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Use of Hydro-electric system in automobile application

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Abstract: So far we have seen 2-3-4 wheel automobile running with the prime mover as Diesel or Petrol or Gas engine. And recently there is Electric motor (BLDC) system which is replacing these pollution makers. But no one has seen Hydro-electric system being used in 2-3-4 wheeler automobile so far. Every electric motor comes with its dedicated controller, Lithium battery and Battery management system and battery charger. It has increased cost of the vehicle by 30% as well as increased dependability on overseas for sourcing of motor, controller, Charger and the battery.

The aim of this paper is to demonstrate how we can use Hydro-electric system into automobile. Instead of electric motor the idea is to use hydraulic motor as a prime mover. And use electric motor to generate sufficient pressure and flow of oil which can run this hydraulic motor. This paper will give an idea how this concept was evolved with benchmark study of existing system. At the same time it will also give the insight of design, development, manufacturing activity involved to complete this project successfully. Also there is comparative data, advantages, dis-advantage of this system over existing system. The budget of the project, benchmark system cost study and development process is described in support with this concept.

Keywords —Hydro-electric automobile, H-electric automobile application, Hydraulic Motor & electric motor application.

I. INTRODUCTION

In India every house has an automobile. This has become part of every family. And at the same time it is undergoing continuous improvement and upgradation to newer technologies. New upcoming technology is electric motor and slowly this will become more and more popular.

As one knows, every technology comes with price. The present electric motor (BLDC) technology is the new technology and the price of motor + controller + battery + battery management system + battery charger contributes 70% of the vehicle cost. Use of electronics in the controller is extensive which makes things more costly. Also we become dependable on overseas companies. As Govt. of India is appealing us to become self-sufficient and self-reliable, one shall think how this can happen.

The object of this project is to demonstrate use of Hydraulic motor as prime mover. There is hydraulic pump which is feeding the oil to motor at required flow and pressure. The DC Motor is used to generate the required flow and pressure. This way it is simple combination of DC motor + Hydraulic Pump + Hydraulic Motor. The selection of DC motor is done for 2 wheeler application and it can be upgraded to use for 3 & 4 wheeler along with increase capacity of Hydraulic pump and the Motor.

All the parts are mechanical in nature. And also all these parts are feasible to manufacture locally.

II. METHODOLOGY

A. RESEARCH AND ANALYSIS

Existing electric two wheeler will be studied to work out the speed and torque needed to drive the two wheeler with load capacity of 150 KG. This weight is considering rider + vehicle. Hydraulic motor will be designed capable to deliver this torque and speed. Based on the torque and speed, oil flow rate and pressure will be calculated which will decide the pump capacity and motor power to drive the pump.

Whole system will be coupled with scooter (activa 110cc) to check the results.

B. THEORETICAL MODEL

A 3D model + 2D drawings of the system components like Hydraulic Motor, Hyd pump will be generated on a designing software like Solid works, Catia and Acad14. The components will be assembled in the software itself to study the functioning of the system and to provide a guideline for all manufacturing and assembly processes.

C. FABRICATION AND TESTING

A scooter (activa 110cc) is taken for demonstrating the functionality. Whole vehicle dismantled to remove unwanted parts like Engine, Transmission etc. Suitable arrangement will be made to assemble Motor with Hyd pump, Hydraulic motor, connection to wheels with fabricated structure. New wiring will be done to make electric circuit to drive and control the system. Hydraulic connections will be done with

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metal pipes of suitable size to handle the oil pressure.

Testing on vehicle include dry run, normal load run and full load run. After reviving the results, components will be modified in case the results are not satisfied. If necessary the vehicle can be taken to vehicle testing agencies to validate the results.

III. PROJECT CONCEPT

This concept is new, unique and there are challenges to adapt this system, especially to transmit the kinetic energy to wheels. The DC motor coupled with hydraulic pump will generate the required flow and pressure. The hydraulic motor which is fed this oil will start generating the torque at certain speed depending upon the flow. This motor output shaft will be coupled with the wheels with pulley mechanism.

The typical characteristics of DC motor is variable speed depending upon the torque. Accordingly it will operate between no load and full load condition. The torque will vary depending on the pump output flow and pressure. The motor is coupled with the help of suitable coupling.

The Pump is 3 piston standard available with 4.5lpm and 150 bar pressure. The same is immersed in the tank having volume of 8.8 litres. The pump output oil is connected to hydraulic motor through the metal piping. The oil coming out from the motor will go back to the tank.

The motor speed will depend upon the vehicle working condition. Generally the torque requirement is maximum when vehicle is moving from idle speed. Also the same is high when there is a gradient.

To control the speed, there are two ways. Either control the DC motor current or control the oil flow.

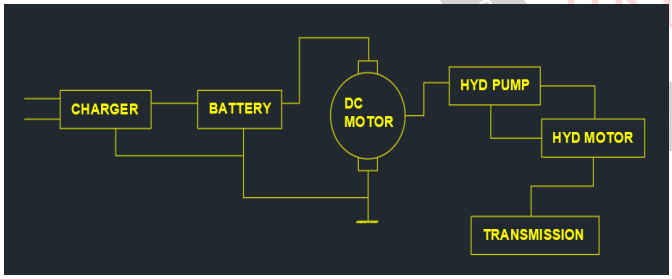

Figure 1. Block diagram of the concept

IV. COMPONENTS SPECIFICATIONS AND CALCULATIONS

1. DC Motor: 4 pole DC motor with operating voltage of 12V is taken. It has capacity to handle current up to 30A under load condition for continuous operation (100% duty cycle)
2. Battery with capacity of 12V, 35AH can feed the required current for Motor. Based on Battery capacity and Motor rating, vehicle can run for minimum 2 hrs. Considering the average speed of 50km, vehicle can run 100 km in one charge. Battery will take 6~8 Hrs. to full charge by trickle charge or 3~4 Hrs. by speed charge mode.
3. Hydraulic pump: The Pump capacity is taken based on flow and power needed to drive the system.
4. Hydraulic motor: This is main component of this system. The specifications are as below.

A. BENCHMARK STUDY

The theoretical calculations on the required torque were made using the torque formulas, To check the authenticity of these values an existing vehicle was considered and its experimental values were obtained from the gear ratio and rpm, given in table 1.

Vehicle : Hero Honda Passion; Weight : 107 kg; Engine : 100 cc; Torque : 8 Nm@ 6000 rpm

Gear Ratio	Speed	Torque
3.182 : 1	1885 rpm	25.6 Nm
1.706 : 1	3516 rpm	13.73 Nm
1.328 : 1	4846 rpm	9.97 Nm
0.958 : 1	6000 rpm	8 Nm

Table 1 . Torque Calculation at all gears

B. THEORETICAL TORUE CALCULATIONS

- Design criteria

a. Gross vehicle weight (W) = 60 kg = 60 * 9.81 = 588.6 N
b. Radius of wheel/tire (Rw) = 22 cm = 0.22 m
c. Desired speed (V) = 10 km/hr = 10 * 1000/3600 = 2.77 m/s
d. Acceleration Time (Ta) = 10 sec
e. Acceleration (acc) = 0.277 m/s^2
f. Maximum incline angle (α) = 3° = 3 * 3.14/180 = 0.0523 radian

$T_f = RR + GR + AR + DR$

$= 8.8 + 30.7 + 163 + 2.58$

$= 205$ N

$T = T_f * R_W * RF$

$= 205 * 0.22 * 1.14$

$=51.414$ Nm

So the theoretical calculations and the benchmark study were considered and it became the underpinning of the complete Hydraulic system.

C. HYDRAULIC SYSTEM

Hydraulics in its most basic definition is the use of liquids to perform work. The Hydraulic systems specifications were then reversely calculated and the components were selected based on these calculations.

The first thing was the hydraulic motor which was selected from the torque value calculated in above calculations, then based on the output torque of the hydraulic motor the input pressure and flow was calculated and this gave the required

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specifications of the hydraulic pump. The hydraulic pump output was known so the input rpm was calculated and the motor required for this purpose was selected. The pump inputs also helped in the selection of a sump and the gauges. A pressure gauge and a relief valve is selected to control the flow thus also controlling the pressure in an inversely proportional relation. The hydraulic piping, connections and oil was selected by studying the application and referring the Hydraulics data book.

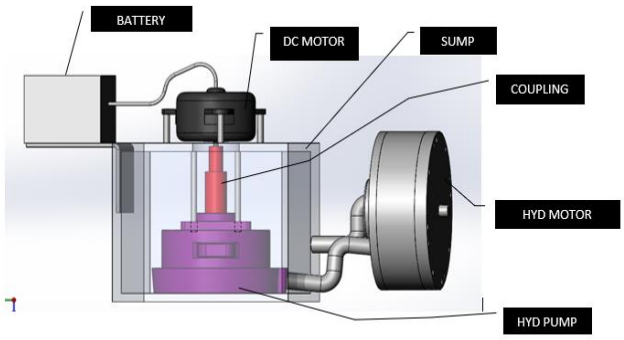

Figure 2. Hydraulic system concept

D. COST COMPARISON

Parameter	Hydraulic system		Electric system	
	Cost	Spec	Cost	Spec
Charger	1500/-	--	1500/-	--
Battery	4000/-	Lead acid	20000/-	Lithium ion
Controller	NA	NA	20000/-	Electronic
Motor	1000/-	DC	7000/-	BLDC
Hydraulic system				
Hydraulic pump	4000/-		NA	
Hydraulic Motor	10000/-		NA	
Hydraulic valves	1500/-		NA	
Transmission	3000/-		3000/-	
Total	25000/-		51500/-	

Table 2. Running cost

Description		Electric system		Hydraulic system	
		Cost	Spec	Cost	Spec
Battery	Service life	500 charge cycles	Lithium ion battery	3 – 5 years	Lead acid battery
	Replacement cost	15000/-	--	4000	--
Motor	Service life	100000 km	--	30000 km	--
	Replacement cost	7000/-	700 per year	700/-	280 per year

Table 3. Service cost

V. WORKING

A. HYDRAULIC PUMP

Hydraulic pump is having 3 pistons which reciprocates to intake the oil from tank and deliver the same at higher pressure to hydraulic motor. Depending on the opposite reaction/force from the hydraulic motor, the pressure will vary. As the pump is driven by DC Motor, the RPM will vary from No load condition to Working Load condition. Typical speed of the motor will be 800-2800 RPM. Accordingly the oil flow will vary. The design flow of 4.51 lpm & pressure 150 bar is at 1440 RPM with fix displacement of the pistons.

B. HYDRAULIC MOTOR

It consists of 12 pistons arranged in two rows which are moving on curvature of profile plate. They are arranged in such a way so as to get the combined maximum output of torque and speed. Each row has 6 pistons. Every piston moves along the curvature to move between minimum to maximum displacement. The hydraulic oil coming from hyd. pump will push the pistons along the curvature. Since the profile plate is fixed, it will apply reaction force on piston contact point which will push it in one direction. Thus rotational movement is generated which rotates piston plate along with all the pistons.

The oil from hyd. pump is at high pressure while the same is returning at low pressure. The high pressure oil is connected through high pressure oil port to piston which are at its lowest position. The high pressure oil will push the piston out. The piston will slide creating rotational movement. This will rotate the piston plate. When the piston plate moves, piston will travel to highest position. Once it start descending, the oil will be pushed out of piston chamber through output port. Every piston will have travel up and down 8 times. Every 45 deg there is torque generated by each piston. At a time there are two pistons in positive torque position while other 4 are ascending as well as descending position. The torque is generated when piston is ascending.

C. TORQUE TRANSMISSION

Transfer of rotational movement to vehicle is through output shaft coupled with pulley mechanism. Depending on the speed of hydraulic motor and vehicle speed needed, pulley ratio is fixed. The requirement of torque depends on vehicle operating condition. When vehicle is moving from idle position, maximum torque is needed. While in running condition at high speed, least torque is needed.

VI. MANUFACTURING

The dc motor and the hydraulic pump were selected according to the requirements of the hydraulic motor. The hydraulic motor is designed and manufactured according to the size requirements and the output. The sump is manufactured using mild steel and the coupling is also manufactured according to the size of the shafts using mild steel. The connections are done by using standard pipes. A pressure gauge and a flow control valve is used to control the flow ultimately also controlling the pressure. The hydraulic motor is designed and manufactured according to the required output and size required. Other components such as

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pulley, bearing, fasteners, joints are purchased according to the requirements.

VII. CONCLUSION

Today the automobiles have different types of systems as their prime mover. The use of electric motors is the recent trend in the automobile industry and the industries are developing electric bikes with variety of features, but the prime mover of these e-bikes is a bldc motor. If the above concept delivers as expected then this will be a very good as the use of bldc motor and its controller is eliminated. The bldc motor and its controller contributes for the half cost of the bike thus if this part is eliminated than we can gain the same results at a very low cost. Also the dependency on China will reduce as today worlds 86% bldc motors are manufactured there. This will open new opportunities for development in a new type of system that can also run an automobile.

The new type of system has potential and once its functionality is tested it can be actually implemented on scooter or motorcycle. Things like speed control, enhancement in torque speed properties can be looked upon

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