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ScienceDirect

Procedia Engineering 149 (2016) 501 – 511

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Manufacturing Engineering and Materials, ICMEM 2016, 6-10 June 2016, Nový Smokovec, Slovakia

Piston development of a microconsumption race car

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Abstract

The constantly increasing fuel prizes one of the main development directions in the vehicle industry is to increase the combustion efficiency. My goal is to decrease the specific fuel consumption but to keep the same performance. The major part of the energy released on combustion transferred to its environment by thermal radiation instead of powertrain. In order to decrease the thermal waste in future vehicles we need to use other materials such as ceramic. This has great attributes of today's commonly used aluminum alloys, but in addition bad heat transfer ability.

Peer-review under responsibility of the organizing committee of ICMEM 2016

Keywords: piston development, ceramic, Al2O3, internal combustion engine

1. Introduction

The vehicles driven with electricity are graining more and more ground in the modern, development world. Electric drive has several advantages. The power used to drive is electric current, which emits no harmful material. Operational costs are low, but some countries make efforts to usher environmentally sound technologies. So these countries are tried to motivate with free loading-stations and tax preferences to use them. Next to the many advantages, there are disadvantages as well. These vehicles are too expensive, to be bought by everyone instead of petrol driven cars. Next to the high costs, the limited range is also a disadvantage. Electric engines are able to work with high efficiency, but batteries are not so well developed to enable long distance journeys. Because of regulations getting stricter and stricter, it is sure, that the time is coming when the electric drive is going to be the most widely spread one.

Nowadays the most used drive of automobiles, agricultural machines, ships, motorcycles and primer movers are still the internal-combustion, piston engines. Thus automotive industry spend much time and money to develop internal-combustion engines next to the electric ones. There are two main way to increase power: decreasing the emissions of harmful stuffs and upgrading the efficiency which can also cause the each other.

I researched the upgrading of efficiency in my work, mainly one of the parts, which gets in direct touch with burning the piston.

The goal of the development was to upgrade the efficiency of the Otto engine of a microconsumpting race car. This race is Eco-Marathon, where the high school and college students competitive with the each other. The goal of the race is to create a vehicle that can work with 1 liter petrol as long as it is possible. The bench test shew us already in the first year, that the manufactured engines, used by many teams have no proper efficiency. Thus we started to develop an own engine, which brought us much success already during the first race. As our knowledge on the field of engine designing were getting deeper, we felt the creating of a new engine necessary. We utilised generally designed pistons, made out of regular materials. Thanks to the donation

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Peer-review under responsibility of the organizing committee of ICMEM 2016
doi:10.1016/j.proeng.2016.06.698

of company working with technical ceramics, we could start do develop a piston, which kind of pistons has been never used in automotive industry.

2. How the piston works and how it is taxed

The piston has an important function of the driving chain. It's main goal is to lock one side of the cylinder of the internal-combustion engine, to create the changing volume, required for working. The thermal energy that comes into existence during the burning of the fuel, sparked with the ignition plugs turns into mechanical energy as the piston moves. The gas-energy takes effect on the surface and makes it move on a straight line. Some alternating move comes into being and turns into turning movement onto the crankshaft. [1][2]

The energy coming from the gas-pressure depends on the diameter of the cylinder and the top pressure of burning, but the underpinning of the piston is the bolt. Depending on the present angle of the crankshaft, this reaction energy presses the piston on the internal surface of the cylinder. Reaching the dead point, it changes the surface to the opposite side. In the dead point, the pinning becomes unsafe, the piston is able to make certainly sized movements, until the energy comes into being that presses it on the surface. This process makes noise and quiver during the engine works. To decrease these phenomenons the axis of the piston and the bolt is 1-2 mm offset, it is the so called deaxilation [1] of the bolt. Thanks to it, the surface changing happens before the piston reaches the dead point. [2]

During working, the piston is heavily taxed not just mechanically but thermal as well. On the side of the burning area, it is touched directly with hot gas, and the flame front. During the burning a top temperature of 1800-2600°C can appear, that decreases till the end of the expansion, and in the stroke of exhausting 500-800 °C hot burned material leaves the burning area. The most of the thermal tax on the piston is heat transfer, and just partly heat radiation. [3]

The thermal tax is not constant because of the fast changing of the working area, Therefore the temperature of the top of the piston can change, during the intake it is the lowest, and during the exhausting it is the biggest. The difference is usually approximately 10 °C, and approaching the center of the piston is decreasing. In practise, this phenomenon is not noticeable 1-2 mm under the top. [4]

3. How the new piston was developed

In the stroke of intake some fresh mixture streams into the burning area, and later it's sparked by the plug. By the explosion thermal energy comes into being, which pushes the piston down. For us, it would be the best solution if the work coming from the temperature would take only effect on the driving of the vehicle. If we could create such an engine, its efficiency would be 100 %, but it can not be made in the practise. The temperature, that we from the burning get, works only in one third part even in the best case, the other third part is absorbed by the exhaust fumes, and the other energy gets lost for cooling Two third parts of the temperature, used for cooling gets through the cylinder head with heat transferring and conducting into the environment, one third part through the top of the piston towards the crankcase. My goal with the development is to reduce the leaving heat, and increase the efficiency of the engine. [5]

3.1. Requirements of the material

As a result of that, after the ignition of the mixture the top of the piston is touched by the flame directly, this area is going to be the most heated one. This value is really important during the static designing, because of the high-temperature strength of the piston's material. The mechanical properties of the material, just like any other kind of materials becomes worse as the heat is increasing. The proper material can conduct heat so fast, that the temperature of the surface will not be higher than the critical fusion heat. [4]

By changing of the material, the most important properties can be seen below:

- heat expansion
- strength
- heat conduction
- coefficient of friction, wear resisting.
- thermal rating
- alloy
- workability

- Heat expansion:
  It is supremely important if the material can be used to manufacture a piston. As we change the fittings, we have to consider, that the piston, if it reaches the working temperature, due to the heat expansion can get stuck in the cylinder. This risk is influenced by the proportion of the alloy and the impurity.