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LTAS Automotive Engineering
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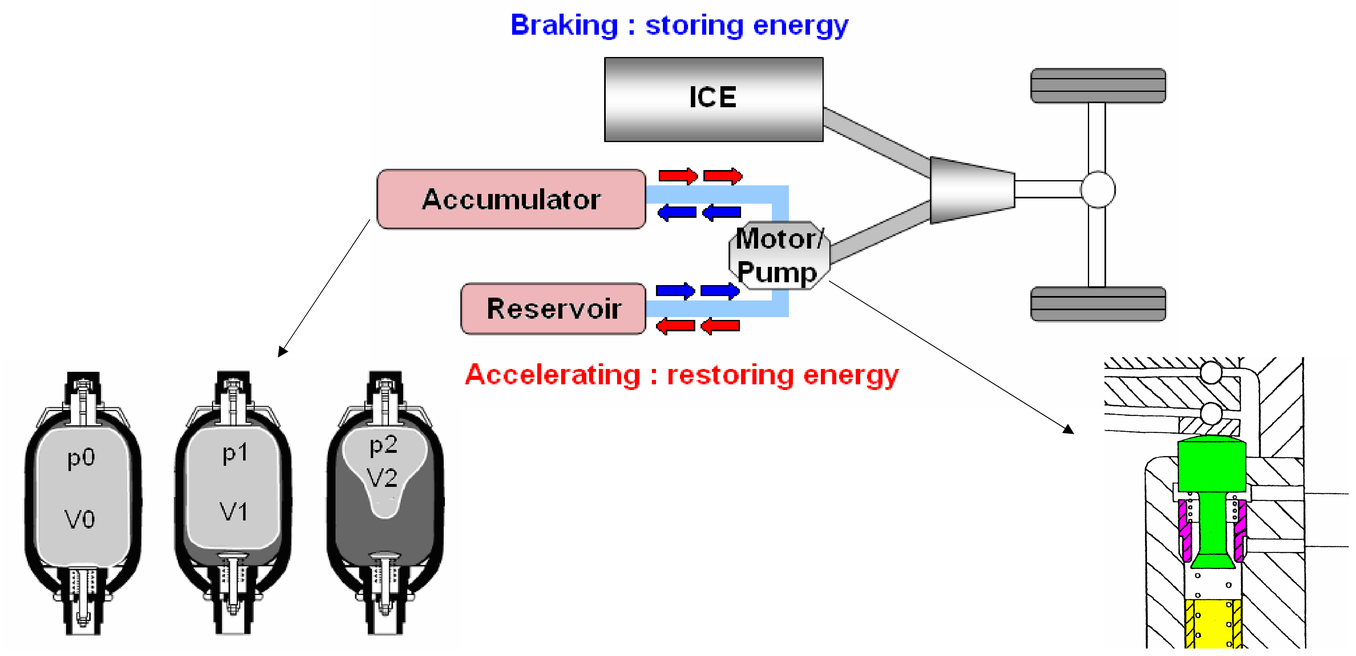
Analysis of hybrid hydraulic vehicles and economical comparison with hybrid electric vehicles

Main ideas

- Taking advantage of recent developments in reversible hydraulic machines, we lead a preliminary study of hydraulic hybrid vehicle (HHV) technology applied to different types of vehicle (a C-segment passenger car, a sport utility vehicle and an urban bus) in order to assess the fuel economy and reduction of CO_2 emissions.
- The second idea is to make a complete economical comparison between HHV and hybrid electric vehicle (HEV) for the type of vehicle that has obtained the most promising results in the first part of the simulation i.e. the urban bus. We compare not only the fuel economy but also the overall cost to develop, produce and maintain a fleet of hybrid hydraulic buses.

Hybrid hydraulic vehicles principle

During braking phases, water or oil is pumped from the reservoir to the high pressure accumulator (the hydraulic machine is working as a pump). This stored energy is used by emptying the accumulator through the hydraulic machine (working as a motor) to provide power assist. The HHV technology suits well for parallel architecture (mild hybrid).



Simulation with Advisor of different types of hybrid hydraulic vehicles

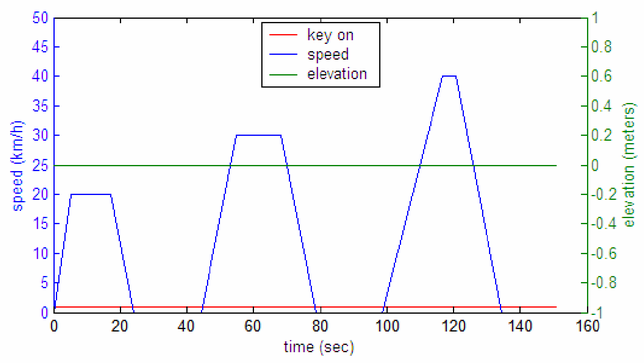
	C-Segment	SUV	Bus
Engine	Diesel	Gasoline	Diesel
P_{max} [kW]	56	102	205
C_d	0,31	0,41	0,45
S [m²]	1,98	3,06	5,88
L [m]	4,2	4,57	12,04
Mass [kg]	1235	1785	15281

C-segment car NEDC	Mass (kg)	Fuel cons. (l/100 km)	Fuel saving (% of ICE)
ICE	1235	5,51	-
HEV	1330	4,96	-9,97 %
HHV: Energy sizing	2780	6,66	+ 20 %
HHV: Mass sizing	1446	5,30	-3,84 %

Urban bus / NYCC	Mass (kg)	Fuel cons (l/100 km)	Fuel saving (% of ICE)
ICE	15 281	101,28	-
HEV	16 000	56,90	-43,82 %
HHV: Energy sizing	57 016	124,10	+22,51 %
HHV: 5 accumulators	16 555	70,50	-30,39 %
HHV: 10 accumulators	17 769	72,44	-28,47 %
HHV: 15 accumulators	18 983	74,92	-26,02 %
HHV: 20 accumulators	20 187	76,52	-24,44 %

Comparison between hybrid hydraulic buses and hybrid electric buses simulated on three SORT drive cycles

HEV bus	SORT 1 30000 km/y	SORT 2 43000 km/y	SORT 3 65000 km/y
Components (€)	21863	20014	20150
Fabrication (€)	7250	7250	7250
Development (€)	2250	2250	2250
Total (€)	31363	29514	29650
Energy storage cost (€/year)	-5914	-4838	-4583
Fuel economy (€/year)	3934	4231	4899
Brake economy (€/year)	500	500	500
Economy (€/year)	-1480	-107	816
Payback time (years)			36,3



Urban drive cycle (SORT 1)

HHV bus	SORT 1 30000 km/y	SORT 2 43000 km/y	SORT 3 65000 km/y
Components (€)	19900	19900	19900
Fabrication (€)	4000	4000	4000
Development (€)	2250	2250	2250
Total (€)	26150	26150	26150
Energy storage cost (€/year)	0	0	0
Fuel economy (€/year)	1870	1550	1024
Brake economy (€/year)	500	500	500
Economy (€/year)	2370	2050	1524
Payback time (years)	11	12,8	17,2

Conclusions

From the single consumption point of view, the HHV technology can not rival with the performance achievable with a HEV. But when the cost is also taken into account, the HHV technology can compete with HEV thus making the HHV technology a valid alternative in niche markets such as urban buses, bin lorries or heavy urban delivery vehicles.

Ingénierie des Véhicules terrestres

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