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Preface

The Workshop on Development of Advanced Battery Engineering Models was held on 14–16 August 2001 in Crystal City, Alexandria, VA. The purpose of this workshop was to assemble experts from industry, national laboratories, and academia to review current research on advanced battery engineering models. Presentations were given by leading scientists and engineers that covered a wide variety of topics related to the chemistry and technology requirements of nickel metal hydride, lithium-ion and lithium-polymer battery systems. The approach was to provide a critical review of the current status of our understanding of vehicle simulation models and battery models and to identify factors that limit the effectiveness of batteries performance, failure and thermal models and vehicle simulation models.

The DOE's Office of Advanced Automotive Technologies sponsored this workshop on the development of advanced battery engineering models to review the key topics being explored in this field as applied to nickel metal hydride, lithium-ion, and lithium-polymer rechargeable batteries being developed for hybrid electric and electric vehicles. Interest in new rechargeable lithium batteries continues to grow and is a result of their superior performance compared to other rechargeable battery chemistries. The exceptional high-energy density of lithium batteries makes them very attractive for consumer, electric vehicle, and defense applications. Yet, the design and optimization of lithium rechargeable batteries are complex processes, requiring evaluation of many chemical and physical variables and interactions. The goals were to characterize the state-of-the-art in battery engineering models and to develop a comprehensive set of recommendations and priorities to guide their future development. The workshop addressed the rapid growth and interest in advanced lithium ion and lithium-polymer rechargeable batteries for both EV and HEV applications.

Selection of a battery system involves comparison with a set of goals, which pull in different directions. The performance goals, for which the energy-storage device is designed, such as high specific energy and power, tend to produce an unstable and possibly dangerous product. The performance goals need to be balanced against the goals of long life and safety. Any product needs to face the goal of low initial and operating costs, and these are particularly stringent in transportation applications. The time of discharge is the principal determinant of battery type and design, and this brings specific power as the second performance characteristic. Organic or even polymeric electrolytes for lithium batteries seriously compromise specific power. A battery with high specific energy requires that strong oxidizing and reducing agents are stored in close proximity. This leads to a high adiabatic temperature rise on short-circuit discharge which may compromise safety. The presence of organic solvents makes the guarantee of abuse tolerance even more difficult. These same factors mean that a high-energy battery is inherently unstable, with serious implications for service and shelf life. Cost issues are important for any product, with applications like the military, aerospace, and consumers' electronics being more tolerant than vehicle propulsion and energy-storage for delivery of solar energy and backup power.

The mentioned criteria frequently conflict with one an other and require trade-offs. The objective of advanced battery research and development should be to obtain the best compromise among the goals. Then a decision must be made of whether the balanced system will be implemented instead of a competing technology. This decision may well be outside of the factors enumerated above to include, for example, noise and pollution. Battery modeling is a cost effective way to make choices among requirements.

Hybrid vehicles have the potential to increase fuel economy by using a primary engine operating at a constant power to supply average power requirements and a battery power unit for peak power demands and to recover braking energy. To date, limited optimization analysis has been performed for hybrid vehicles. The role of the driving cycle, the time of discharge and maximum current (or power) levels are the most important parameters. A combination of both vehicle model and battery model is required to determine the complex interaction between hybrid vehicle design and battery power. A major concern is the limitation on battery calendar life when operated at partial states of charge. Battery modeling promotes our understanding of processes. Battery modeling identifies critical parameters and materials properties. Battery modeling permits performance simulation, optimization relative to design goals and allows us to approach failure mechanisms. Battery modeling improves a context for invention and characterization of materials.

The preferred vehicle battery control algorithm development process begins with a quality battery model. The ideal battery model not only defines a response to a defined input, but also is predictive in nature. This allows the opportunity

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for preventative actions in advance of system failures. Battery models must exhibit extremely quick response time to be applicable to dynamic full HEV and soft hybrid (42 V) applications.

Research efforts presented at the workshop are summarized in this proceedings volume entitled, ‘‘A Workshop on Development of Advanced Battery Engineering Models.’’ The papers in this proceedings volume are representative of the blend of science and engineering that is needed to create batteries for new technological applications such as electric vehicles and hybrid vehicles. These papers present the most recent findings and thinking of the scientists working in this important and challenging field. It is hoped that these papers aid the reader in gaining a better understanding of some of the complex issues involved in the science that underlies the development of new battery technologies.

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