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ANALYSIS AND DESIGN OF A TRANSMISSION FOR POWERTRAIN OF AIR POWERED VEHICLE [5]

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Abstract: *The paper reviews existing methods of special seismic protection and discloses the added value of their application The report presents an analysis to select transmission design for powering an air-powered vehicle. The advantages and disadvantages of possible options for the design of a transmission for the drive of a vehicle according to a pro-ject of the Faculty of Transport of the University of Ruse have been exam-ined. From the various structures analyzed, the optimal one for the designed vehicle was selected. The necessary calculations have been made to prove the efficiency of the selected transmission design.*

Keywords: *transmission, air motor, design.*
JEL Codes

INTRODUCTION

For a car, it is of great importance that the engine provides enough power to the drive wheels to provide the necessary power and speed of movement. This move-ment of energy from the engine to the drive wheels is accomplished through a properly designed and installed transmission. The report analyzes the application of existing design options for the transmission of a car powered by a compressed air engine. This analysis is part of a project by teachers from the Faculty of Transport at University of Ruse in the design and implementation of a compressed air vehicle drive. The goal of the project is to look for alternative ecological sources of energy for driving cars, compared to the existing ones: gasoline, diesel, natural gas, hydro-gen and electricity. The report analyzes the application, advantages and disad-vantages of existing transmission options. Conclusions have been made as to which option is the most suitable and expedient for the realization of the real prototype of the project.

TRANSMISSIONS IN VEHICLES - TYPES, CHARACTERISTICS, ADVANTAGES AND DISADVANTAGES

ANALYSIS OF THE APPLICATION OF TRANSMISSIONS IN VEHICLES

The change in torque in the transmission is related to the change in rotation frequency and depends on the gear ratio of the transmission. It is defined as the ratio of the rotation frequency of the engine (compressed air motor) and the rotation frequency of the drive wheels of the corresponding gear. The transmission can consist of mechanical gears (one, two or many gears), hydraulic or pneumatic. As the gear ratio of the transmission increases, the torque transmitted to the drive wheels increases and the speed of the machine decreases.

According to the principle of operation, transmissions are: mechanical, hydraulic and electric. Mechanical transmissions find the greatest application due to their advantages: stable transmission of power flow, guaranteed transmission of constant torque, relatively simple construction, available modern technologies for manufac-turing, assembly and disassembly. Recently, combined hydromechanical and elec-tromechanical transmissions have also been used [1], [2], [3], [4].

[5] Докладът е представен на 24 октомври 2025 г. в научната секция „Транспорт и машинознание“ с оригинално заглавие на български език Анализ И Проектиране На Трансмисия За Силово Устройство На Превозно Средство С Въздушен Поточен Транспорт

The aim of the project is to install a transmission meeting the following require-ments in the prototype of the designed car powered by compressed air:

- Simple construction;
- Easy to maintain and repair, assembly and disassembly;
- Stability during torque transmission;
- Low cost of components
- Possibility of multi-variant execution.

All the mentioned requirements are met only by the mechanical transmission consisting of only one transmission box. In order to design the transmission, the following input data are determined:

- Technical parameters of the selected motor from the manufacturer Gaston Chi-na: Power – 0,56kW, Torque – 7,6Nm, Rotation speed - 650rpm;
- Adopted tires for the drive wheels - 12" ÷ 14";
- Requested maximum vehicle speed – 20÷40km/h.
- Mass of the prototype – 130kg.

An existing mini car with an electric drive will be used as a base prototype, and this drive will be replaced with a compressed air drive. The prototype is a tricycle, with the front wheel being the driving one. The car is designed for two passengers and a load capacity of 300 kg. Possible application: internal factory transport, inter-nal transport in park, shop, mall. Movement will always be on hard and smooth surfaces (concrete etc.), for short distances.

In order for the vehicle to meet these requirements, it is necessary to calculate the speed of rotation of the driving wheels for the tires used and the desired speed of movement, and then the gear ratio range of the transmission. Taking into account the fact that the design is looking for a maximally simplified construction, it is assumed that the transmission has only a gearbox, which is a splined shaft and a gear that connects the engine to the drive wheel. Calculations are made according to the for-mulas for determining the forward speed (1) and determining the rotational speed of the driving wheel (2):

$$v = \omega . R \qquad (1)$$

$$n = \frac{3600.v}{\pi.D} \qquad (2)$$

whereas:
ω – angular velocity (rad/s)
n - rotational wheel speed [rpm]
v - vehicle speed [km/h]
D =2.R- outer tire roll diameter [mm]

The results of the calculations based on the formulas are shown in table 1.

Table 1. Results for rotational speed of the driving wheel [rpm]

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Tire size	Max. speed	
	20 (km/h)	40 (km/h)
12“	75 rpm	150 rpm
14“	64 rpm	128 rpm

After the calculations, it was determined that the transmission, which will be composed only of a gearbox, must have a gear ratio in the range – 4,3÷10.

It is analyzed by what mechanical gears the gearbox of the transmission can be designed. The possible options are shown in Fig.1.

Fig. 1. Scheme of possible structural units of a mechanical transmission.

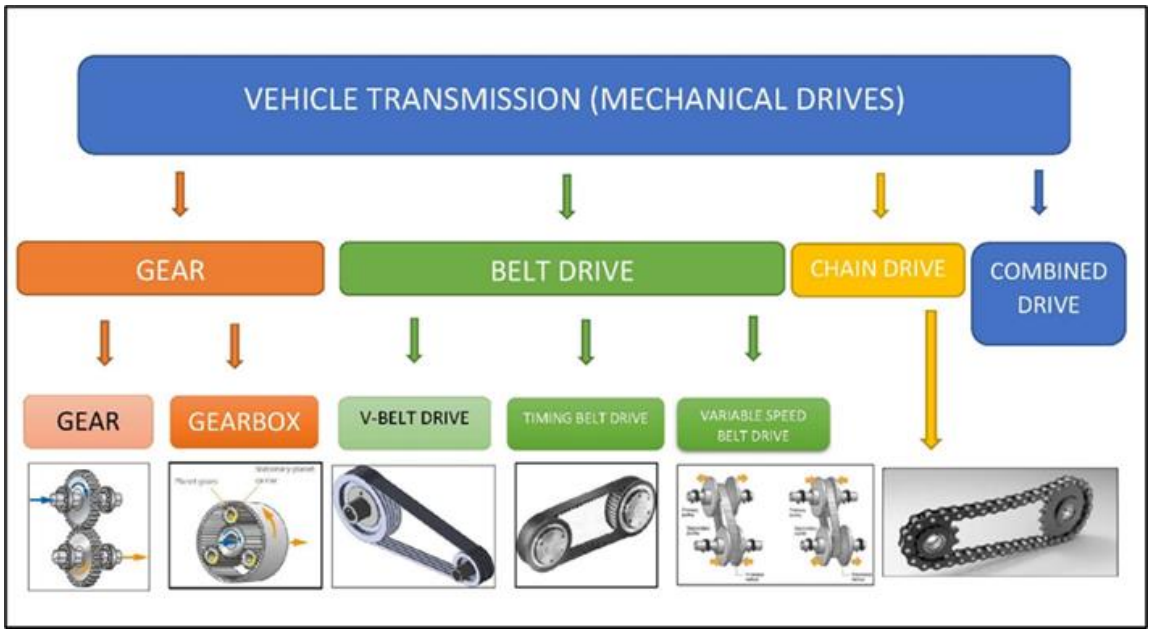


Fig.1 Scheme of possible structural units of a mechanical transmission.

APPLICATION OF GEARS IN TRANSMISSIONS.

Similar to recent production electric cars, a transmission with one or two gears after the engine is used. The most common application of gears in transmissions is as an independent open gear, or if this is not enough, gearbox or directly motor-gearbox assembly are used. [5], [6], [7].

The advantages of gears are:

- Great durability and reliability;
- High efficiency;
- Constancy of the gear ratio;
- High load capacity;
- Possibility of application at a wide range of speeds;

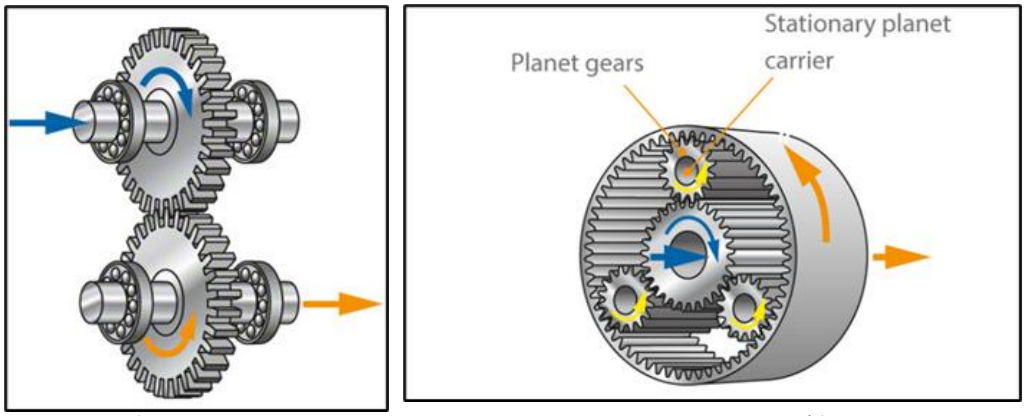
The disadvantages of gears are:

- Presence of noise during work;
- Sensitivity to dynamic loads and overload;
- Increased requirements for manufacturing and installation;
- Not suitable for long wheelbases.

How many and what type of gears will be used depends on the transmitted power, the torque and the required gear ratio. The manufacturers of engines working with compressed air, in addition to only engines, also produce motor-reducers with a gear ratio of up to 200.

For the purposes of the project, a gear ratio in the range of 4,3-10 is required. This can be achieved with the following options involving the use of gears:

- one-stage gear and chain or belt drive;
- motor-gearbox assembly



a) b)

Fig. 2 General type of constructions of a) single-stage gear and b) planetary gearbox (https://www.ksb.com/en-global/centrifugal-pump-lexicon/article/gear-drive-1116570)

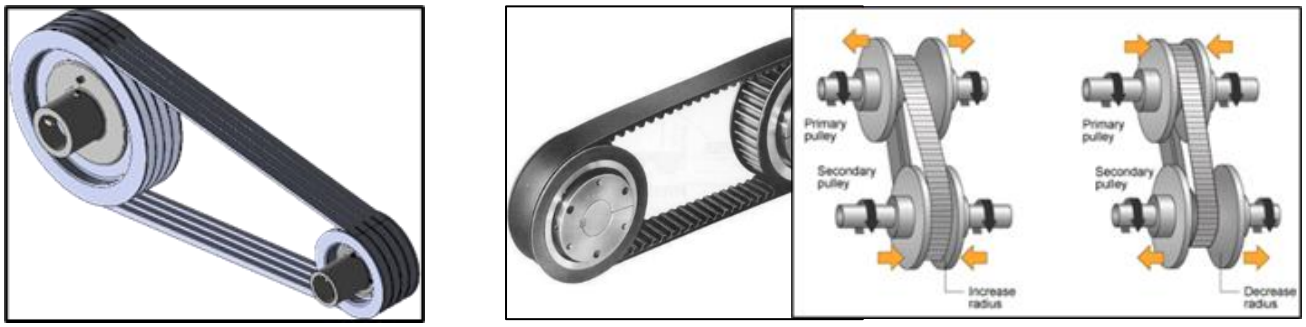
APPLICATION OF BELT DRIVES IN TRANSMISSIONS.

The following three types of belt drives are mainly used in mechanical drives: V-belt drive, timing belt drive and variable speed belt drive.

When choosing a belt drive, the following advantages should be reviewed:

- work smoothly and silently;
- protect mechanisms from dynamic loads and momentary overloads;
- simple construction and easy service

The main disadvantage of the first indicated belt type is the non-constant gear ra-tio due to the presence of slippage. This drawback is eliminated with timing belt. Their durability is relatively small due to the presence of a flexible element and intense friction, which is why it is not recommended to use them at high powers.



a) b) c)

Fig. 3. General type of constructions of a) V-belt drive, b) timing belt drive and c) variable speed belt drive (https://grabcad.com/library/roller-chain-drive-and-sprockets-16b-type-iso-606-din-8187-1, https://es.mathworks.com/help/autoblks/ref/continuouslyvariabletransmission.html, https://www.indiamart.com/proddetail/belt-pulley-9767281173.html)

Looking at their great advantages and the actual selected location of the front wheel for installing the transmission of the project vehicle, an option for a combined transmission, combining the advantages of the gear and the timing belt drive can be chosen.

APPLICATION OF CHAIN DRIVE IN TRANSMISSIONS.

Chain drives are widely used in automobiles, but not basic in transmissions. These may be found in the drive of various units in cars. However, these drives have a number of advantages and can be used as

part of the transmission of the prototype car driven by a compressed air motor from the University of Ruse project.

The main advantages of chain drives are:

- Higher efficiency compared to belt drives;
- Greater load capacity compared to belt drives;
- Lack of slippage;
- Constant gear ratio.

But chain drives also have major disadvantages:

- Noise during operation of the chain drive;
- They require very precise assembly and adjustment of the chain drive, due to wear in the chain;
- Require tensioning of the chain from the chain drive;
- Unfavorable dynamic loads for the shafts arise in the gear;
- Not suitable for high peripheral speeds.

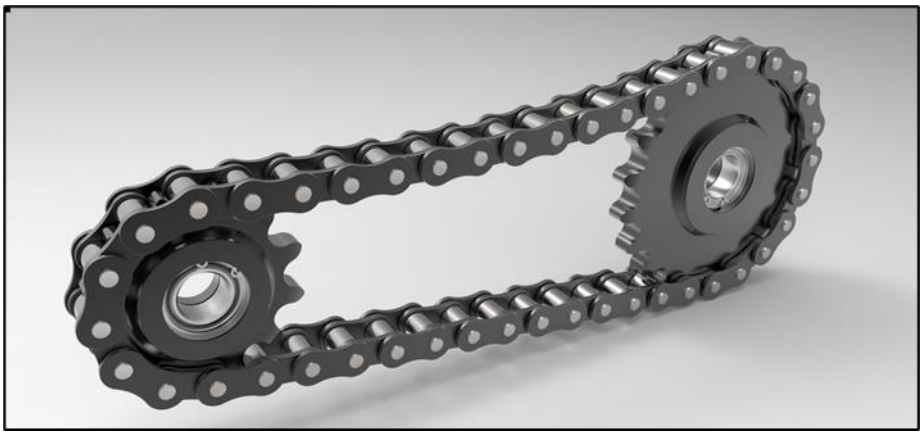


Fig. 4. General type of constructions of chain drive
(https://grabcad.com/library/belt-drive-26)

Due to the many disadvantages, it is not recommended to use a chain gear in the design of the project car transmission.

CONCLUSION

An analysis of the possible options for implementing the transmission of a car driven by a compressed air engine has been made. All the advantages and disadvantages of the possible drive gears are reviewed. From the drives and gears application analysis presented in subchapters and the gear ratio range sought, it is determined that depending on the size of the drive wheel tires and the desired maximum speed, possible good options for the designed transmission are:

- Transmission designed by combined mechanical drives: one toothed gear and one timing belt;
- Transmission designed from combined mechanical drives: motor with gearbox (cylindrical or planetary) and one timing belt;

It is agreed to the project to develop and analyze both options, and the analysis of the results obtained from both options will be presented in subsequent reports.

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