Hybrid vehicles with two or three wheels
Ph.D. Research Activity
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Hybrid three wheeled vehicles equipped with linkage

Three wheeled vehicle with linkage
- Mechanical characteristics of the vehicle.
  - Three wheeled vehicle: for urban and sub-urban mobility; it is suitable to novel rider.
  - Titting front module (one wheel) and non-titting rear module (two wheels).
  - Four-bar linkage: to improve the stability and the handling of the motorcycle.
  - Transmission: chain drive without differential.
  - Good dynamics performance and comfort.
  - Passenger and/or auxiliary bags are allowed.

Series hybrid propulsion system
- In-wheel motor
  - 2.5 kW @ 1800 rpm
- I.C.E. + Ge
  - 4.1 kW @ 6000 rpm
- Batteries
  - 1.8 kWh @ 70 Ah
- Charging time
  - 2.5 kW @ 11.5 kW @ 2800 rpm
- SPM electric generator

Working modes:
1. only electric mode with regenerative braking and i. c. engine switched off.
2. electric mode with regenerative braking and i. c. engine switched on.
3. plug-in mode for the batteries charge.

Matlab code for the designing of three wheeled vehicles

A computer code has been developed for better integrating the mechanical design of the chassis with the hybrid propulsion system. The program features are:
- Estimation of dimensions and weights of electric components and optimal position of every component on the vehicle.
- Calculation of vehicle range, only electric mode, with electric generator switched on, regenerative braking.
- Performance calculation: acceleration, speed.
- Curve stability (Steady Turning).

Graphical examples concerning the performance calculation are given.

MO.bi regional project - Aprilia RS4 125 Hybrid

Feasibility study of a mild-hybrid motorcycle
The goal was to estimate the increase of weight and volume due to the substitution of the traditional alternator with a more powerful one, in order to improve the thermal engine torque (I.C.E. torque) realizing a parallel hybrid.

A specific torque profile (hybrid torque) has been designed for satisfying the limitation in terms of maximum power (11 kW). The project of an optimized SPM machine has been carried out.

A computer code has been developed for testing the system composed by the motor, the drive and the energy storage, in terms of range calculation on a reference cycle for motorcycle (WMTC).

Practice realization
The mechanical characteristic of the electric motor has been obtained experimentally by means of a specific test bench in Aprilia.

Final results
Finally, the whole motorcycle has been tested on the private track of Piaggio factory. Telemetries concerning the motorcycle behavior have been acquired.

Future Works
- Improvement of the matlab code in order to estimate the advantage of a variable transmission between the electric motor and the wheels.
- Design of the electric machine for the Velomobile and realizing of a prototype of the whole vehicle in cooperation with EUROSYSTEMS Company.

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