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Modelling approach on a Gerotor pump working in cavitation conditions

Dario Buono^{a, *}, Fulvio Domenico Schiano di Cola^a, Adolfo Senatore^a, Emma Frosina^a,
Giorgio Buccilli^b, Jonathan Harrison^b

^aDepartment of Industrial Engineering, University of Naples Federico II, Via Claudio 21, Naples 80125, Italy

^bGamma Technologies, 601 Oakmont Lane, Suite 220 Westmont, IL, 60559, USA

Abstract

Gerotor pumps are widely used on engine hydraulic circuits. The design of these pumps is mainly focused on the study of the leakages through the rotors. Modelling or experimental techniques can be adopted during the components design and optimization phases.

The study presented in this paper shows results of a research study made on a gerotor pump. The study has been approached with modeling and experimental techniques.

The pump has been tested on a hydraulic bench of the University of Naples “Federico II”. Tests have allowed the complete characterization of the pump including in worst conditions like cavitation. In fact, calibrated orifices have been installed on the suction and delivery side of the pump forcing the cavitation. This research is focused on the detection of the cavitation that, as well known, is induced by the low pressure at pump suction, by the presence of air in the pumped oil, by the sloshing of the oil inside the sump and by the recent reduction of sump capability (to reduce maintenance costs).

The experimentation phase has been followed by modeling; an accurate model of the pump has been built using the commercial 1D software GT-SUITE. The code developers have added new applications to replicate, with the best accuracy, the experimental data especially in cavitating conditions.

The model results have been compared with the experimental data showing a good agreement.

The model is able to correctly predict the pump performance including delivery flow rate, total power loss, volumetric efficiency and temperature influence.

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* Corresponding author. Tel. +39-081-768-32-76, Fax. +39-081-239-41-65,
E-mail address: darbuono@unina.it

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1. Introduction

As well known, the demands of an increasing environmental control for the reduction of atmospheric gaseous emissions has led the automotive world to an ever tighter control of engine exhaust emissions. On one hand, great attention has been paid to obtain a greater efficiency in the "Top Part" of the engine (intake system, combustion, exhaust system, yet on the other hand recently greater attention is being paid to its "Bottom Part". In other words the reduction of losses from auxiliaries can assume an important role. In this sense, referring to the engine lubrication circuit, increased attention must be paid to the optimization of all the oil consumers such as bearings and of the oil pump. As a consequence, in the last years many studies on the pumps of the lubrication circuits have been addressed to the reduction of the absorbed power. Many of these are concerned with Gerotor pumps that are widely used for engine lubrication, although there are some examples of different solutions used, however, by much higher costs. Therefore, studies aimed to optimize the performance or to reduce problems of Gerotor pumps are really important.

There are many research studies focused on the improvement of performance of the Gerotor pumps. Studies have been done with modeling and experimental techniques. Modeling techniques can adopt, depending on the objective and the modeled object, 3D or 1D solutions. Several authors have written about modeling of Gerotor pumps with 1D modeling techniques. For example, Neyrat et al [1], Fabiani et al [2], Senatore et al [3-5] have modeled the Gerotor pump with 1D method. Frosina et al [6] developed a Gerotor pump model with the same methodology well correlating the experimental pressure ripples. Also in this paper a Gerotor pump has been studied adopting an experimental-1D modeling techniques. The aim of the research is the study with a modeling approach of conditions in possible malfunctions caused by cavitation. In particular, low inlet pressure conditions coupled with the presence of air in the aspirate oil (typically around 7%) and with the sloshing of the oil in the sump due to dynamic of the vehicle are causes of Cavitation. Therefore, recently the manufacturers are reducing the sump capability to reduce maintenance costs. However, in addition to the above causes of cavitation, also the risk of a very small swing on the strainer of the pump must be added. During sudden accelerations of the engine or in high speed operating conditions some other cavitation causes can occur for, as an example, the presence of oil foam in the sump. As a consequence, cavitation is a phenomenon that can occur much more frequently than known or what can be supposed. There are not many studies available in literature, L. Ippoliti et al [7] and Yuan, YQ et al. [8]. This paper, therefore, is focused on the analysis of the cavitation on the Gerotor pumps. The investigated pump has 9 teeth on the inner rotor and 10 teeth on the outer. The study has been approached with both experimental and modeling techniques. A first experimental campaign has been done to validate the 1D simulation model built up with the commercial code GT-SUITE [9], developed by Gamma Technologies. The research is a result of a close collaboration between the Hydraulic Power Research Group of the University of Naples "Federico II" and the engineers of Gamma Technologies.

The pump has been tested on a hydraulic bench of the University of Naples, where it has been forced to cavitate by placing calibrated orifices on the suction and delivery side of the pump. Tests have given important information on the pump performance. Then, data have been used to validate the accurate 1D numerical model. The model has demonstrated a good agreement with the experimental data, it is able to replicate the real pump in cavitation conditions.

2. Test equipment and measuring method

The pump has been tested in the hydraulic Lab of Industrial Engineering Department of University of Naples "Federico II". The test bench layout is shown in Figure 1. The bench is able to drive the pump in the real operation condition reaching a shaft rotational speed of 8000RPM. The pump is powered by a hydraulic axial piston motor of 12 cm³/rev. The motor is connected to a power unit that consists of an oil tank with a nominal capacity of 100 L, an axial piston pump with theoretical displacement of 71 cm³/rev, a three phase electric motor with 4 poles, capable of

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