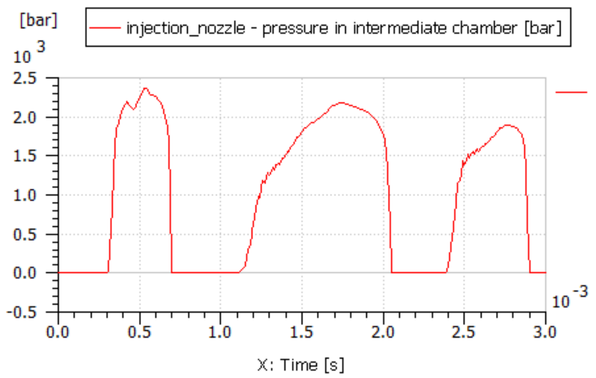
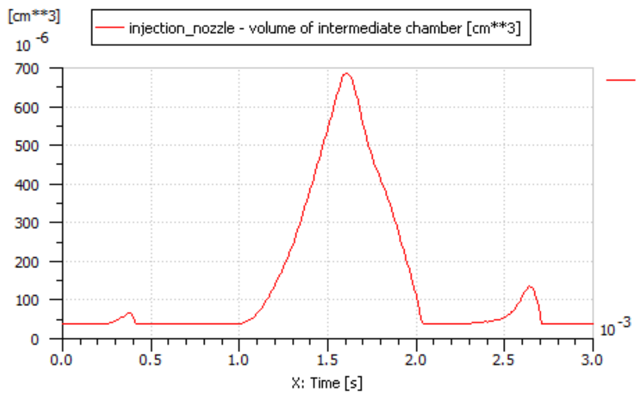


Fig.12. The evolution of fuel pressure in the intermediate chamber of the injector nozzle (case 1)

Fig.13. The evolution of fuel pressure in the intermediate chamber of the injector nozzle (case 2)



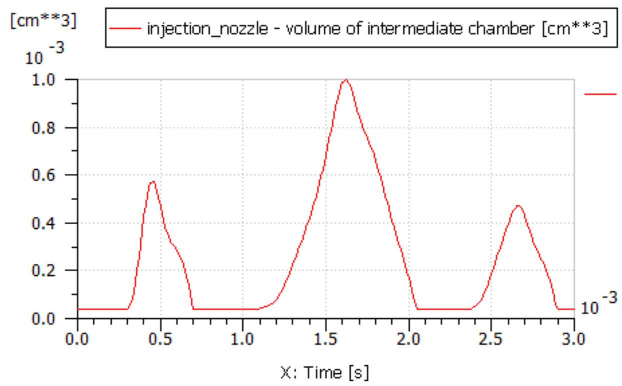


Fig.14. The evolution of the volume in the intermediate chamber of the injector nozzle (case 1)

Fig.15. The evolution of the volume in the intermediate chamber of the injector nozzle (case 2)

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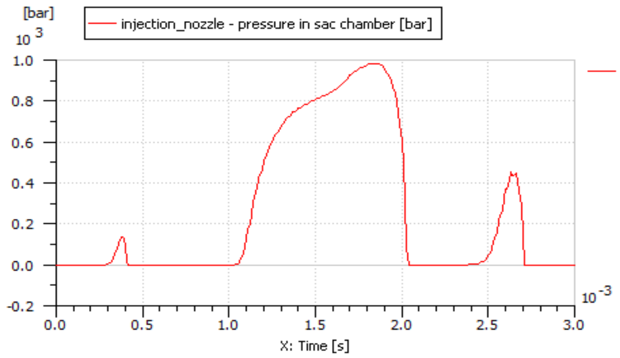

Fig.16.The evolution of fuel pressure in the volume chamber of the injector nozzle (case 1)

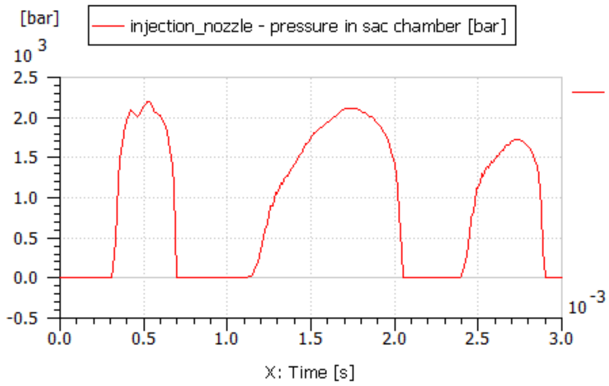

Fig.17. The evolution of fuel pressure in the volume chamber of the injector nozzle (case 2)

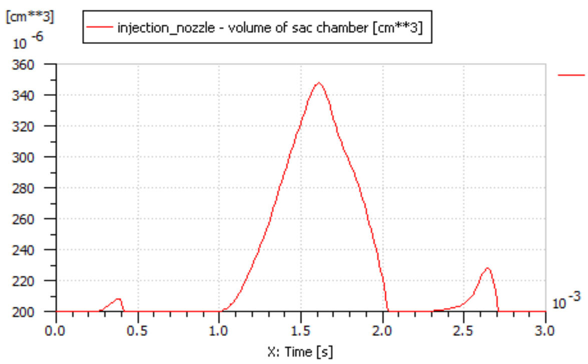

Fig.18.The evolution of fuel pressure in the volume chamber of the injector nozzle (case 1)

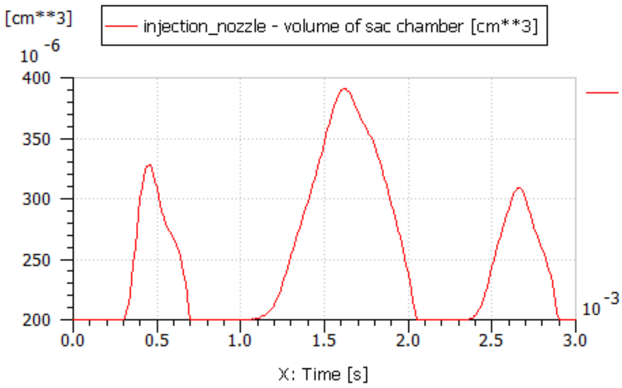

Fig.19.The evolution of fuel pressure in the volume chamber of the injector nozzle (case 1)

III Conclusion

Following the analysis of the graphs presented above, the following conclusions can be drawn:

- The time between the pilot injection and the main injection is a very important parameter. The pilot injection will trigger a significant wave effect on the injector which will influence the amount injected at the wetting moment respectively the main injection.
- The duration of pre-injection and post-injection increases with increasing pressure in the common ramp of the injection system.
- There is a delay between the solenoid input signal and the actual raising of the needle. This is due to the complex dynamics of the solenoid masses and the hydraulic network.
- From the analysis of the pressure variation graphs in the ports of the injector nozzles it is observed that with the increase of the pressure in the central ramp the pressure fluctuations are low determining the reduction of the drip phenomenon.
- As the pressure increases, the flow of fuel injected into the combustion chamber also increases.
- The pressure in the volume chamber of the injector nozzle increases with increasing pressure in the common rail of the injection

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system, which will require a higher stress on the injection nozzle.

- Increasing the pressure reduces the downtime, increases the steady value towards which the injected flow tends and increases the injection time.

The simulation allows the experimentation of real or hypothetical situations, impossible or difficult to achieve in the real operation of a system. Increasing the pressure reduces downtime, increases the steady state to which the injected flow tends and increases injection time.

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