PNEUMATIC VEHICLE. RESEARCH AND DESIGN

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ABSTRACT

This experimental vehicle was designed for an international competition organized by Bosch Rexroth yearly in Hungary. The purpose of this competition is to design, build and race vehicles with a fuel source of compressed gas. The race consists of multiple events: longest run distance, the smartness track and the best acceleration event. These events test to the limit the capabilities of the designed vehicles.

Keywords: chassis, pneumatic engine, piston, PLC, three wheeled vehicle

1.Introduction

The team called METALMOBIL was formed in November 2010 when 4 students decided that they want to create something out of the ordinary: a vehicle with an alternative fuel source, in this case compressed gas. The team decided that it was going to compete with this vehicle in the international competition called Pneumobil.

In order to compete in this competition we had to come up with a feasible design for a pneumatic powered vehicle. We decided to design a vehicle with which we could compete in all the races and perform well. As such the vehicle had to be as light, and as maneuverable as possible. The designed vehicle uses compressed gas (Nitrogen, Argon or air) stored in a 10 liter tank as a fuel source.

2.The chassis and the steering mechanism

The chassis of the vehicle is built using rectangular hollow steel profiles. Our main objective was to make the vehicle as rigid as possible and also as light as possible. In order to increase the stiffness of the chassis we designed it to resemble a box structure as seen in fig. 1. The main components of the vehicle are integrated in this box-like structure which protects the sensitive electric and pneumatic components. Future plans include building the chassis out of aluminum profiles to improve the overall performance of the vehicle by reducing the overall weight of the vehicle.

The steering mechanism is based on the Ackermann steering geometry to account for the fact that in a turn the inner wheel is travelling on a path with a smaller radius than the outer wheel. The steering mechanism is completed with a series of pivots and linkages. It can be seen in fig. 2.

In order to make the car roll as easy as possible we had to use very light but strong wheels. We used a special bicycle wheel with an outer diameter of 556 mm and with a tire-width of 25 mm. The chassis with the steering mechanism and the wheels can be seen in fig. 3.

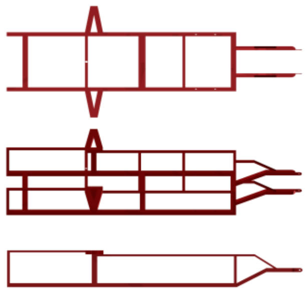

Fig. 1 The chassis of the vehicle

Fig. 2 The steering mechanism

Fig. 3 The assembled chassis

3.The engine

The engine uses two double-acting cylinders with a piston diameter of 80mm, stroke of 320mm and a working pressure of 1.5 bar to 10 bar. These cylinders are linked together with a series of bicycle chains. The cylinders rotate the main shaft of the engine with the help of racketing gears. The main shaft is linked to the rear wheel with a bicycle chain and gearing mechanism. The engine assembly can be seen in fig. 4.

Fig. 4 The engine of the vehicle

4.The engine control system

In order to control the engine and the vehicle we used a programmable logics controller (PLC) to control the parameters of the engine [1] and to limit the air usage. The PLC, mounted in the front of the vehicle (fig. 5), controls the solenoid-valves based upon the inputs of the four magnetic sensors. These sensors measure the position of the piston inside the cylinder. This allowed us to control the stroke of the double-acting cylinders. Buttons and switches were used to change the way the engine works, optimizing the performance of the vehicle for the different events.

Fig. 5 The engine control system

Figure 6 shows the general view of the pneumatic system of the engine:

1. Lockable isolation valve
2. Pressure regulator valve
3. Pressure regulator valve
4. Quick exhaust
5. 5/3 valve
6. Quick exhaust valve
7. Flow control valve
8. Double-acting cylinder
9. Magnetic sensors
10. PLC

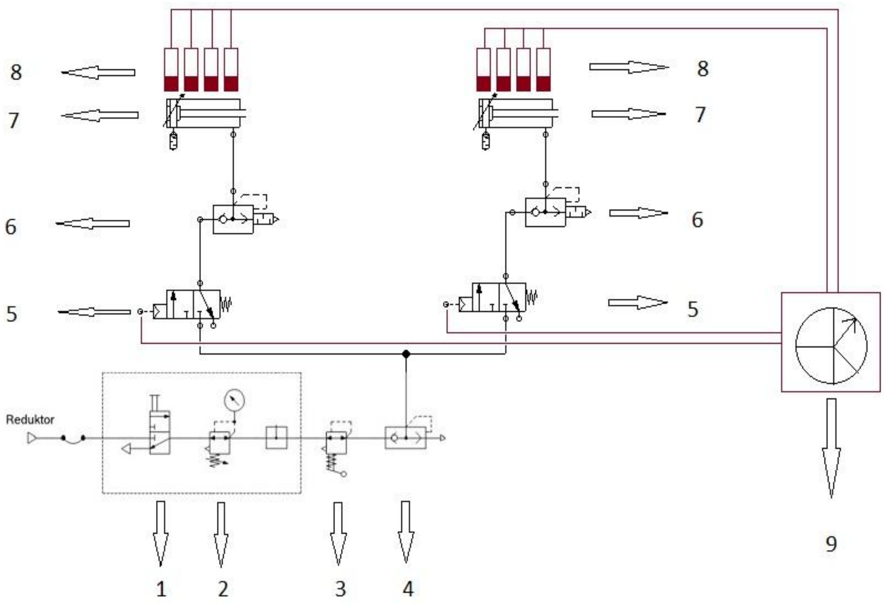

Fig. 6 The pneumatic system [2]

5.Experimental results and conclusions

A part of the experimental research was performed in Mechatronics and Robotics Laboratory from the Engineering Faculty, "Petru Maior" University of Tirgu-Mures. The general view of the vehicle can be seen in fig. 7 and fig. 8.

After the initial tests the steering mechanism had to be redesigned to increase the stability of the vehicle at speeds exceeding 30km/h. The new steering mechanism resembles that of a quad-type vehicle.

Also we tested how far the vehicle can travel using one 10 liter tank of compressed argon at 200 bar. The pressure in the cylinders was set to 8 bar. The vehicle travelled 6 km with an average speed exceeding 12 km/h. After the tests we developed a new program with which we managed to travel more than 9 km, and we manage to come in second place in the long distance race in Hungary.

The top speed of the vehicle on a test track, with a pressure of 8 bar in the cylinders, was 32 km/h. The vehicle can achieve a top speeds exceeding 40km/h with a pressure of 10 bar.

Fig. 7 The pneumatic vehicle

Fig. 8 The experimental pneumatic vehicle

References

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