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THE PNEUMATIC DUAL-MASS FLYWHEEL

Summary. Reduction of exhaust gas emissions, increasing of combustion process efficiency and lowering of fuel consumption are the most significant characteristic features in the development process of diesel combustion engines. All these mentioned trends are integrated with an increasing of power output and torque but also with a higher level of vibrations and noisiness. In order to reduce the vibrations of diesel engines it is necessary to apply a dual-mass flywheel as an unavoidable part of the piston combustion engine. The dual-mass flywheel replaces the classic flywheel in such way that it is divided in two masses (the primary mass and the secondary mass), which are jointed together by means of a flexible interconnection. This kind of the flywheel solution enables to change resonance areas of the engine with regard to the engine dynamic behaviour what leads to a reduction of vibrations consequently. However, there is also a disadvantage of the dual-mass flywheels. The disadvantage is its short-time durability. There was projected a new type of the dual-mass flywheel in the framework of our workplace in order to eliminate disadvantages of the present dual-mass flywheels, i.e. we projected the pneumatic dual-mass flywheel, taking into consideration our experiences obtained during investigation of vibrations.

Keywords. Combustion engine, vibrations, dual-mass flywheel.

DWUMASOWE PNEUMATYCZNE KOŁO ZAMACHOWE

Streszczenie. W rozwoju diselowskich silników spalinowych obecnie kładzie się wielki nacisk na obniżnie emisji gazów wydechowych, zwiększanie efektywności spalania oraz obniżanie zużycia paliwa. Wszystkie te trendy niosą ze sobą również zwiększenie mocy, momentu obrotowego, ale także wzrost wibracji oraz hałasu. W celu obniżenia wibracji silników Diesla musi być stosowane, jako nieodzowna część silników spalinowych, dwumasowe koło zamachowe. Dwumasowe koło zamachowe zastępuje klasyczne koło zamachowe w ten sposób, że jest podzielone na dwie masy (pierwotną i wtórną), które są ze sobą połączone w elastyczny sposób. Z punktu widzenia dynamiki taka konstrukcja koła zamachowego zapewnia zmianę rezonujących stref silnika, czego efektem będzie obniżenie wibracji. Dużą wadą dwumasowych kół zamachowych jest ich krótka trwałość. Na podstawie uzyskanych w naszej pracowni danych dotyczących wibracji, w celu wyeliminowania wad obecnych kół dwumasowych, zaprojektowaliśmy nowy typ dwumasowego koła zamachowego, którym jest pneumatyczne dwumasowe koło zamachowe.

Słowa kluczowe. Silnik spalinowy, wibracje, dwumasowe koło zamachowe.

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1. INTRODUCTION

Reduction of the gaseous emissions together with an effort to reach the highest engine power outputs and torques are typical in the design area of the piston combustion engines presently. This trend presupposes also application of the mechatronic systems in order to manage the combustion process with the aim to minimise the exhaust gas emissions and to increase efficiency of the fuel mixture combustion. Regulation of the combustion process in the individual cylinders is bringing also negative consequences in the form of occurrence and extension of vibrations in the combustion engine. In the case of a controlled combustion process there is typical an occurrence of amplitudes of the secondary harmonic vibration components [1]. The torsional vibrations arising in the combustion engine are transmitted into the whole driving system. Afterwards these vibrations have negative loading impacts on the tooth-wheels in gearboxes, on the connected shafts and on other components of the driving mechanism as well. A very negative consequence is transmission of the vibrations and noisiness into the surrounding.

The company LuK presented in the year 1985 a new solution of the dual-mass flywheel, Fig. 1. The main purpose of the dual-mass flywheel is a reduction of torsional vibration amplitudes. Such reduction can be reached using separation of the flywheel on two individual masses that are jointed each other by means of a flexible connection. Application of the dual-mass flywheels in the diesel engines has also disadvantages with regard to the durability of them. The durability of the flywheel depends on the loading regime predominately. The flexible connection between the both masses is realized with a metal spring, which is stressed due to repeated dynamic impacts during starting-up of coupling, which is connected with one of both masses. The starting phase is characterised by a low speed and high loading. Such kind of fatigue of the connecting spring causes a higher noisiness and higher level of vibrations.

Fig. 1. Dual-mass flywheel LuK
Rys. 1. Dwumasowe koło zamachowe LuK

The dual-mass flywheels are designed nowadays in such way that they are able to transmit the torque up to 300 Nm with the angle of twist 40° at least. Concerning spatial dimensions it is important to say that the new flywheel has to be similar to the classic flywheel and must be able to be mounted to the coupling lamella.

2. THE PNEUMATIC DUAL-MASS FLYWHEEL

Our research team obtained a great amount of experiences in the development area of machineries and systems projected at our workplaces for reduction of torsional vibrations. Therefore we developed also a new pneumatic dual-mass flywheel, Fig. 2, which consists of the primary mass (1) and the secondary mass (2). The secondary mass is pressured with the pneumatic flexible chambers that are shaped like half-moons and are filled with the air (3). The primary mass is joined to the carrier (4), which is equipped with the compression pistons (5). The pistons are linked with the pneumatic flexible chambers. The chambers are compressed towards the pistons when they are loaded [21,25]. The pneumatic dual-mass flywheel is attached to the pneumatic accumulator situated out of the combustion engine. The main task of the pneumatic accumulator is keeping of a constant air pressure in the pneumatic flexible chambers.

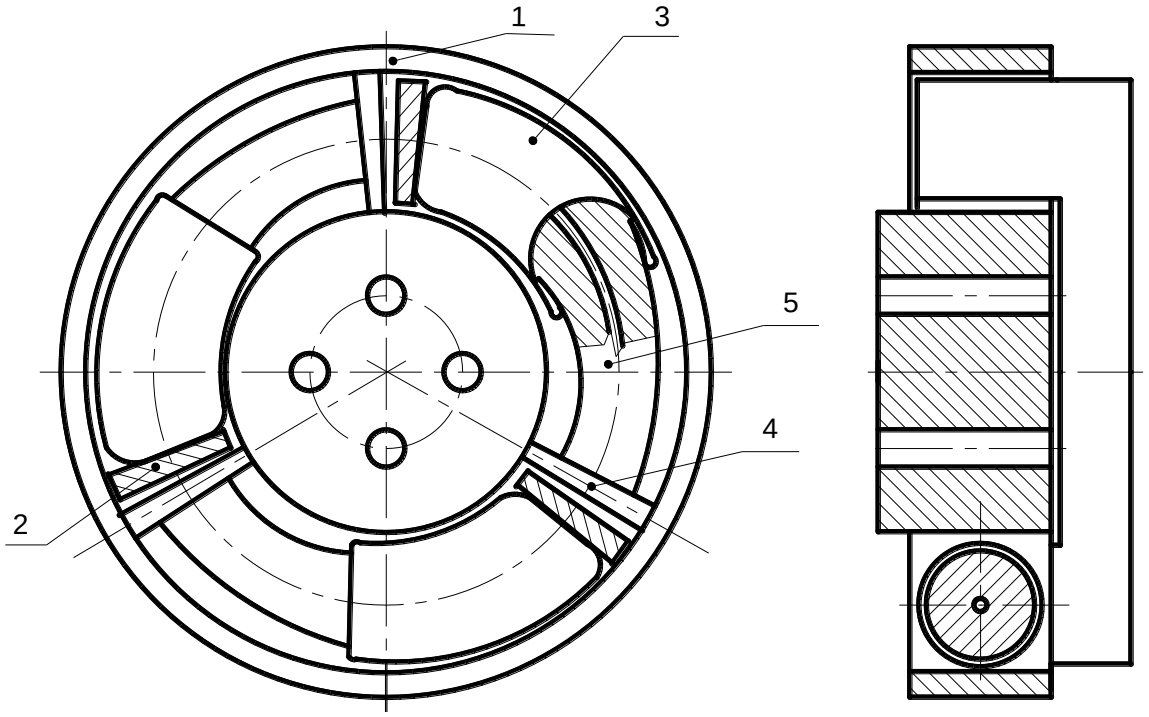

Fig. 2. Pneumatic dual-mass flywheel
Rys. 2. Pneumatyczne dwumasowe koło zamachowe

There were defined the basic loading characteristics according to the performed theoretical analysis, Fig. 3 and it was specified the static torsional stiffness of the designed pneumatic dual-mass flywheel, Fig. 4. The air pressure in the pneumatic dual-mass flywheel can be changed from the 100 kPa up to 800 kPa. The behaviours signed with the letters from *a* to *h* in the Fig. 3 are the loading characteristics and in the Fig. 4 are presented the courses of static torsional stiffness of the pneumatic dual-mass flywheel operating at the pressure levels from the 100 kPa up to 800 kPa.

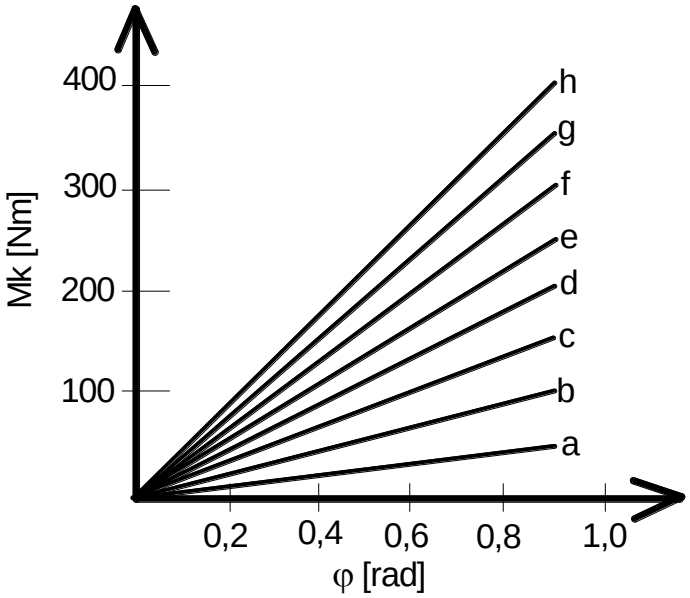

Fig. 3. Loading characteristics of the pneumatic dual-mass flywheel
Rys. 3. Charakterystyki obciążeniowe pneumatycznego dwumasowego koła zamachowego

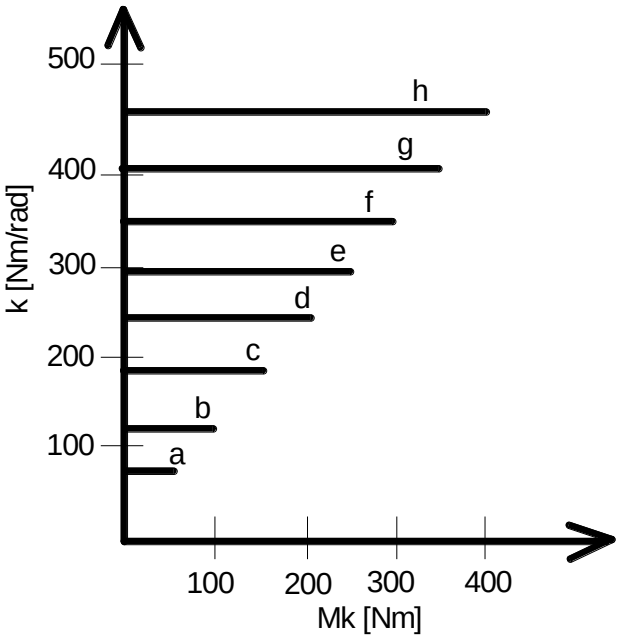

Fig. 4. Characteristics of torsional stiffness of the pneumatic dual-mass flywheel
Rys. 4. Przebiegi statycznej sztywności skrętnej pneumatycznego dwumasowego koła zamachowego

3. SUMMARY

The pneumatic dual-mass flywheel was projected on the basis of experiences gained at our department in the area of the torsional oscillation tuners. This new construction of the pneumatic dual-mass flywheel is able to fulfil the required parameters, namely the angle of twist 40° minimally and the transmitted torque 300 Nm. The given new pneumatic dual-mass flywheel reaches the angle of twist 50° with the maximum torque 400 Nm at the pressure level 800 kPa. A very important advantage of this pneumatic flywheel is a fact that its flexible

elements are not subjected to the fatigue process because they are developed in the form of the flexible chambers filled with the air. The constant air pressure is maintained by means of the pneumatic accumulator. The pneumatic dual-mass flywheel is a suitable technical solution for reduction of the combustion engine vibrations.

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