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FAKULTA STROJNÍ

KATEDRA ENERGETICKÝCH STROJŮ A ZAŘÍZENÍ

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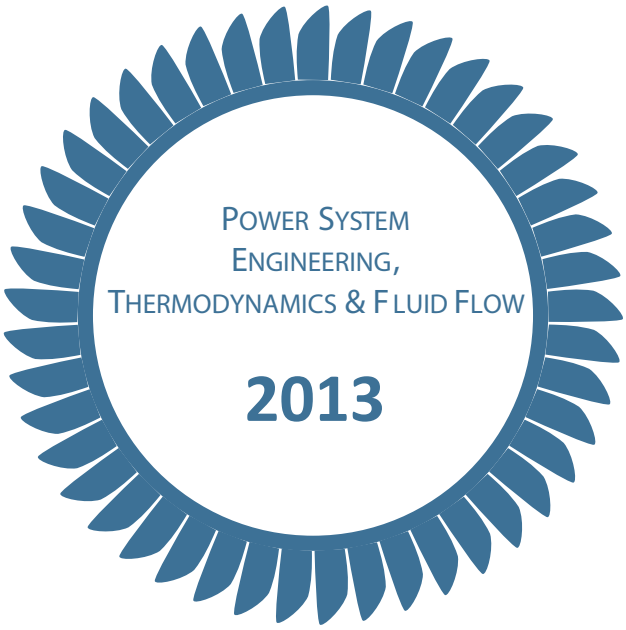

JEDNOTLIVÝ PŘÍSPĚVEK ZE SBORNÍKU

evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

DESIGN OF PULSE JET ENGINE

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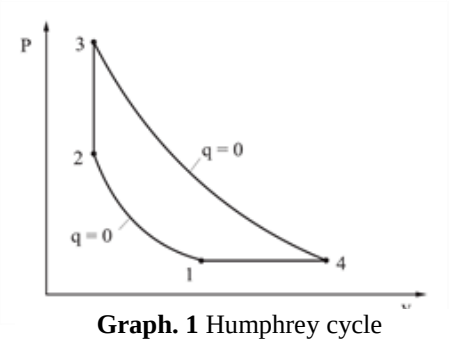
A pulse jet engine was very important step in history of jet engines. The pulse jet has interesting physical function. Therefore the aim of my report is to design functional pulse jet engines. The body of this report is creating overview of technologies and fuel use. Then thermodynamic cycle of the pulse jet engine is calculated. In the first place I deal with history development of pulse jet and describe parts of it. The next part of the body is result, where a one cycle of the engine is calculated. Very interesting is pressure in front of the valve, there is pressure two times smaller than atmospheric pressure. This difference of pressure is well seen on the p-v diagram, which is in this work, too. The design of the pulse jet engine was fabricated based on experience amateur's inventors and a famous theory of pulse jet engine.

Keywords: the Argus, pulse jet, Humphrey cycle

Introduction

A pulse jet engine is one of the simplest and lightest types of reactive (jet) engines. For most reactive engines, the fuel burns continuously. However, the fuel for the pulsejet is combusted at regular intervals, making the engine has the characteristic sound. Frequency of the engine depends on its length and speed of sound. Frequency can be up to 250 pulsations per second for small engines pulsation, but is only 45 pulsations per second for large engines such as the Argus 103. Work of the engine can be described by the Humphrey cycle (Graph 1). Ideal flow is based on the adiabatic compression, expansion, isochoric and adiabatic expansion of gas. The pulse jet engine reaches only to the speed of sound. The supersonic pulse jets are not produced.



Graph. 1 Humphrey cycle

A general engine design is very simple. The engine composed of a suction chamber, which supports an increase of pressure, the valve, the combustion chamber and the outlet nozzle. The valve is replaced by a special shape of the valveless engine.

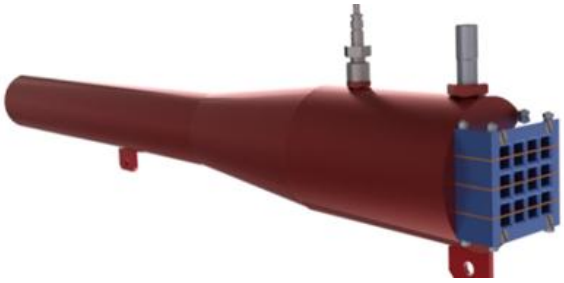


Fig. 1 Describing pulse jet engine

One moving part is only in the valved engines. It is just one-way valve, which prevents back flow of combustion gases into the suction line. Distinguish two main types of pulse jets. In English they are called valved and valveless.

2. History

The first man who followed up the pulse jet engine was Russian engineer V.V. Karavodin in 1906. Karavodin experimented with the pulse jet engine and in 1907 Karavodin patented it. The pulse jet engine was only a long tube. It did not have one-way valve in front of the engine, then the engine got name the Valveless pulse jet engine. Fuel the engine run on hydrocarbon.
French Georges Marconnet was the second invented. He patented his Valveless pulse jet engine in 1908.
German engineer Paul Schmidt took over the pulse jet engine by Marconnet. Paul gave a one-way valve in front of engine then it created the Valved pulse jet engine. At the same time the Argus developed a Valveless pulse jet engine. Paul Schmidt worked for the Argus company and together they developed very famous pulse jet engine witch has name As 109-114. The As 109-114 was best balance between cost and performance. It was engine for a V-1. The V-1 was a bomb witch used Germany in the World War II.

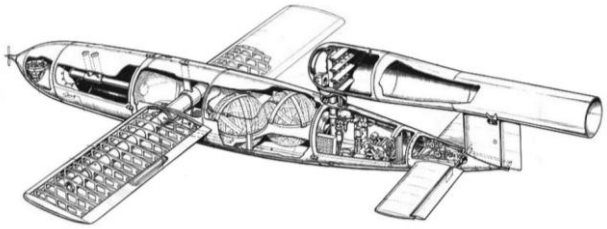


Fig. 2 Fi-103 (V-1)

Pulsation engines are also used to power helicopters, there were placed at the ends of the main rotors. In 1952, the U.S. Army constructed a reconnaissance helicopter driven by pulsating engine. Helicopter called Co. XH-26 Jet Jeep.

Fig. 3 Co. XH-26 Jet Jeep

The pulsejet is used for aircraft models now. A lot of amateurs produce the engine in their workshop.

4. Describe of function

Intake

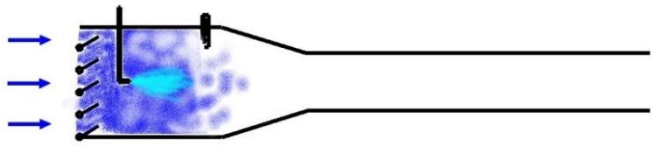


Fig. 4 Intake stroke

The first stage, the engine sucks fresh air. Intake of fresh air is a result from the vacuum generated in the combustion chamber. The inlet valve causes the sucked air is compressed. The compressed air flows through the openings in the valve open and the air is mixed with fuel. When the engine is necessary to create an overpressure at the inlet, it is possible to provide a compressor or compressed air suction.

Burning/Expansion

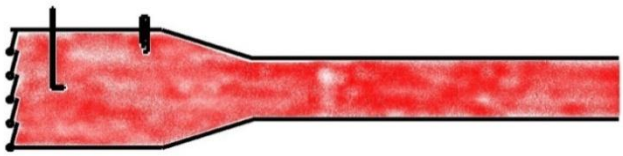


Fig. 5 Expansion stroke

The second stroke circulation is ignited air/fuel mixture. Ignition of the mixture takes place using a spark plug, when pulse jet is first started. The mixture in the next cycle is ignited by exhaust gas output. Igniting the mixture an explosion lead to a sudden, almost isochoric rise pressure in the combustion chamber. Pressure causes closure of the valve at the inlet, therefore, the exhaust gases leaving only exhaust.

Exhaust

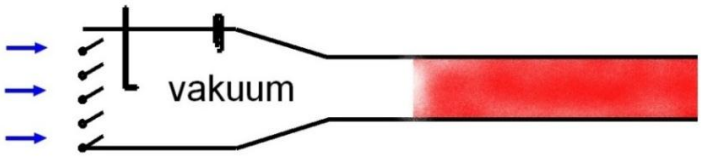


Fig. 6 Exhaust stroke

In the third stroke, the exhaust gases expand from the combustion chamber through the exhaust. The chamber pressure begins to equalize with atmospheric pressure. The front wave exhaust begins to move high kinetic energy at the end of the outlet exhaust. When the wave of the exhaust gas reaches the output end of the nozzle, the pressure is equal to the exhaust pressure. However, the front portion of the exhaust gas still has kinetic energy and will further expand behind the pulse jet. This phenomenon creates a vacuum in the combustion chamber. The vacuum leads to the opening of the inlet valve, sucking fresh air into the combustion chamber.

Ignition of a new cycle

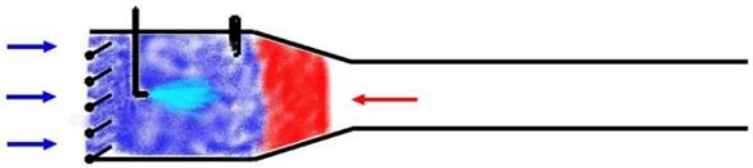


Fig. 7 Ignition of a new cycle

Back gases were not managed expand the influence of pressure reduction, lose momentum and reverses. These back gases go backwards into the combustion chamber and ignites the new mixture. Spark is therefore useful only ignite the first cycle, the other cycles are ignited by the previous gases.

The cycle is then repeated.

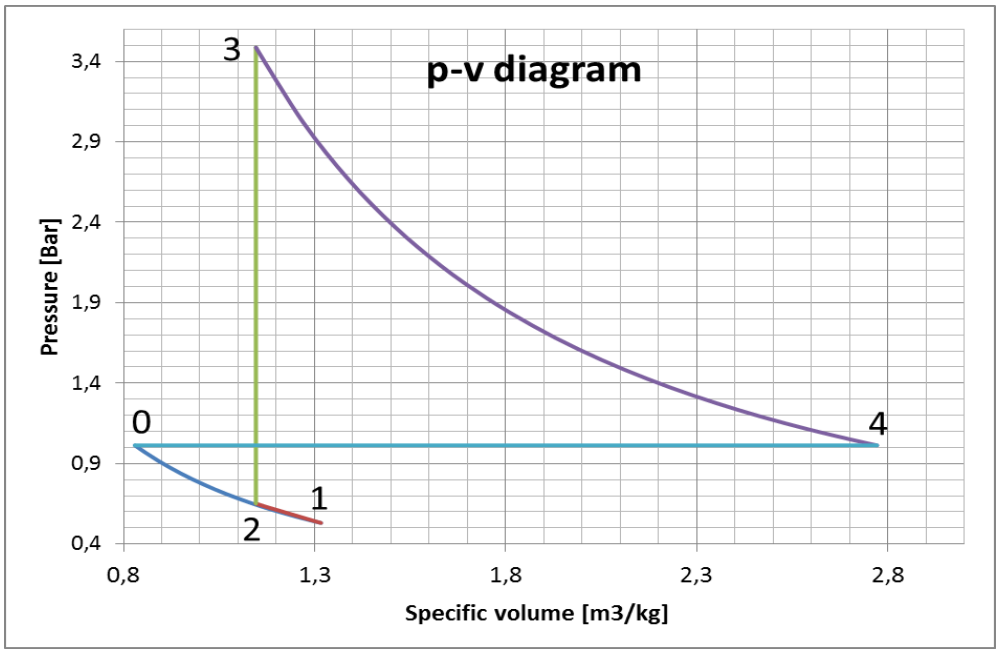
5. Results

Table 1 represents one of the results my work. It is a calculation of all the parameters in interesting parts of the engine. Calculated numbers are maximum or minimum conditions because during the time of one cycle, all the parameters vary over time. A very interesting finding is the negative pressure at the inlet (state 1), where the pressure is approximately twice lower than atmospheric pressure.

	state 0	state 1	state 2	state 3	state 4
Pressure (Bar)	1,01	0,53	0,65	3,48	1,01
Temperature (K)	293	236	260	1388	975
Density (kg/m^3)	1,20	0,76	0,87	0,87	0,36
Specific volume (m^3/kg)	0,83	1,32	1,15	1,15	2,77

Tab. 1 Calculated values for my pulse jet

Another result of this work is p-v diagram describing the operation of one engine cycle. At first sight obvious difference from the Humphrey cycle engine air intake. This difference is due to the location of the engine because the engine in its function will be fixed to the ground and will not move.



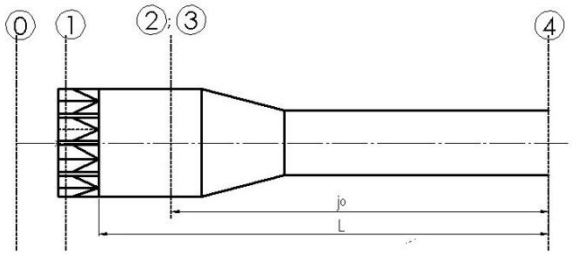


Fig. 8 Pulse jet with states

Finally my work is the drawings of the pulsejet, based on which the pulsejet manufactured. Basis for design pulsating engine, according to the theory formulated by Mr. Tharratt and according to the experience of amateur producers.

Conclusion

The Pulse jet engine is a simplest type of turbojet engine. It is very light and it has high performance. It is not much used because he has great fuel consumption and it make strange notice. An interesting finding in my work is the difference between my p-v diagram and diagram describing the Humphrey cycle. The difference between diagrams is due to the fact that my pulse jet engine is calculated as motionless. However Humprey cycle is calculated as a flying engine, where the engine´s inlet creates dynamic pressure.
The engine will be used to measurement values. Further use is attaching the engine on the vehicle where it will be powered by pulse jet engine.

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Acknowledgment

These results were achieved in specific research SGS – 2012 - 072.

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