UNIONE EUROPEA

Ministero dell'Istruzione
dell'Università e Ricerca

UNIVERSITÀ DEGLI STUDI DI SALERNO

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Dottorato di Ricerca in Ingegneria Meccanica
X Ciclo N.S. (2008-2011)

"Sperimentazione e controllo di un veicolo ibrido-solare con tetto orientabile"

ABSTRACT

Ing. Gaetano Coraggio

Il Tutor
Ch.mo Prof. Gianfranco Rizzo

Il Coordinatore
Ch.mo Prof. Vincenzo Sergi

ABSTRACT

For some years the environmental energy issues are now become public domain, losing perhaps from the scientific point of view, but affecting on the behavior of an increasingly large part of the population.
The main objective of the thesis is the research of an alternative to the traditional vehicles whose their impact on the environment is growing.
Of course, a good alternative is represented from the hybrid vehicles, vehicles equipped with two propulsions system (i.e. internal combustion engine and electrical engine in the hybrid electric vehicles).
The integration of PV panels, as a solution that can further contribute to reducing fuel consumption and emissions, is a solution that doesn't exclude others but can add their own benefits to those obtained, for example, with the hybrid electric vehicles (HEV).
We speak in this case of hybrid solar vehicles (HSV). Many prototypes of HSV have already been presented. Among these there is the prototype developed at the University of Salerno.
In the medium long term, the likely further price reductions and efficiency improvements of photovoltaic cells, integrated from the design phase in the vehicles with low energy consumption, can lead to almost complete autonomy, at least for the large part of motorists who use the car mainly in urban areas for a few hours per day.
Obviously, an increase in terms of captured energy by solar panels has a positive effect on the fuel consumption and emissions. One way to increase this captured energy is design a solar orientable roof , which is capable to follow the movements of the sun during the day.
The main goals of the research are focused on the study of the prototype of hybrid solar vehicle and on the development of a mobile solar roof that can be arranged at right angles to the sun when parking to increase the captured energy

The first part of the research has focused on the study of a control strategy for the optimal on board energy management of an hybrid solar vehicle with series structure. This vehicle is supplied to the Department of Industrial Engineering, University of Salerno. It is a Porter Van Glass of Microvett, an electric vehicle converted in an hybrid solar vehicle, thanks to the integration of solar panels on the roof and in the rear compartment of a motor generator.
The control strategy is called Rule-Based. The control architecture RB consists of two main loops: an external one, which determines, as a function of the solar contribution expected during the parking, the state of charge of the battery (SOC) to be reached at the end of the driving phase; the second one is internal and its objectives are: the identification of the optimal scheduling of the generator group and the control of the variations of the SOC around the final value indicated by the first loop.
The performance obtained from the RB architecture were analyzed by a detailed simulation analisys. This simulation, performed in real time on the vehicle, has demonstrated the high potential offered by the proposed strategy.
The second part has focused on the design and implementation of a mobile solar roof for an hybrid solar vehicle. This model was created with the SolidWorks software. As a base knowledge have been used the influence of the angle of incidence on the fraction of incident energy with respect to

the energy captured, the solar radiation for different cities, and the kinematics of parallel robots.
Obviously a suitable tilt of the panels accumulates more solar energy. So a mobile panel is more suitable than a fixed one. This was underlined by the use of a American simulator: PVWATTS (valid for Americans cities). Since the solar radiation varies according to the place of reference, in this simulator must be provided as input data: latitude and longitude of the location, angle of the fixed panel or movable panel rotatable about two axes. In this way it was possible to check the gain of a mobile panel with respect to a fixed one. From these results, it was confirmed the convenience of having a mobile solar roof.
The model has been designed with two software: MATLAB and SolidWorks. Later they were made and automated three scale prototypes.
It has been demonstrated how the use of a mobile solar roof during parking phases can contribute significantly to increase the solar energy captured in the hybrid solar vehicles.
In addition, the percentage contribution can be particularly significant at high latitudes, thus helping to extend the potential market for these vehicles.
In order to improve the benefits of the mobile roof, the energy consumption due to its movement must be minimized, and must be avoided unnecessary movements. So it was presented a control strategy based on the combined data of: solar energy provided by the solar panel, the information from a GPS module and processing images of the sky taken by a digital camera. For this purpose has been developed a control system implemented in LabVIEW and tested on a small scale prototypes under conditions of artificial light.
Has also been presented a strategy that allows to determine the optimal interval of time between two consecutive orientations of the roof. This interval depends on the time of day, the seasons of the year and the actual conditions of the sky.
From the considerations made is apparent, therefore, that it is advisable to adopt the presented control strategy , in order to maximize the advantages of a mobile solar roof in the hybrid solar vehicles.