INTERVIEW: FRANCISCO TRINIDAD

«For the medium cars and Sport Utility Vehicles (SUVs), the technology of choice will be HEV»

Francisco Trinidad is a Doctor in Science, electrochemical major for the *Autonoma* University of *Madrid*. He started his professional career in *TUDOR* (1977), developing several research projects related to Zinc primary batteries and polymeric batteries. In 1986, he was designated Head of the Research Laboratory and subsequently in 1992 became Director of Industrial batteries development in *Madrid* and *Soet* (Germany); where he managed the development department of the *Hagen* company. In 1994, *EXIDE*, the first world battery manufacturer, acquires TUDOR and joined together with other French, German, Italian and British companies, to create the *EXIDE Holding Europe Group* (with social head office in Paris). He was the role of Development Director until 1996 and Research Director until 2002. Currently, he is the Director of Innovation in the Transport Division.

EXIDE Research

Buran: Could you please give a brief explanation of the research aims that EXIDE are currently involved with; particularly on the focus of systems storage in hybrid electric vehicle (HEV) applications?

Francisco Trinidad: EXIDE is one of world's largest manufacturers of lead-acid batteries and the R&D focus is in this technology, trying to improve performance (mainly specific power) and durability under partial state of charge conditions that are particularly relevant for HEV applications. The most recent innovation that we have introduced is the use of special graphite and micro-fibre glass in the negative active material of Valve-Regulated Lead-Acid (VRLA) batteries.

Hybrid Electric Vehicles (HEVs)

Buran: Why is lead-acid technology a good choice for HEVs? What are the current limitations of the technologies?

FT: In terms of cost of the energy or power needed for HEV functions lead-acid is the most favourable technology. However due to the high density of lead there is a limitation on the specific power as well as in terms of cycle life, still low as compared with other advanced technologies.

Buran: From a technical perspective,

which battery technology (Lead-acid, Nickel-cadmium, Nickel-metal Hydride and Lithium-Ion) would be best suited for the application of full HEVs, what are the overall advantages and disadvantages of this technology type?

FT: From the performance point of view, Lithium-ion is the most suitable for HEV because its combines a very high specific power with long life. However cost and safety are strong limitations, for that reason today's technology of choice is Nickel-Metal Hydride is spite of the high cost of the raw materials. Cadmium is not allowed for environmental reasons and lead-acid's power and durability are still not sufficient for full HEVs.

Buran: Currently on the market there are parallel configured HEVs of varying voltages. How do you choose the optimum voltage? What are the differences in capabilities in choosing different voltage outputs?

FT: That depends on the degree of hybridisation. Start/Stop and regenerative braking is possible at low voltages (14V/42V) but full electric power requires much higher voltages (>144V) to reduce ohmic losses.

Buran: What would you consider to be the most important factor to improve in batteries for HEVs? Are there any improvements which are crucial to the developments of HEVs growth?

FT: Specific power for acceleration, charge acceptance for regenerative braking and durability under partial state of charge conditions are the most critical battery issues for the development of HEVs.

Buran: Is the Battery Management System (BMS) of an HEV important? If so, why, and what are the capabilities of a BMS? What specific actions does the BMS require / produce?

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FT: BMS is an integral part of the electrical system. It has to be able to determine precisely the state of charge, state of health and power capability (in charge and discharge) of the battery. Actions to be taken depends on the vehicle design and battery technology, the most common are related to thermal control and energy management.

Battery Requirements

Buran: Are there any new requirements for vehicles in terms of batteries? If so, what are they?

FT: In conventional vehicles, the battery is intended to start the engine and is almost fully charged all the time. In HEVs, the battery has to accept power from regenerative braking and should be able to launch the vehicle, even for a full acceleration period. As a consequence the most important requirements are specific power (end terms is W/kg) and energy (in Wh/kg) and last but not least durability under high rate partial state of charge conditions.

Buran: Which other measurements within HEVs are governed by the movements of legislation?

FT: Environmental legislation is the trigger for HEV application: Fuel consumption and emission reductions are being enforced by legislation, then batteries are an integral part of new legislation on vehicles emission.

«Nearly 100% of lead-acid batteries are recycled today»

Buran: What is the life-expectancy of the lead-acid technology? Would this battery technology be able to last the life of the full HEV, or would they need changing during the useful life of the vehicle?

FT: Life-expectancy would depend strongly on the amount of energy to be stored as well as the temperature, rate and state of charge. For full HEV the requirements today are not achieved by the state of the art lead-acid battery.

Buran: In the case of a crash, are the battery packs safe? If so, what measures have taken place to ensure the safety of both the driver and the battery packs?

FT: This depends on the technology: Lead-acid and Ni-MH are safe, but high temperature technologies (Na-S) were not considered safe enough in the past. Lithium safety is still a concern and should be proven in large scale applications.

Buran: When the vehicle comes to the end of its life, who is liable for the safe disposal of the battery packs? How is the disposal of the battery packs dealt with?

FT: There are special companies to deal with this environmental issue. Nearly 100% of lead-acid batteries are recycled today, but other technologies should develop further the recycling process to be economically viable.

Buran: Battery packs can either be designed with four connectors (2 anodes and 2 cathodes) or two. What would you consider to be the best option? Are there significant differences between either choice?

FT: Double connector reduces the electrical resistance and improves efficiency of the charge/discharge process. On the other hand, material and manufacturing cost are increased. For lead-acid technology this design is still in development and reliability needs to be improved.

Migration towards 42V

Buran: Is a 42V network power system safe enough to drive with?

FT: Yes, there are some mild hybrid vehicles in the market (Toyota crown, GM Silverado) with 42V network where safety problems have been overcome.

Buran: Does a 42V power system easily meet the power demands of the vehicle?

FT: The 42V network power is not intended for full power hybridisation, but for power assist (launching) and regenerative braking, that means around 10-20% of the total power needed for the vehicle.

Buran: According to Igor Demag (Peugeot and Citreon's hybrid vehicle developments), there is no significant connection between HEVs and 42V supplies. Do you agree?

FT: Yes, most car manufacturers are looking for high voltage HEVs (>144V), whereas 42V network is more considered for future high power demands on conventional vehicles.

Buran: According to E. Karden (Leading automotive engineer at the Ford Research Centre, Germany), the current 12V technologies are suffice, and states it is not necessary to move towards 42V systems for conventional vehicles. Do you have any views

on this matter? Why has this not taken affect as yet?

FT: Start/Stop applications are in the market with 12V batteries (Citroen C3, for instance), but regenerative braking is in the development phase because of the difficulty to accept charge at high rate in lead-acid batteries.

The Future: New Technologies

Buran: Is it possible to apply the technology of supercapacitors to vehicles today; including HEVs? If so, how can this be achieved / implemented? If not, what measures would need to be put into place in order for the operation of such a technology to take place?

FT: From the technical point of view, the combination of capacitors and lead-acid batteries is feasible because the power (and charge acceptance) of capacitors is superior to any battery technology, whereas lead-acid is the most economical energy storage system for automotive applications. However, in order to be economically viable, capacitors should reduce its price at least one order of magnitude.

Buran: What is your opinion of hydrogen fuel-cell technology? What are the current limitations, preventing it from being introduced?

FT: Fuel cell technology is not new; it was invented almost 2 centuries ago. The technology is still too expensive for automotive applications and will need further development to be a reality in high volume consumer or industrial applications.

Buran: Do you see HEVs as the transitional technology nearing towards the long term plan for fuel-cell operated vehicles?

FT: Yes, this can be a possibility, but the transitional period is going to be significantly larger than expected (10-20 years).

«The transitional period to fuel-cell is going to be significantly larger than expected (10-20 years)»

Buran: What other technologies do you think may progress in the future? Is HEV the best option?

FT: Electric vehicles (EVs) with Lithium batteries is a viable alternative for small urban vehicles, particularly some manufacturers in Europe and Japan are bidding for this technology. However, for the medium cars and SUVs, the technology of choice will be HEV due to the performance and range constraints of EVs.

Buran: What are the future possibilities for EXIDE in terms of HEV research?

FT: EXIDE is developing the ORBITAL VRLA Technology and will further improve durability in the present decade in order to offer the lowest cost alternative for HEV applications. We still believe that lead-acid technology will take a significant share of the HEV market because cost of energy per Km will still be the most important factor for car manufacturers.

by Diego Sánchez Repila & John Poxon