THE ADIABATIC ENGINE FOR ADVANCED AUTOMOTIVE APPLICATIONS

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ABSTRACT

The high temperature adiabatic diesel emerges as a possible contender for future automotive powerplants. The powerplant under consideration is the insulated diesel type engine without a cooling system. A waste heat recovery system is considered for further improvement. Considerable progress has been made in this technology by many organizations. Currently the thermodynamics, high temperature tribology, materials, design emissions and performance aspects of the adiabatic engine are being investigated worldwide. The possible role of the adiabatic engine in future automotive type engines, and the rotary Wankel type engine are also presented. Its potential performance improvement is discussed. The advantages of the adiabatic engine concept for multi-fuel capability in direct-fired coal combustion and other degraded fuels are covered. Finally, the technical problem areas holding back its commercialization are presented.

INTRODUCTION

The feasibility of the adiabatic turbocompound truck diesel engine was recently demonstrated by Cummins Engine Company and the U.S. Army Tank Automotive Command of Warren, Michigan. A five-ton U.S. Army truck installed with one of these first generation adiabatic engines was tested for performance, reliability and cold start. The engine without a cooling system demonstrated its capability quite ably.

Since the above demonstration, many organizations and institutions have embarked on similar research endeavors. Approaches to adiabatic engines are many and results are also diverse. Nonetheless, most of the major engine manufacturers worldwide are involved in adiabatic engine technology.

R. L. Evans (ed.), *Automotive Engine Alternatives*

The reciprocating heterogeneous combustion machine, the rotary Wankel engine, gas turbines, and the Stirling engine can all benefit with advanced high performance ceramics. Higher temperature operation of adiabatic engines with ceramics has shown excellent fuel economy and the potential for cost reduction by eliminating cooling water, radiators, fan and water pumps. Reductions in NO_x, unburned hydrocarbons, and carbon monoxide and particulates can also be expected. The hot engine with short ignition delay offers a smooth, quiet combustion diagram. Multi-fuel capability of the hot engine is another important feature. The density of ceramics is usually lower than its metal counterpart and provides lightweight features. Uncovering the potential of each powerplant with advanced materials could represent a new era for ceramic and engine industries.

ADIABATIC DIESEL ENGINE

An adiabatic engine is one in which no heat is added or subtracted during a thermodynamic process. Obviously, a true adiabatic engine with zero heat loss (100% degree of adiabacity) is not possible. However, 50% to 60% degree of adiabacity can be achieved with the use of advanced ceramic materials[1]. In many circles, the adiabatic engine is called the low heat rejection engine (LHRE) which more accurately describes today's adiabatic technology.

An advanced adiabatic engine with no cooling water jacket is shown in Figure 1. A through bolt anchored in the crankcase block holds the cylinder head and the cylinder liner in compression. Practically all major engine components and accessories could use high performance ceramics somewhere in their design.

The adiabatic diesel engine with waste heat utilization is a rewarding concept with extremely challenging design problems. It offers reduced brake specific fuel consumption in future diesel engines as a result of the following basic revisions:

- Insulating the combustion chamber (cylinder liner, piston crown, and cylinder head), exhaust and intake ports, and the exhaust manifolds.
- Elimination of the cooling system and its associated parasitic losses.
- Waste exhaust heat utilization by turbocompounding.

A schematic of the basic adiabatic turbocompound diesel engine is shown in Figure 2.

There are a number of potential advantages in operating an adiabatic turbocompound diesel engine. They are:

- Reduced fuel consumption
- Reduced emissions and white smoke
- Multi-fuel capability
- Reduced noise level
- Improved reliability and reduced maintenance
- Longer life