Direct Injection Systems

The Next Decade in Engine Technology

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Library of Congress Cataloging-in-Publication Data

Stan, Cornel

Direct injection systems : the next decade in engine technology / Cornel Stan.

p. cm.

Includes bibliographical references.

ISBN 0-7680-1070-5

1. Automobiles—Motors—Fuel injection systems.

I. Title.

TL214.F78 S7323 2002

629.25'3—dc21

2002070812

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ISBN 0-7680-1070-5

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SAE Order No. R-347

Printed in the United States of America

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Preface

The worldwide demand for automobiles as well as the requested diversity of their types, forms and performances increase continuously. In every vehicle class, a high power or torque response, combined with technical ingenuity become more and more a main criteria of acceptance. Simultaneously, the limited crude oil reserves and the ecological impacts provoked by vehicle engines are subjects of large interest, respectively objects of drastic limitations by law.

An adequate compromise between high performances and low pollutant emission respectively low consumption is achievable by a continuous correlation of the internal processes – scavenging, fuel induction, mixture formation and combustion - within a combustion engine, depending on the variable operation conditions such as load, speed or surrounding parameters.

The actuality of the problem is demonstrated for example by the rapidly changing regulations for fuel economy or pollutant emission such as CAFE (Corporate Average Fuel Economy), ULEV (Ultra-Low Emission Vehicle), SULEV (Super Ultra-Low Emission Vehicle), EU3, EU4, EU5 (European Union Norms). Practically, every new norm, appearing with a cadence of 4-5 years, imposes the reduction at a half concentration of every pollutant component in comparison with an existing norm.

The challenge of the internal combustion engine on the way between high performance and low consumption / low pollution becomes stronger because of a promising competitor in propulsion – the fuel cell operated motor. The utilized energy sources are similar for both internal combustion engines and fuel cells: hydrogen, methanol or gasoline, reacting with air [1]. This allows to evaluate their efficiency in base on similar criteria – the specific fuel consumption [g/kWh] and the pollutant emission [g/kWh], [g/km].

Obviously, the utilization of gasoline or alcohols in fuel cells lead to a carbon dioxide emission as well. Furthermore, the technical feasibility of both concepts can be compared in similar terms: costs resulting from the technical complexity, weight, volume and safety of the system on-board. Apparently, the fuel cells attain a higher efficiency, a main reason

being the difference between the continuous chemical reaction of the two basic flows separated by a membrane (fuel cell) and the strong turbulent mixing of the components during a combustion (internal combustion engine). However, a high energy density or a transient operation impair this initial benefit of the fuel cell.

In this context of challenges and competitions, the present development of IC engines shows a much higher intensity than in the past. New potentials are recognized and successfully applied: fuel direct injection, fully variable valve control, down-sizing, operation within hybrid scenarios as well as the utilization of alternative fuels.

The next decades will be marked by an accelerated development of the internal combustion engine – thus, his replacement in the next future is not evident. On the other hand, in the following years, a concrete comparison base with the fuel cells appears as very probable.

Fig. P.1 Development conditions for internal combustion engines

Fig. P.2 Comparability of conditions between SI engines and fuel cell powered motors