Notes on the Operation of the Stirling Engine

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Received: March 21, 2018; Accepted: April 12, 2018

Abstract. The problem of using the Stirling engine for traction purposes has attracted researchers and constructors for many years. Unfortunately, the current state of the art and its structural properties do not allow for its use on a wider scale, apart from the prototype test vehicles.

Key words: Stirling engine.

INTRODUCTION

An overview of the possibilities of using the Stirling engine for traction purposes has been presented in the article on its use in motor vehicles [2]. It is a description of possible implementations and attempts to date which have ended with failures, as the authors have stated. Their analysis lacks a broader discussion of the reasons for this state of affairs. Their statements should be supplemented with an analysis of the operational reasons that have caused little interest in this kind of vehicle propulsion. In general, publications regarding this subject lack reference to such parameters as motor flexibility, labor economics and inter-repair runs (which it is too early to discuss). First of all, the information should be given what operating medium is used in a given engine, because this is what its efficiency depends on (Fig. 1).

The practical solution for the design of the engine operating according to the Stirling cycle amounts to the solution of three technical problems contained in the basic national publications on this subject [3]:

– continuous movement of the positive displacement element,
– displacement of the total mass of gas from the space covered by the low temperature heat source into the space covered by the high temperature heat source without changing its volume,
– completion of the full heat regeneration process during one cycle.

The practical implementation of this idea are double-acting engines. The practical solution consists in the fact that the upper and lower part of each piston is used in the implementation of thermodynamic transformations in two separate working planes containing separate volumes of gas (Fig. 2).

Fig. 1. The Stirling engine efficiency depending on the working medium [1,3]

Fig. 2. Constructional solution for double-acting engine, scheme [3], H – heater space, R – regenerator space, K – radiator space, E – expansion, C – compression
These engines (Fig. 5), with the designation Philips A-215, were supposed to drive the Foid Tarino car. The rated power was 63-70 kW at the rotational speed of 4500 1/min, with the general efficiency of 20-21% [2, 4]

Whereas the production version were the United Stirling engines, designed for the propulsion of underwater vehicles at the draft of up to 600 m (Fig. 6) [3]. In these engines the combustion system of hydrocarbon fuels in pure oxygen was used, whose consumption in the Y4-275 R engine was 820-950 g/kWh.
Fig. 7. Universal characteristics of the Stirling engines of the United Stirling Company

![Diagram of Universal Characteristics](image)

Table 1. Parameters of the Stirling engines of the United Stirling Company

<table>
<thead>
<tr>
<th>Engine designation</th>
<th>V4-95 S</th>
<th>V4 - 275 R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cylinders</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Stroke volume</td>
<td>380 cm³</td>
<td>1100 cm³</td>
</tr>
<tr>
<td>Durable engine power</td>
<td>Depending on the working medium</td>
<td></td>
</tr>
<tr>
<td>Helium</td>
<td>10-20 kW</td>
<td>75 kW</td>
</tr>
<tr>
<td></td>
<td>1800 l/min</td>
<td>1800 l/min</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>10-20 kW</td>
<td>100 kW</td>
</tr>
<tr>
<td></td>
<td>1800 l/min</td>
<td>1800 l/min</td>
</tr>
<tr>
<td>Rotational speed of engine</td>
<td>1000-3200 1/min</td>
<td>1500-2600 1/min</td>
</tr>
<tr>
<td>Mass</td>
<td>430 kg</td>
<td>600 kg</td>
</tr>
</tbody>
</table>

Fig. 7. and Tab.1 show the ranges of operation of production engines that indicate the possibility of their use and inconveniences that prevent their use in road transport. At the speed of 4000 l/min, their efficiency ranges from 0.10 to 1.17.1. 24, whereas the flexibility coefficient of the engine, and thus the ability to adapt it to changing operating conditions, is 1.97 at 2.87 for engines of comparable power (VW and SAAB) used in cars. Hence, numerous problems of exploitation nature arise, causing the lack of interest of car manufacturers in this drive source and orientation of interest towards drives using electric energy.

REFERENCES

Eco-mobility - new solutions and technologies in urban transport

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Received: ????, 2018; Accepted: ?????, 2018

Abstract. The article addresses modern technical solutions and technologies in the field of eco-mobility, which help solve problems of public transport in large agglomerations. Based on the example of Szczecin, specific ideas and projects were presented, the implementation of which is the basis for the functioning and development of the city.

Key words: eco-mobility, technology, urban transport.

INTRODUCTION

All urban agglomerations, irrespective of the nationality or geographical location, face similar problems as a result of the large number of people gathered in a relatively small area. This has a negative impact on the development of infrastructure, standard of living, pollution of the environment, it also reduces the possibility of planned management of available human resources and equipment.

There are, of course, many good solutions to these problems but there is no one specific, universal and timeless solution. The most effective seems to be a hybrid combination of two or more ideas that are matched ideally to the needs, possibilities and expectations of local authorities and residents.

Transporting huge numbers of inhabitants from many thousands of 'bedrooms' and suburban residential estates to work, educational institutions or offices, and in the afternoon providing a collision-free and as short as possible time of return is a challenge both for the city authorities and the urban transport.

1. METHODS OF URBAN TRANSPORT REORGANISATION

1.1 Application of new technologies

A very good example is the use of alternative fuels and power systems for urban buses. In order to meet the EU and national regulations and the expectations of the more aware part of the population, the authorities create legislation and regulations that promote such solutions.

a. Hybrid drives

- the bus is equipped with 2 coupled and complementary engines, most often diesel engines and electric one motors. Switching between the drive types is automatic under the specified operating conditions or it can be done by the driver when required.

b. Fully electric drives

- The depot charging system consists of a power supply infrastructure and e-buses that run on designated routes for a maximum of 18 hours a day, covering a distance of 120 - 200 km with the option of changing drivers, and then the buses must appear in the depot to recharge the battery. The process of charging with the devices with 50 - 150 kV voltage is long and necessary after every day of operation. We need to purchase a sufficient number of stations to ensure that we can load all or part of the vehicle fleet at a particular depot at the same time.

- The opportunity charging system is based on a completely different charging system of 300 kV or more and batteries of different construction, chemical composition and capabilities. Thanks to this solution, the bus is charged in 5-12 minutes at a bus terminus or junctional stops where different routes cross. The whole process of charging with the current of very high values is carried out safely and smoothly during the exchange of passengers.