Preface

In recent years the concept of a fuel cell propulsion system has gained in attention as a result of the need to reduce the fossil fuel consumption and greenhouse gas emissions. Since the fuel cells suitable for vehicle application (polymeric electrolyte membrane fuel cells) are fuelled by hydrogen, and deliver power as long as fuel and air are supplied, they potentially can provide the range capabilities of an internal combustion engine when used in a power system, but with clean and quiet operation. Therefore, the fundamental benefit of this type of propulsion consists in the possibility to adopt pollution-free electric drive-trains, without the drive range limitations typical of traditional electric vehicles.

A fuel cell propulsion system operates in hybrid configuration with an electric energy storage system (batteries and/or supercapacitors), in order to take advantage of the best attributes of both power sources. In fact, against the driving range capabilities of fuel cells, batteries and supercapacitors are characterized by defined and limited energy storage, but are able to deliver large peak current without the limitations due to the dynamic behavior of auxiliary sub-systems of the fuel cell generator. Fuel cells and storage systems, therefore, complement each other in a hybrid configuration where they supply the electric drive through an electric parallel connection. Suitable management strategies have to be implemented to optimize the energy flows within the overall power train, as function of power size and road mission of the vehicle, with the goal of achieving peak acceleration power, long range and recharge capabilities.

This book is organized to provide a general view of the present status of this moving field, taking into account that the study of a propulsion system using hydrogen as a fuel, an electric drive train for traction and electrochemical systems as power sources requires some basic knowledge in different scientific disciplines. The text is aimed at undergraduate or graduate-level students, and has been structured in a theoretical part, dealing with the fundamental concepts involved in the study of a fuel cell power train, and in a final practical section where the principles previously illustrated are applied in design, realization and experimental characterization of two real fuel cell propulsion systems.

The introduction in Chap. 1 tackles the problem of energy strategies and their implications in the transportation sector. Future availability of fossil sources, potentialities of alternative sources, well-to-wheel analysis of conventional and innovative propulsion systems are discussed in relation to their impact on the future feasibility of efficient and carbon-free transportation means.

Hydrogen production, onboard storage and distribution technologies are reviewed in Chap. 2, while basic concepts of electrochemistry are recalled in Chap. 3, with an assessment of the state of development of fuel cells for automotive applications, in terms of performance and durability.

The analysis of the main aspects to be faced in design and realization of a fuel cell system as power source of an electric drive train is described in Chap. 4. Here the problems connected to the choice of auxiliary components, their energy consumption and integration in the overall system are discussed, paying particular attention to the management of membrane humidification, hydrogen purge and air supply as a way to optimize system efficiency and reliability.

The general theme of electric vehicles is covered in Chap. 5, with particular reference to hybrid vehicles that adopt both fuel cells and batteries/supercapacitors as power sources. The analysis of possible hybrid configurations is presented together with a review of different types of electric energy storage systems.

Chapters 6 and 7 refer to two practical case studies, in particular two fuel cell propulsion systems of different size. Here the technical characteristics of all individual components are described, and the results of an experimental characterization carried out on laboratory dynamic test benches are discussed. The findings of these two chapters evidence the limitations and potentialities of fuel cell power trains at the present state of development, in terms of performance, efficiency, environmental impact and durability.

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