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A Comparison of Lumped Parameter and Computational Fluid Dynamics-Based Approaches for a Helical Gear Pump

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Introduction

External Gear Pumps (EGPs) are positive displacement machines that are extensively utilised in hydraulic and fluid power systems for both industrial and mobility applications. They are chosen for their simplicity, low cost, small size and weight, great efficiency and ability to function in a wide variety of pressures and rotational speeds. One of the key disadvantages of this type of machine is the comparatively high levels of noise and vibration emissions. Until recently, this type of issue was neglected because the prime mover utilised to power these hydraulic devices was the Internal Combustion Engine (ICE), which produces more noise and vibrations [1].

Description

The goal of this work is to fill a gap in the scientific literature by comparing a numerical model with a new feature of helical gears with a lumped parameter model implemented in a multi-environmental tool completely developed by the named Ege MA, in order to identify the strengths and weaknesses of each when used for helical EGPs. These two ways are extremely detailed, demonstrating and discussing all of the modifications and configurations required for accurate simulations. The simulation results were then compared to experimental data obtained from the reference pump on a specialised test rig. The comparison was carried out by examining both steady-state and dynamic variables, the average flow rate and dynamic pressure under various operating conditions [2].

A flexible coupling connects a servomotor to the tested pump. The proportional pressure relief valve V1 generates the needed pressure load for the pump, while the proportional pressure relief valve V2 is installed in parallel for safety reasons. The pressure signal is obtained using two strain gauge sensors, one on the inlet side and one on the delivery side. Before the flowmeter, a high-pressure filter is fitted to prevent pollutants from entering the reservoir and to protect it from debris. Finally, the thermal conditioning system includes a water-cooled heat exchanger that recovers oil from the reservoir directly. It is installed after the loading valve and enables for temperature regulation of the oil.

The temperature was maintained during tests with an oil grade HL. The pump has been tested, with the supply pressure ranging from lowest to maximum continuous at various speeds. The experimental campaign included the examination of numerous working circumstances as well as the measuring of noise and vibration levels. Because the numerical models were primarily concerned with fluid dynamics, only a subset of the gathered parameters corresponding to the operating circumstances evaluated were employed to validate the numerical models. The most sophisticated method for assessing the flow field in positive displacement pumps is 3D computational fluid dynamics numerical modelling. The Navier-Stokes equations are solved in a three-dimensional domain discretized with a variable geometry mesh in this methodology [3].

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The pressure force effect on the gears has been modelled by translating them along the vertical axis towards the intake side, limiting the clearance between the tooth tip of the gears and the housing. This creates an issue for the 3D CFD numerical model, which does not allow for the inclusion of null clearances. As a result, selecting the value of these gaps is critical in replicating real-world working situations. To simulate contact with the driving gear, the driven gear has also been turned.Turbulence and cavitation evaluations are included in the numerical model. The turbulence was predicted with a typical k-turbulence model and the Renormalization Group Theory (RNG) statistical approach. This statistical technique allows for an improvement in the model's response to quick strains, boosting the accuracy of the results while using only a little amount of more computer resources. Numerous publications in the literature demonstrate the validity of this adopted methodology. The model incorporates the conventional k- turbulence model and more information can be found in prior papers published by the study group [4,5].

Conclusion

This section compares the experimental test campaign data, the 3D CFD and the numerical models with lumped parameters. The analysis is divided into two parts: The first section concentrated on flow-rate mean values, with available experimental data utilised to assess the accuracy of the created models on a steady-state basis. The second section focused on a comparison of the two numerical models and experimental data about pressure ripples on the delivery outlet, focusing on a more dynamic component. If not otherwise mentioned, the following findings are based on a rotating speed of 1500 rev/min and a delivery pressure of 200 bar, which is the reference pump's typical operational value. The 3D CFD method provides high accuracy for the rotational speed of 1500 rev/min. However the other two analysed speeds provide less accuracy. This is most likely due to the constraint imposed by the simulations simulating the real pump settings for the rotating speed of 1500 rev/min compared to the others.

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Conflict of Interest

There are no conflicts of interest by author.

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