International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

Mild Hybrid Technology in Automotive: A Review

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Abstract - *In this generation vehicles have professed to be one of the generally possessed resources on the planet however vehicle proprietorship has a foreordained cost to guarantee it and variable expense to utilize and work the vehicle. Two or three investigations have attempted to make sense of the costs and favorable circumstances of MHEVs (Mild Hybrid Electric Vehicle's) yet none examine the price and focal points of MHEVs at a degree of characteristic like what specifically has been carried out on other vehicle progressions. The CO2 institution has gotten more restrictive in time, and to accomplish the targets constrained by this establishment and to satisfy this goal car industry chose to create mixture vehicles. Advancements like Mild, Plugin and full hybrid emerge to attain the constrained targets. This article will give a review of the estimation of Mild Hybrid innovation (cross-breed development) and give you that such advancement is a key progression until the obstructions are not outperformed and electric vehicles become the norm.*

Key Words: *CO_2 reduction vehicle, Cross-breed innovation, Hybrid, MHEV, Mild Hybrid.*

1. INTRODUCTION

Engine/motor is a machine which has function to convert the energy one form to another like chemical into mechanical energy. Internal Combustion (IC) Engine which burns the fuel to produce heat and use that heat to perform some mechanical work, Electrical motor transform electrical energy into mechanical energy, pneumatic motors or compressed air engine performs mechanical work by expanding Compressed air, and clockwork motors use elastic energy to perform mechanical work. The first commercially successful IC engine was built by Jean Joseph Etienne Lenoir in 1859 and the first IC engine based on the otto cycle was designed by Nikolaus Otto in 1876. And later on, in 1885/1886 Karl-Benz designed his won 4-stroke engine (Built-in 1885 and patented in 1886).

A heat engine is a motor or machine which is used to convert thermal and chemical energy into mechanical energy which can be used to perform some mechanical work. On the bases of its working and its output it can be divided into three parts which are as follows:

1.1 External Combustion (EC) Engine: An engine in which inward working liquid is heated by the ignition of an outer source through a heat exchanger [1]. The liquid is extended & followed up on the motor's mechanism which assists with creating the movement and valuable work and after that liquid is chilled off, compacted, reused or dumped and this procedure happens within the sight of some oxidizer so the ignition of the liquid can be singed appropriately with no misfortune.

Fig-1 Stirling External Combustion Engine

1.2 Internal Combustion Engine: An engine in which combustion of fuel takes place internally with an oxidizer (typically air) in a shut ignition chamber. In this engine, high temperature developed and gases occurs by burning which legitimately send the power to part's of the motor, for example, a cylinder, turbine sharp edges/spout, and by moving them over a separation, produces mechanical work [2].

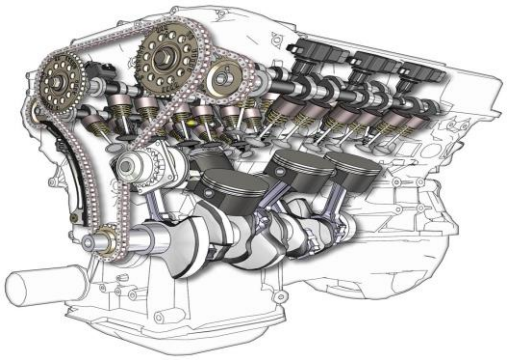

Fig-2 Internal Combustion (IC) Engine

1.3 Air-breathing combustion engines: This type of engine utilizes oxygen (in barometrical air) to consume the fuel, instead of conveying an oxidizer.

2. Semi/Mild Hybrid Engines:

Semi hybrid/mild hybrid are generally the vehicles equipped with internal combustion engine and one electric motor/generator at the same time in a parallel mixture design which permits the motor to be killed when the vehicle is halted at the traffic signal/wherever for over 5 seconds and can restart the motor immediately when the clutch pedal is again squeezed. Mild Hybrid/Semi hybrid can utilize regenerative slowing down and somewhat of intensity help to the IC motor, yet they don't have the electric-only method of impetus. In mild/semi hybrid technology utilize an electric engine that gives more prominent productivity by supplanting the alternator or starter engine with a solitary instrument that underpins the force train and mellow/semi crossover doesn't require a similar measure of battery power level and efficiency headway when contrasted with full mixture vehicles. For instance, in 2005-2007 Chevrolet directed a test by propelling its one vehicle with a similar innovation named Chevrolet Silverado (Parallel Hybrid Pickup Truck). [4] In this pickup truck, a solitary 3-stage 7kW electric engine was mounted in the chime lodging (between the regular transmission and the motor) and with the assistance of this Chevrolet had the option to expand the 10% city eco-friendliness in the Chevrolet Silverado by beginning and halting at whatever point essential and diminishing the parasitic burdens. Notwithstanding, Parallel Hybrid Truck (PHT) is not having power help or EV highlights and a restricted measure of regenerative slowing down properties.

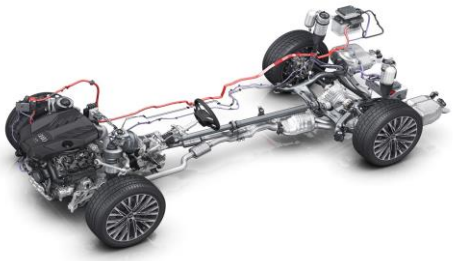

Fig-3 Mild Hybrid Engine [14]

3. SHVS (Smart Hybrid Vehicle System):

SHVS (Smart Hybrid Vehicle System by Maruti Suzuki) is an advancement in the existing fuel consumption/efficiency, it helps us to increase the fuel efficiency of the car and increase its driving performance.[8] SHVS technology stops the engine when the vehicle is not moving or in the stopped mode for more than 5 secs and silently starts the engine when the driver again presses the clutch pedal. SHVS technology has four main features i.e. power assist, idle engine start-stop, gear-shift indicator, brake energy regeneration.

3.1 Power Assist: All the energy is stored in high capacity batteries but there is an extra battery in the Maruti Suzuki hybrid vehicles which helps the engine power throughout the acceleration period and all these results in improving the engine performance/efficiency and forbid the wastage of fuel.

3.2 Brake Energy Regeneration: It normally means retrieving the kinetic energy which is lost when we have applied the brakes. Maruti Suzuki hybrid vehicles comes with a device named as Integrated Starter Generator (ISG), which converts the energy released by applying brakes or decelerating the vehicle speed and stores it in the battery. Energy stored in the battery will be used later to run the ISG, which helps the engines start-stop function.

3.3 Idle engine Start-Stop: This function normally helps to turn off the vehicle engine when vehicle is not moving or it is in the standstill position for more than 5 secs and it silently starts the engine when driver presses the clutch pedal again. But for this function to work properly, the vehicle needs to be in the stopped position or in standstill mode, gear should be in the neutral position and your left foot should be removed from the clutch pedal.

3.4 Gear-Shift Indicator: As we can guess by the name of the function itself what it is and what it does in the vehicle. Gear-shift Indicator is a function which reminds the driver to change the gear at accurate speed which results in improving the fuel efficiency of the engine.

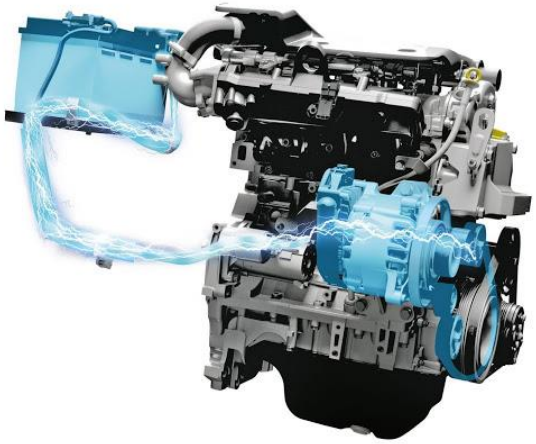

Fig-4 Maruti Suzuki SHVS Engine

4. Intelli Hybrid Vehicle System:

Intelli hybrid system is advancement in the existing fuel consumption technology by Mahindra & Mahindra, this technology help us to improve the fuel consumption/efficiency of the vehicles. In this technology, Mahindra & Mahindra uses a Belt driven starter Generator (or BSG) and the conventional alternator is replaced with an electric motor which is mounted on the engine. And this technology also offers the power assist, regenerative

braking, gear shift indicator which is placed on the instrument console.

5. BSG or Belt Driven Stator Generator:

The purpose of BSG is to convert the energy which is lost during acceleration and braking into electricity and help us to recharge the battery. When we apply the brakes, sensors and controllers detect the braking of vehicle and automatically switch to generator mode. It then utilizes the braking energy by working as generator. This technology is very helpful in metropolitan cities bumper to bumper traffic [7].

5.1 Power Assist: All the energy is stored in high capacity batteries which helps the engine power throughout the acceleration period. This technology also helps to detect, when the driver has started accelerating hard then it shifts the engine to the power assist mode depending on the accelerator pedal input and all these results in improving the engine performance/efficiency and forbid the wastage of fuel.

5.2 Brake Energy Regeneration: It normally means retrieving the kinetic energy which is lost when we have applied the brakes. Mahindra Intelli hybrid system comes with a device named as Belt-Driven Stator Generator (BSG), which converts the energy released by applying brakes or decelerating the vehicle speed and helps to recharge the battery.

5.3 Idle engine Start-Stop: This function normally helps to turn off the vehicle engine when vehicle is not moving or it is in the standstill position for more than 5 secs and it silently starts the engine when driver presses the clutch pedal again. But for this function to work properly, the vehicle needs to be in the stopped position or in standstill mode, gear should be in the neutral position and your left foot should be removed from the clutch pedal.

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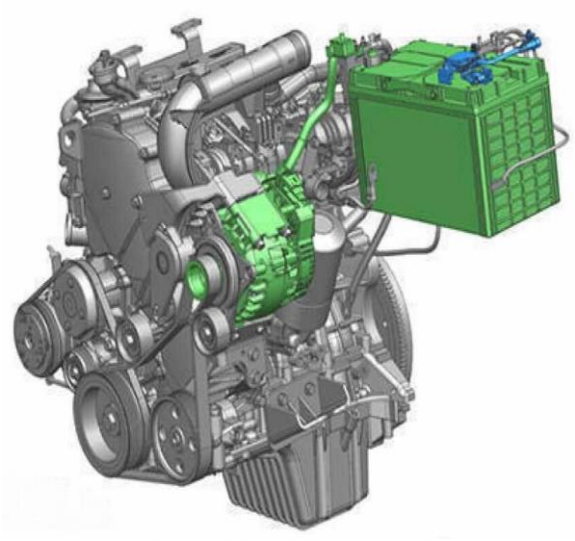

Fig-5 Mahindra Intelli Hybrid Engine [6]

6. Integrated Motor Assist:

Integrated Motor Assist (IMA) is a hybrid technology which was introduced by Honda in 1999 in their Honda Insight Project. In this technology, an electric motor is used to act as traction assist motor, starter motor, and as an engine balancer between transmission and IC engine. The first generation of IMA, it isn't powerful so that it can power the vehicle on electricity alone, so the motor alone can't be used to assist or start the IC engine. But in 2006, they come back with the up-gradation in the existing technology in their new project known as Civic Hybrid. Civic Hybrid 2006, however, can make the electric motor operational while the vehicle is moving easily without turning on the IC engine. But IMA has a less effective motor in contrast to Toyotas HSD (Hybrid Synergy Drive) motor. This technology comes with starting, regenerative braking.

6.1 Starting: Vehicles having IMA (Integrated Motor Assist) technology can turn off their engines when the vehicle is not moving and when the driver releases the brake pedal it switches it on rapidly with the help of an electric motor and in manual transmission variants, it starts the engine when gear shifter is placed into gear from the neutral position.

7. Regenerative Braking: IMA (Integrated Motor Assist) uses a regenerative braking technique to store the energy which is going to be lost to heating during deceleration and use that energy later to accelerate the vehicle. This technique has 3 main effects on the vehicle: reduces the workload required by the engine, increases the acceleration rate, and reduce the frequent brake hardware replacement.

Fig-6 Honda Insight IMA(1999)

Fig-7 Honda Insight IMA(2009)

Semi hybrid vehicle does not have any crucial variation with Hybrid vehicles in reference of hardware but they are different in control algorithm. In other words we can say that semi hybrid vehicle is a hybrid vehicle but with lower power of hybridization (about 15%). In semi hybrid vehicles the size of a driving force of electric component is much smaller than the hybrid vehicle because production of propulsion energy mainly depends on the IC engine.

Table-1 Features of the vehicles

		Conventional	Mild Hybrid
Vehicle Configuration	Type	VHE_SMCAR	VHE_SMCAR
	Mass (kg)	592	592
	Rolling Resistance Coefficient	0.0054	0.0054
	Aerodynamic Drag	0.25	0.25
	Project Area (m^2)	1.9	1.9
	Wheel Radius (m)	0.282	0.282
Combustion Engine	Type	Geo Metro 41 kW 1.0 Liter	Geo Metro 41 kW 1.0 Liter
	Mass (kg)	131	131
	Thermal Efficiency (%)	34	34
Electrical Motor	Type	----------	8 kW, AC
	Mass (kg)	--	14
	Electrical Efficiency (%)	--	93
Gear box	Type	5-speed manual transmission	5-speed manual transmission
	Mass (kg)	114	114
	Mechanical Efficiency (%)	95	95
Battery	Type	--	Nickel-Metal Hybrid
	Number	--	9
	Feeding Voltage (V)	--	122
	Mass (kg)	--	104
Total Mass (kg)		984	1100

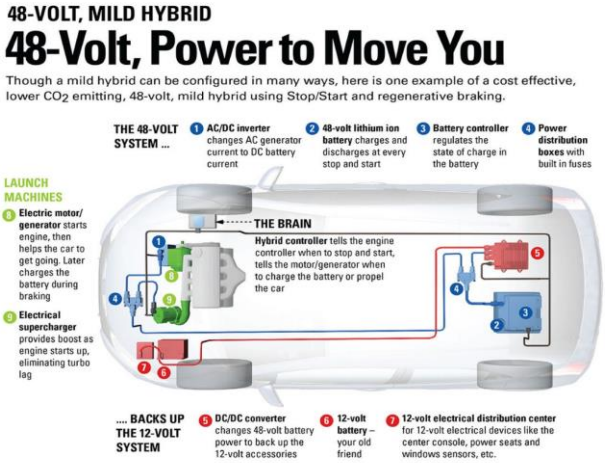

Fig-8 48V System

MHEV is also a described functional/ operating modes which can be performed. Beneath given table illustrates the combination of vehicle hybridization at various levels, power property purpose and working modes.

Table-2 Different features in different Vehicles

	Micro Hybrid	MHEV			HEV	PHEV	EV
Topology	Regular starter	BiSG	TiMG	CiSG	Power-split	Power-split / Parallel	Direct Drive
Electric power [kW]	2-4	10-15	< 21	15-20	25-60	40-100	> 60
Operating voltage [V]	12	48	48	< 160	150-350	< 400	<450
Cold engine cranking	Yes	No	Yes	Yes	Yes	Yes	Yes
Idle Stop & Start	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Moving Stop & Start	Optional	Optional	Yes	Yes	Yes	Yes	Yes
Engine load shift	Optional	Yes	Yes	Yes	Yes	Yes	Yes
Torque assist(fill)	No	Yes	Yes	Yes	Yes	Yes	Yes
Torque boost	No	Yes	Yes	Yes	Yes	Yes	Yes
Sailing / Coasting	No	Optional	Yes	Yes	Yes	Yes	Yes
Energy recuperation	Optional	Yes	Yes	Yes	Yes	Yes	Yes
Brake regeneration	No	Optional	Yes	Yes	Yes	Yes	Yes
Electric driving / creep	No	No	Optional	No	Yes	Yes	Yes
External charging	No	No	No	No	No	Yes	Yes

8. Conclusions:

Published work regarding on mild hybrid engine and its recent developments had been looked upon completely during this paper. The need for a hybrid engine has come up to counter with the conventional resources of fuel, the study of the available engines arises the need of an efficient platform with the capability of switching to required power mode as per the pre-requisites. There are existing versions of hybrid engines but none of them have met the requirements efficiently.

We need an engine which can work up to 80% efficiency. In Mild Hybrid vehicles 48V generator/motor replaces the regular alternator and starter motor which further help in smoother starting, efficiency and weight saving. Mild Hybrid vehicles may not save as much fuel as standard hybrid but mild hybrid vehicles can improve the engine efficiency/CO_2 reduction potential from 15-20% and they are indeed cheaper than full hybrid vehicles. The normal average cost of full hybrid car starts from $23,000 - $35,000 + taxes (₹1720572.50 - ₹2618262.50) and on the other hand mild hybrid cars cost only half of the full hybrid cars price. So, it becomes quite difficult for a middle class person to buy full hybrid car.

9. Acknowledgment

This whole research work is done under the guidance of Professors, Automobile Department Chandigarh University, Gharuan, Mohali who has provided all necessary resources like data book, research articles for getting necessary and valuable information for the completion of this work and learned about the AI methods and above all, utmost appreciation to the almighty God for the divine intervention in this endeavor.

References:

1) Gao, Y. and Ehsani, M., "A Mild Hybrid Vehicle Drive Train with a Floating Stator Motor-Configuration, Control Strategy, Design and Simulation Verification," SAE Technical Paper 2002-01-1878, 2002, doi:10.4271/2002-01-1878.

2) Gao, Y. and Ehsani, M., "A Mild Hybrid Drive Train for 42 V Automotive Power System—Design, Control and Simulation," SAE Technical Paper 2002-01-1082, 2002, doi:10.4271/2002-01-1082.

3) Emadi, A., Fahimi, B., Ehsani, M., and Miller, J., "On the Suitability of Low-Voltage (42V) Electrical Power System for Traction Applications in the Parallel Hybrid Electric Vehicles," SAE Technical Paper 2000-01-1558, 2000, doi:10.4271/2000-01-1558.

4) Shida, Y., Kanda, M., Ohta, K., Furuta, S. and Ishii J., "Development of Inverter an Power Capacitors for Mild Hybrid Vehicle (MHV) -TOYOTA CROWN ", International Journal of Automotive Technology, Vol. 4, No. 1, pp. 41-45, 2003.

5) Gieras, J.F. and Wing, M., Permanent Magnet Motors Technology: Design and Applications, Marcel Dekker Inc., New York (U.S.A), 1st Edition, 444 pages, 1996; 2nd edition revised and expanded, 590 pages, 2002.

6) http://overdrive.in/news-cars-auto/features/mahindra-intelli-hybrid-technology-explained/

7) http://overdrive.in/news-cars-auto/mahindra-scorpio-with-intelli-hybrid-technology-launched-at-rs-12-84-lakh/

8) https://www.wheelmonk.com/feature/Suzuki-s-SHVS-Mild-Hybrid-System-Explained-20180912/

9) MIT/Industry Consortium on Advanced Automotive Electrical/Electronic Components and Systems". 17 September 2004. Archived from the original on 17 September 2004.

10) Peterson S, Michalek J. Cost-effectiveness of plug-in hybrid electric vehicle battery capacity and charging infrastructure investment for reducing US gasoline consumption. Energy policy 2012; http://dx.doi.org/10.1016/j.enpol.2012.09.059.

11) Simpson A. Cost-benefit analysis of plug-in hybrid electric vehicle technology. In:22nd International battery, hybrid and fuel cell electric vehicle symposium and exposition (EVS-22). Yokohama (Japan): National Renewable Energy Lab;2006.

12) https://x-engineer.org/automotive-engineering/vehicle/hybrid/mild-hybrid-electric-vehicle-mhev-introduction/

13) https://www.carmagazine.co.uk/hybrid/what-is-a-mild-hybrid-system-how-work/

14) Al-Alawi B, Bradley T. Total cost of ownership, payback, and consumer preference modeling of plug-in hybrid electric vehicles. Appl Energy 2013;103: 488–506. http://dx.doi.org/10.1016/j.apenergy.2012.10.009. ISSN 0306-2619.

15) Bishop J, Martin N, Boies A. Cost-effectiveness of alternative power trains for reduced energy use and CO2 emissions in passenger vehicles. Appl Energy 2014; 124: 44–61.

16) Wu X, Dong J, Lin Z. Cost analysis of plug-in hybrid electric vehicles using GPS□based longitudinal travel data. Energy Policy 2014; 68: 206–17. http://dx.doi.org/10.1016/j.enpol.2013.12.054.

17) Plotkin SE. Examining fuel economy and carbon standards for light vehicles. Energy Policy 2009; 37 (10):3843–53.

18) Govardhan OM. Fundamentals and classification of hybrid electric vehicles abstract:, 2017; 3(5):194–8.

19) Lee S, Choi B, Lee J, Won C. 48 V to 12 V soft-switching interleaved buck and boost converter for mild-hybrid vehicle application. In: 2016 19th int. conf. electr. mach. syst. 2016,