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A COMPARATIVE STUDY REGARDING THE USE OF INTERNAL COMBUSTION ENGINES WITH DIFFERENT POWERS

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Abstract. *In this paper, we present the results of a comparative study of the internal combustion engines used to the operation of machines from agriculture, transport and industry.*
Internal combustion engines convert the kinetic energy of the combustion gases into mechanical energy, by the action of their own pistons that have an alternative translation motion. Through the connecting rods the translation motion becomes a rotation motion of the crankshaft. At the four-stroke cycle, the succession of the processes is carried out at four piston strokes, i.e. at two rotations of the crankshaft.
The periodic resumption of the motor cycle requires the emptying of the cylinders of the combustion gases, followed by the filling of the cylinders with another air-fuel mixture.
The caloric energy, produced by the combustion of the fuel, is converted into mechanical energy by 25-40%, which represents the yield of the internal combustion engine. The power transmitted by the internal combustion engine, through the crankshaft, is given by the product between the torque and the engine speed. The increase of the power can be achieved by two ways: by increasing the maximum speed or by increasing the torque. The speed increase is limited by the mechanical strength of the moving parts, so this solution is not sustainable. Increasing the torque can be done in two ways: by increasing the engine displacement or by turbocharging of the engine. Increasing the engine displacement results in increased engine mass, increased fuel consumption and pollutant emissions. The turbocharger causes the mass of the fuel mixture in the cylinder to increase, respectively increasing the engine power. In conclusion, to increase the power of an internal combustion engine, the mass of the engine and / or the speed of the crankshaft must be increased.
Taking into account of these, were analyzed the technical and functional characteristics for several types of internal combustion engines. The parameters analyzed in this study were: the engine power, the engine speed, the engine torque, the engine displacement, mass of the engine, fuel consumption, ratio of engine mass to engine power, ratio of engine speed to engine power.
The conclusions and recommendations resulting from this study refer to the optimal use of internal combustion engines in different fields of activity.

***Key words**: internal combustion engine, power, speed, torque, mass, fuel consumption*

INTRODUCTION

By machine, we generally define a technical system consisting of parts with determined movements that transform a form of energy into another form of energy or in a useful mechanical work. Machines that transform a certain form of energy into mechanical energy are called motors. Heat engines transform thermal energy, obtained by burning a fuel, into mechanical energy. If fuel combustion takes place inside the engine, then the heat engine is called an internal combustion engine (ABĂITĂNECEI D., 1978; BĂȚAGĂ N. ȘI COLAB., 1995; BERTHOLD G., 1980; CHIRIAC R., 2015; CHIRU A., ȚÂRULESCU S., 2018; ILEA R., 2003).

The mechanical yield of an internal combustion engine shall be expressed by the ratio of the mechanical energy output from the engine over the heat input into the engine. This report shall be subunit and expressed in percentages. The main disadvantage of the internal combustion engine is the low mechanical yield, the heat produced by combustion of fuel turning into mechanical energy in a percentage of 25-40 (BURNETE N., 2008; MARIAȘIU F., 2005).

Given that the mechanical energy over time represents the mechanical power, the increase in that yield of the engine power can be done by increasing the parameters of mechanical power characteristics. Depending on the form of movement, mechanical power is expressed by the product between the force and the tangential speed in the translation movement, namely the product between the moment of force (torque) and the angular speed in the rotation movement (ILEA R., 2009; SILAȘ GH., GROȘANU I., 1981;).

The engine mechanism transforms the translation movement of the piston into the rotating motion of the crankshaft. Therefore, the engine power can be increased by increasing the compression ratio and the speed (BREBENEL A., 1978; TECUȘAN N., IONESCU E., 1982; TOMA D., 1981). Increasing the compression ratio is achieved by increasing the engine displacement, i.e. by increasing the engine mass. The increase in speed is achieved by increasing the mass of the fuel mixture, i.e. supercharging the engine by increasing the mass of the cold air inserted into the cylinder. Depending on the destination the internal combustion, engines can have large mass and/or high speed (DUMA COPCEA ANIȘOARA, 2017; POP V., 2018).

Studies in this paper have been carried out on several internal combustion engines. The main parameters analysed in these engines were power, mass, engine torque, and speed. Based on the studies conducted, conclusions on the use of internal combustion engines of different powers were established (MIHUȚ CASIANA, 2018).

MATERIAL AND METHODS

Internal piston combustion engines turn the kinetic energy of burnt gases into mechanical energy, which they transmit through the crankshaft to the rest of the transmission.

In the movement of rotation, mechanical power is expressed by the formula:

$$P = \overline{M} \cdot \overline{\omega}$$

where: P - mechanical power measured in watts;
M - engine torque to be measured in Nm;
ω - angular speed measured in rad/second.

Therefore, to get mechanical power, it takes torque and speed.

The engine torque is obtained from the operating force of the burnt gases multiplied by the arm of the force. So, to have a larger couple, we need to increase the piston stroke and/or the cylinder bore, and the engine mass, respectively.

Angular velocity is directly proportional to the speed as in the relationship:

$$\omega = 2\,\pi\,\nu = \frac{2\,\pi\,n}{60}$$

where: n - speed measured in revolutions per minute.

In conclusion, to increase the power of an internal combustion engine, the engine mass and/or crankshaft speed should be enlarged.

Based on these considerations, we studied the technical and functional characteristics of the following internal combustion engines:

- Spark ignition engine Ford EcoBoost 1.0;
- Spark ignition engine Dacia 102-00;
- Compression ignition engine D-110;
- Caterpillar C 6.6 compression ignition engine;
- Caterpillar C 18 compression ignition engine;
- Wartsila Sulzer RTA 96 C compression ignition engine.

Studies focused on the analysis of parameters, operation and performance of these internal combustion engines. In these engines, we analysed the following parameters: power, speed, engine torque, engine displacement, cylinder bore, piston stroke, compression ratio, engine mass, fuel consumption, mass/power ratio, speed/power ratio.

RESULTS AND DISCUSSIONS

The comparative study monitors current upgrades in the construction of internal combustion engines, which are fundamentally distinguished from those previously manufactured. This is why agriculture tends to replace morally worn tractors with modern high-performance ones.

Analysed parameters are centred in Table 1. Based on the data in Table 1, the graphs in Figure 1 were drawn.

Table 1.

Parameters of internal combustion engines

Parametrul	Engine type					
	Ford Ecobost 1.0	Dacia 102-00	U-650 D-110	Caterpillar C 6.6	Caterpillar C 18	Sulzer RTA 96 C
Power [CP]	125	61	65	188	578	108908
Speed [rpm]	4000	3000	1800	2200	2100	90
Torque [Nm]	170	97	258	580	2160	7603000
Displacement [liter]	1,0	1,4	4,76	6,6	18,1	25480
Cylinder bore [mm]	72	73	108	105	145	960
Piston stroke [mm]	82	77	130	127	183	1640
Compression ratio	10	8,5	17	16,2	16,5	16,4
Engine mass [kg]	97	126	485	648	1000	2300000
Hourly consumption [kg/h]	6,8	9,4	11,4	34	106	11765
Specific consumption [g/CPh]	56	154	175	182	183	171
Mass/power ratio [kg/CP]	0,78	2,07	7,46	3,45	1,73	21,12
Speed/power ratio [rpm/CP]	32	49,02	27,69	11,70	3,63	0,00083

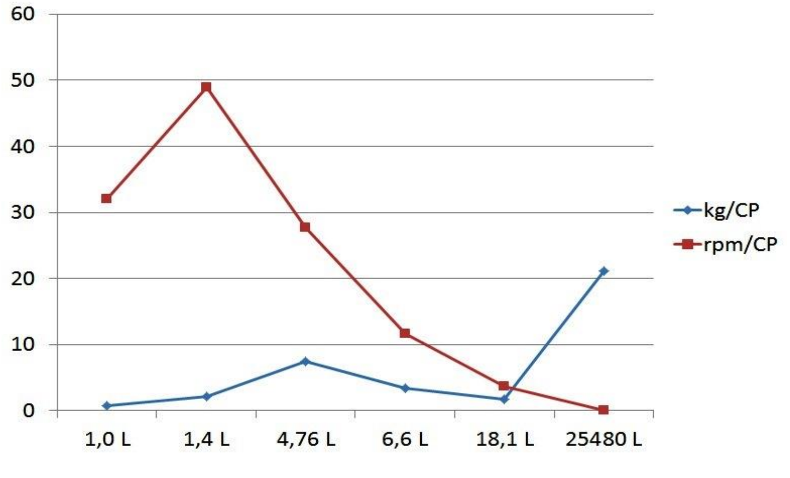

Figure 1. Mass/power ratio and speed/power ratio variation at the engines analysed

CONCLUSIONS

The following conclusions resulted from the study conducted:

From the point of view of how mechanical power is obtained, internal combustion engines may be classified into three categories:

- Motors that achieve the power predominantly by their mass;
- Motors that achieve the power predominantly by their speed;
- Mixed motors that achieve power from mass and speed.

Internal combustion engines that equip tractors, trucks and seagoing ships are high-mass motors that achieve mechanical energy due to the inertial properties of the mass. These engines usually have lower speed, high fuel consumption and high reliability. Diesel engines on tractors are "high motors" that carry out large cylinders due to the large stroke of the pistons (they have the engine block taller than the large bore motors) and, therefore, the crankshaft sleeves are larger leading to a large engine torque.

High-speed internal combustion engines are usually on cars and two-stroke engine aggregates. These engines have lower fuel consumption, small mass and lower reliability due to higher nominal speed.

Mixed engines are increasingly present in operation because they use the advantages of other engine types (mass and speed) in a useful way. These are actually tractor and overpowered trucks engines.

Using supercharged Diesel and electronic injection engines in tractors, they reduce fuel consumption, and pollutant emissions, and improve their yield.

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