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Experimental measurement of cooler pressure loss of Formula student car

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Abstract. To achieve the maximum performance of an engine while maintain safety of the race car, it is essential to cool it properly. Therefore, this article deals with the experimental measurement of the cooling modules pressure drop of the formula student car. Leading to the right choice of the fan behind the radiator. Series of measurements were taken at the UWB in the wind tunnel of the department of Power System Engineering.

1 Introduction

Every formula student car must be built according to strict rules which are controlled before the race. The cooling system of the entire car falls under these rules, of course. There are few specifications relating to the cooling system such as that there must be a firewall to separate the driver from all the parts of the fuel supply, the engine oil, any high voltage system, and liquid cooling systems. The other rule says that cooling or lubrication system must be sealed. The main rule relating to our research is that no power device may be used to move or remove air from under the car except fans designed exclusively for cooling. To properly design or select these fans, it is necessary to know the pressure drop of the cooling systems radiator.

In the formula student car from the University of West Bohemia is used the engine from the YAMAHA R6 – 2013 with the power of 91 kW. With this amount of the engine power, it is necessary to use the water-cooling system. To understand why, the next chapter describes different types of cooling systems and its use. [1],[2]

1.1 Cooling system types

Today, there are two types of cooling systems that are the most used. The first one is air cooling system and the second one is water cooling system.

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1.1.1 Air cooling systems

This system is mainly used in small engines approximately up to 15 – 20 kW. It refers to scooter or motorbike engines and to airplane engines. This means that the system is used in engines that are directly exposed to the air. To help the heat to dissipate to atmospheric air by conduction the outer surface of the engines cylinder and its head, these are provided with the fins. See **Fig. *1***. [3],[4]

Fig. 1. Air cooling system [3]

1.1.2 Water cooling systems

Since the formula student of UWB is using more powerful engine it is necessary to use the water-cooling system.

This system is used in the engines in all vehicle types with combustion engine such as cars, trucks etc. The cooling medium is water, which is provided around the engine in the water jackets. The water absorbs heat from the engine while its kept constantly in the motion by the centrifugal water pump. The hot water is then cooling in the radiator and by the fan and by the air flow developed from the motion of the vehicle. The cooled water then circulates again trough the water cooling jackets. [4],[5]

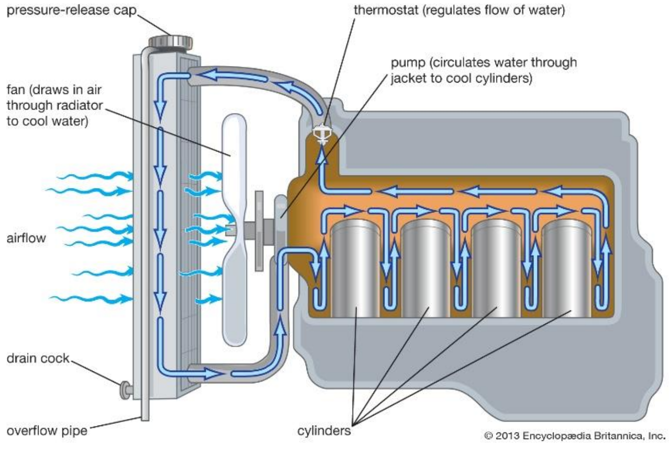

Fig. 2. Water cooling system [4]

To keep the engine safe from cracks in the cylinder blocks, radiator, and piping which it is important to prevent the cooling water from freezing. Therefore, the antifreeze mixture is added to cooling water. This measure is keeping water in the liquid state and protecting the engine in colder days when the temperatures go below the zero.

Components of the water-cooling system are thermostat valve, water pump, water jackets, antifreeze mixtures. And two components that are essentially for the research are the fan and the radiator.

The fan is provided behind the radiator to help cover the pressure drop and to blow the air over it for cooling purpose. This part is chosen after the pressure drop of the radiator is known.

The radiator consists of an upper and lower tank with honeycomb core between them. This is the part which produces the greatest pressure drop. [4],[5]

2 Experimental measurements

The measurements were taken at the department of Power System Engineering of the UWB. For the experiment the wind tunnel (**Fig. *3***) that we have available was used.

Since the speeds of the car on the racetrack for student formulas are not very high, due to a very technical track and safety of the students of course, the measuring of the pressure drop of the radiator was the most important during the flow velocity between 40 – 80 km/h. These flow velocities are provided by the wind tunnel without any difficulty.

The measurements, however, where taken for a bigger range of flow velocities. This range was from 4 m/s up to 25 m/s which refers to 14.4 – 90 km/h. This was done to get more complete view of the pressure drop trend. In the end the two out of three measurements were used for the evaluation. The third one was not successfully completed due to technical issues in the last measurement series.

During the measurements the temperature in the laboratory was 26.4 C and the barometric pressure was 96.97 kPa. These conditions correspond to the race which is held in the Czech Republic.

Fig. 3. Wind tunnel

2.1 Set up

Before the measurement was taken the whole system needed the proper set up. This means that the measuring volume had to be modified so the part of radiator could be placed in it. After the placing the radiator into the measuring volume, it was essential to seal all the gaps, to prevent the air leakage. After the sealing and placing the pressure sampling the measuring set up (**Fig. *4***) was ready for the experiment.

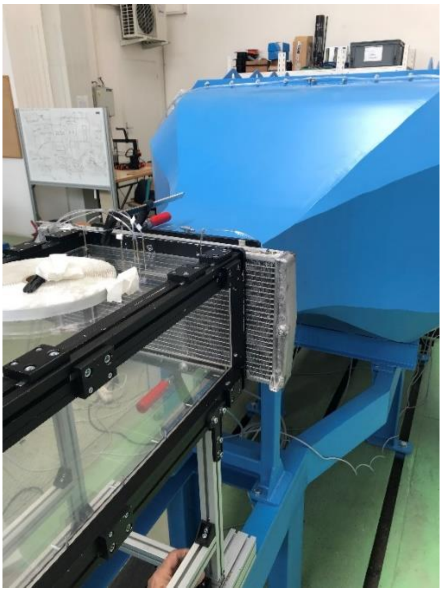

Fig. 4. Sealed radiator

The pressure samplings were placed in front of the radiator and behind it. So, the pressure drop is measured right behind the honeycomb of the radiator. These samplings were placed 70 mm from both sides of the radiator (**Fig. 5**). This was important for choosing the fan according to pressure drop of the radiator.

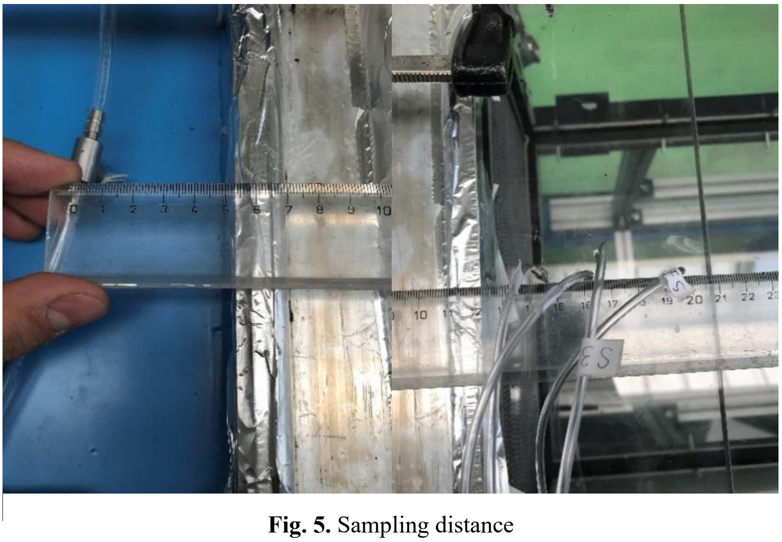

Fig. 5. Sampling distance

2.2 Devices

All the devices used during the experimental measurement are listed below. Also, all of them were provided by the department of Power System Engineering.

The used wind tunnel is able to produce the flow velocity from 0 – 90 m/s. Its cross section of the measuring volume is 200×300 mm.

The name of the pressure system used to measure the pressure drop is NetScanner 9116 (

Fig. 6). It is a pneumatic intelligent pressure scanner with 16 sensors and micro-processor technology. The accuracy of this system is ± 0.05 % FS and it is designed for measuring with the gas and for the wind tunnel.[6]

Fig. 6. Pressure system

Traverzer_2D & Pressure was the software used to control the pressure system and wind tunnel. This software is made of two parts. The first part is provided by the supplier of the wind tunnel. The second part of the software was specially made for collecting, processing and display of the data. This second part of the software was developed by one of the co-workers at the Department of Power System Engineering. [7]

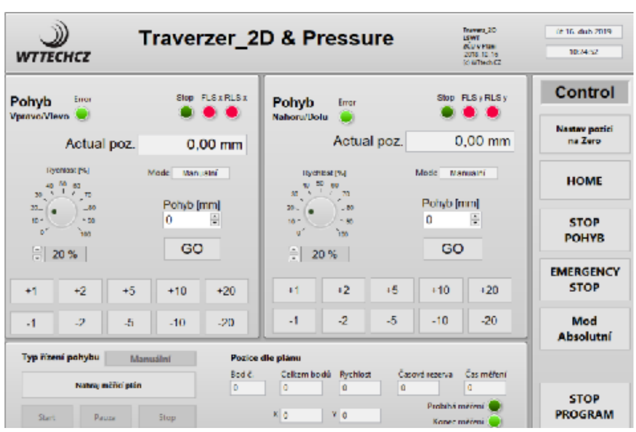

Fig. 7. Screenshot of the Traverzer_2D & Pressure [7]

3 Evaluation of the measurements

For creating the characteristics of the pressure drop at different flow velocities, the values from the measurement series were used. The pressure system directly measures the value of the pressure drop between the first and the last sampling. Also, it should be mentioned that the measurements were taken with used radiator which was damaged by the rocks during the races. This fact caused higher pressure drop then when the calculations were performed in previous researches few years ago.

Following figure (**Fig. *8***) shows the dependence of pressure drop on flow velocity. As expected with the growing speed the difference between two pressure samplings increases. This characteristic of pressure drop will help to choose the fan for the future formula student cars at the UWB.

This fan should be chosen so it covers the pressure drop and therefore the whole cooling module works properly.

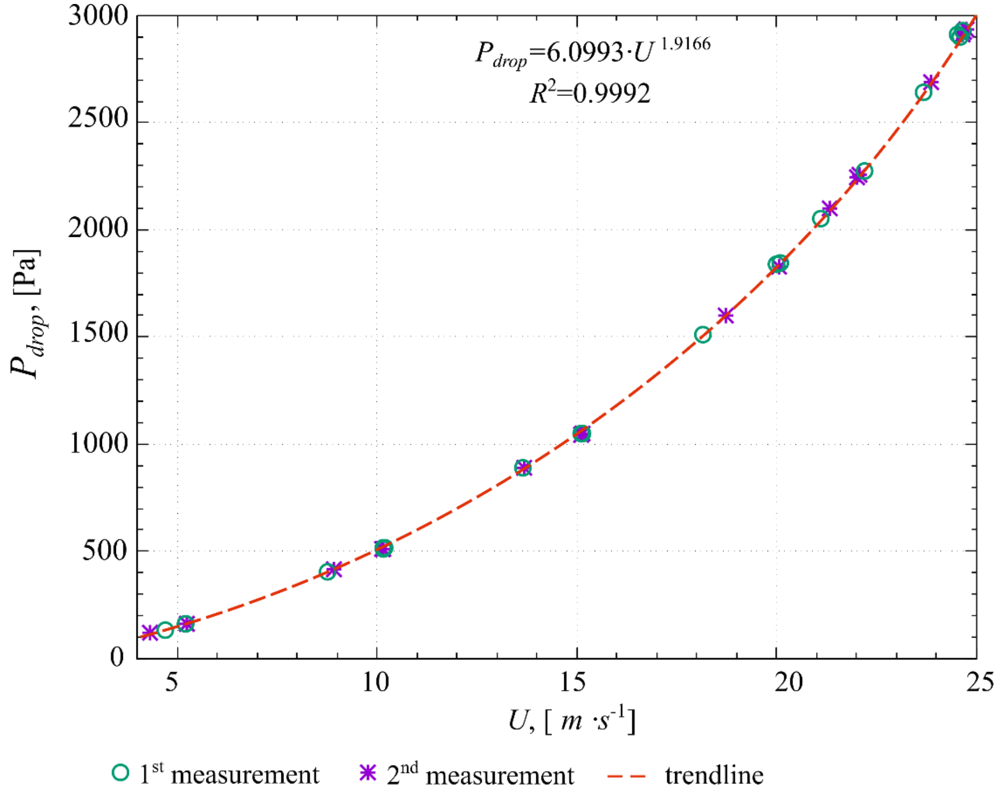

Fig. 8. Pressure loss of the radiator – experimental measurement

4 Conclusion

This research should contribute to the future students with developing new racing car in the UWB Racing Team, especially to those who will be responsible for designing the cooling module. This research will continue with numerical simulation to confirm the trend from experimental data. Since the numerical simulations are more flexible regarding to boundary conditions, they will be performed with different temperatures of the air. This should help with choosing the fan to cover the different range of the pressure drop e.g., when racing in hotter weather. If the fan is chosen wrong and it doesn't cover the pressure drop it can potentially cause overheating of the engine. The radiator will be also scanned by 3D scanner and compared with the model without any damage from the race.

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