Analysis and Fabrication of Drive Train for Hybrid Electro Mechanical Tricycle

Abhinay Nigam

PG Scholar, Department of Automobile Engineering, S.I.R.T. Indore M.P.

Dr. Suman Sharma

Head of Department, Department of Mechanical Engineering, S.I.R.T. Indore M.P.

ABSTRACT

Hybrid EMT is a Human Powered Vehicle that uses both human power and electric power to drive the vehicle. Analysis shows any of this combination increases weight ratio and complexity of the system. The key destinations behind this analysis is to reduce weight ratio, complexity of ready-made market gear-set arrangement and also find out the best 4 gears arrangement instead of 13 gears arrangement. With this paddle assist arrangement the maximum gear ratio and enhancement of speed in single cadence without over effort from initial to final gears is increase around 2 to 3 times than other conventional vehicle. There are different outlines of human electric vehicle yet they have several issues identified with Fuel crises, pollutions, Depletion of non renewable energy resources etc. This requires the change of EMT, managing a fragment of the issues in existing. In the event that a man is feeling exertive by pedal exertion so electric assistance is accessible at the driver wheel, DC motor is connected at the back side, which run a vehicle by method for battery with economic speed rate.

Key words: Hybrid EMT, Human Electric Powered vehicle, Non renewable energy, paddle assistance, electric assistance etc.

INTRODUCTION

Drive train arrangement called pedal assist has pure mechanical system worked for ride by rider's effort applied on pedal by his leg. Systems include sprockets, chain drive and pedal crank. The roller chain and sprocket framework is made out of a couple of few various parts. It requires at least 4 sprockets, a chain, and some sort of pedal for the user to apply torque. The torque that is associated with the pedal is exchanged utilizing the roller anchor from one sprocket to the sprocket that requires the torque. Where the Hybrid EMT changes from most other option fundamental vehicles, is the rider gives pedal power, which power is reached out around 2 to 3 circumstances by the EMT drive plan. EMT runs snappier than other cycle by technique for pedal alone in any case If a man is getting drained by pedal effort. The roller chain and sprocket is an external drive train system, which leaves opportunity for injury in the system. For the reason of geometry tightening, weight factor and speed enhancement, sprocket and roller chain arrangement is taken as purely differential in terms of peddled sprocket 1 connected with roller chain to the smaller sprocket 2. Both sprockets have connected in series now by differential geometric concerned sprocket 2

attached with sprocket 3 in same shaft and another roller chain connected from sprocket 3 to smaller sprocket 4. Arrangement of number of teeth and diameter of sprocket 3 is same as of paddled sprocket 1 also a sprocket 2 as same configured as of rear wheel sprocket 4. This imagines depends on after making a pedal work electric human effort vehicle. [1]

PROBLEM STATEMENT AND OBJECTIVES

Derailleur arrangement has 13 gear combination are arranged together with complex manner. With this arrangement, weight is a major factor and a chain and sprocket set up would add substantial amount of weight to the design and another downfall of the chain and sprocket would be the maintenance requirement when we are going to run a vehicle with derailleur (market gear-set arrangement). For the system to operate at maximum efficiency it is required that the chain and sprocket stay properly lubricated and cleaned. Due to required maintenance the chain and sprocket system would have to be located in a position that is easily accessible for removal and maintenance reasons.

The significant targets and related work plan to satisfy these can be extensively compressed as:

- To dispense with fuel.
- To run a vehicle by rhythm at expressway speeds with the motor.
- To keep away from consistent accelerating
- Reducing human efforts
- To lessen the heaviness of the vehicle.
- To develop an environmental friendly system.

ANALYSIS OF DRIVE MECHANISM

Market gear set arrangement name derailleur has 13 gear set, 3 in front side and 10 in rear side. Analysis shows that any of this arrangements increases weight factor and complexity of the system. Here prime focus is to select the best arrangement according to drive ratio out of 13 gear arrangement.

I. Drive Mechanism Analysis using Mathematical Formula:

Conceptual arrangement of drive train or transmission system for Hybrid EMT as shown in figure below, which has 4 gears with 2 separate chain drive arrangement.

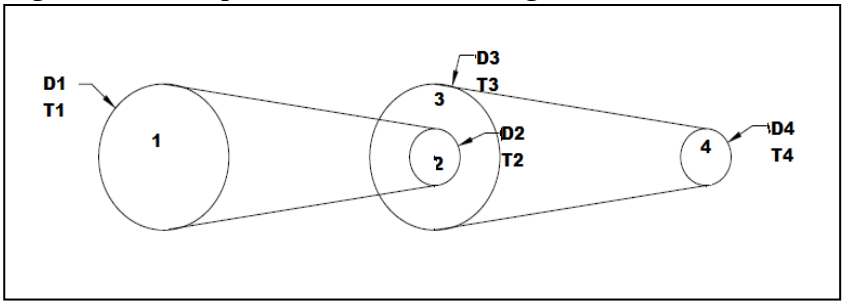

Figure 1: Initial concept of drive train arrangement

With the help of MATLAB and Simulink R2008b software we had tried to find out specific dimension and drive ratio of above geometry. At the time of analysis, took 44, 38 and 32 no. of teeth on front sprocket and the combination of 26,24,22,20,18,16,15,14,13,12 no. of teeth on rear sprocket with the size of rear wheel as 25 inch.

II. Coding behind the MATLAB report as mention below:

```
clc;
d1 = 0.18;
d2 = 0.07;
d3 = 0.18;
d4 = 0.07;
T1 = 44 ;
T3 = T1;
fid = fopen('MyTable.txt','w');
for T1 = 44:-6:30
   fprintf(fid,' \n\n For Chain Ring (T1) = %d \n',T1);
   fprintf(fid,'Rear COG \t\t\t\t 110RPM \t\t\t\t\t\t\t 100RPM \t\t\t\t\t\t 90 RPM \t\t\t\t\t 80RPM
\t\t\t\t\t 70RPM \t\t\t\t\t\t\t 60RPM \n');
   fprintf(fid,'--------- \t\t ---------- \t\t ----------\t\t ----------\t\t ----------
----------\t\t ---------- \t\t ---------- \n');

   for T2 = 26:-2:16
      fprintf(fid,'\n %d \t',T2);
      for N1 = 110:-10:60
         T4 = T2;
         N2 = T1 * N1 /T2;
         N3 = N2;
         N4 = T3 * N3 / T4;
         w = 2*pi*N4/60;
         r = 0.3175;
         v = r*w*3600/1000;
         fprintf(fid,'\t\t %5.5f \t %5.5f  ', v,(v-25));

      end
   end
   for T2 = 15:-1:12
      fprintf(fid,'\n %d \t',T2);
      for N1 = 110:-10:60
         T4 = T2;
         N2 = T1 * N1 /T2;
         N3 = N2;
         N4 = T3 * N3 / T4;
         w = 2*pi*N4/60;
         r = 0.3175;
         v = r*w*3600/1000;
          fprintf(fid,'\t\t %5.5f \t %5.5f  ', v,(v-25));
      end
   end
end
fclose(fid);
```

III. Computation of speed for various estimations of cadence with respect to chain ring:

Drive Train arrangement has found out with the assistance of simulated results at shown below clearly, which gives drastic enhancement of speed.

Table 1: Computation of speed for various estimations of cadence as for 44T, 38T and 32T chain ring

For Chain Ring (T1) = 44

Rear CC	110RPM		100RPM		90RPM		80RPM		70RPM		60RPM	
26	37.70737	12.70737	34.27942	9.27942	30.85148	5.85148	27.42354	2.42354	23.9956	-1.0044	20.56765	-4.43235
24	44.25378	19.25378	40.23071	15.23071	36.20764	11.20764	32.18457	7.18457	28.1615	3.1615	24.13843	-0.86157
22	52.66566	27.66566	47.87787	22.87787	43.09008	18.09008	38.3023	13.3023	33.51451	8.51451	28.72672	3.72672
20	63.72545	38.72545	57.93223	32.93223	52.139	27.139	46.34578	21.34578	40.55256	15.55256	34.75934	9.75934
18	78.67339	53.67339	71.52127	46.52127	64.36914	39.36914	57.21701	32.21701	50.06489	25.06489	42.91276	17.91276
16	99.57101	74.57101	90.5131	65.5131	81.46719	56.46719	72.41528	47.41528	63.36337	38.36337	54.31146	29.31146
15	113.2897	88.28968	102.9906	77.99062	92.69156	67.69156	82.3925	57.3925	72.09344	47.09344	61.79437	36.79437
14	130.0519	105.0519	118.229	93.22903	106.4061	81.40613	94.58322	69.58322	82.76032	57.76032	70.93742	45.93742
13	150.8295	125.8295	137.1177	112.1177	123.4059	98.40592	109.6942	84.69415	95.98238	70.98238	82.27062	57.27062
12	177.0151	152.0151	160.9229	135.9229	144.8306	119.8306	128.7383	103.7383	112.646	87.64599	96.55371	71.55371

For Chain Ring (T1) = 38

Rear CC	110RPM		100RPM		90RPM		80RPM		70RPM		60RPM	
26	32.56545	7.56545	29.60496	4.60496	26.64446	1.64446	23.68397	-1.31603	20.72347	-4.27653	17.76297	-7.23703
24	38.21918	13.21918	34.74471	9.74471	31.27024	6.27024	27.79576	2.79576	24.32129	-0.67871	20.84682	-4.15318
22	45.48398	20.48398	41.34907	16.34907	37.21416	12.21416	33.07926	8.07926	28.94435	3.94435	24.80944	-0.19056
20	55.03561	30.03561	50.03238	25.03238	45.02914	20.02914	40.0259	15.0259	35.02266	10.02266	30.01943	5.01943
18	67.3452	42.3452	61.76837	36.76837	55.59153	30.59153	49.41469	24.41469	43.23786	18.23786	37.06102	12.06102
16	85.99315	60.99315	78.17559	53.17559	70.35803	45.35803	62.54047	37.54047	54.72291	29.72291	46.90535	21.90535
15	97.84109	72.84109	88.94645	63.94645	80.0518	55.0518	71.15716	46.15716	62.26251	37.26251	53.36787	28.36787
14	112.3176	87.31758	102.1069	77.10683	91.8962	66.8962	81.68551	56.68551	71.47482	46.47482	61.26413	36.26413
13	130.2618	105.2618	118.4198	93.41983	106.5778	81.57784	94.73586	69.73586	82.89388	57.89388	71.0519	46.0519
12	152.8767	127.8767	138.9788	113.9788	125.0809	100.0809	111.1831	86.18306	97.28518	72.28518	83.38729	58.38729

For Chain Ring (T1) = 32

Rear CC	110RPM		100RPM		90RPM		80RPM		70RPM		60RPM	
26	27.42354	2.42354	24.93049	-0.06951	22.43744	-2.56256	19.94439	-5.05561	17.45134	-7.54866	14.95829	-10.04171
24	32.18457	7.18457	29.2587	4.2587	26.33283	1.33283	23.40696	-1.59304	20.48109	-4.51891	17.55522	-7.44478
22	38.3023	13.3023	34.82027	9.82027	31.33824	6.33824	27.85622	2.85622	24.37419	-0.62581	20.89216	-4.10784
20	46.34578	21.34578	42.13253	17.13253	37.91927	12.91927	33.70602	8.70602	29.49277	4.49277	25.27952	0.27952
18	57.21701	32.21701	52.01547	27.01547	46.81392	21.81392	41.61237	16.61237	36.41083	11.41083	31.20928	6.20928
16	72.41528	47.41528	65.83207	40.83207	59.24887	34.24887	52.66566	27.66566	46.08245	21.08245	39.49924	14.49924
15	82.3925	57.3925	74.90227	49.90227	67.41204	42.41204	59.92182	34.92182	52.43159	27.43159	44.94136	19.94136
14	94.58322	69.58322	85.98475	60.98475	77.38627	52.38627	68.7878	43.7878	60.18932	35.18932	51.59085	26.59085
13	109.6942	84.69415	99.72196	74.72196	89.74976	64.74976	79.77757	54.77757	69.80537	44.80537	59.83317	34.83317
12	128.7383	103.7383	117.0348	92.0348	105.3313	80.33132	93.62784	68.62784	81.92436	56.92436	70.22088	45.22088

With the help of Table 2, Table 1 report pattern can easily understand.

Table 2: Format of Analysis Report

Pedal Per Minute or Cadence	
(Speed of Drive Mechanism + Speed of motor with 25 km/hr)	(speed of Drive Mechanism alone)

Further analysis has estimate to determine the best combination of chain of ring (COG) and sprocket, which gives a top speed and ride comfort.

According to report finally got achieved a top speed of 177.01513 km/hr. with the combination of 44T-12T for a cadence of 110 rpm with the wheel of 0.635m as diameter.

- Speed analysis with DC motor drive at max. motor speed 25 km/hr

Finally get speed around 96.55371km/hr when rider applies 60 cadences during paddling. These speed lies above of economic range but rider applied a pedal force maximum at 110 cadences, therefore it achieve a maximum speed around 177.01513km/hr

- Speed analysis without DC motor drive at max. motor speed 25 km/hr

Finally get speed around 71.55371km/hr when rider applies 60 cadences during paddling. These speed lies above of economic range but rider applied a pedal force maximum at 110 cadences, therefore it achieves a maximum speed around 152.01513km/hr.

IV. Fabrication of Drive Mechanism for Hybrid EMT

The derailleur comprises of various sprockets of different diameter connected to each other, and an instrument that moves the chain from one sprocket to another. As the chain drive moves from a larger diameter sprocket to a smaller diameter sprocket the gear ratio increases.

In fabrication, selection of sprockets had done from the behalf of availability and genuine end of speed range. For fabrication purpose I had selected 3 sets which are of 44T & 18T sprockets, 32T & 18T sprockets and combination of 44T & 18T sprockets with 32T & 18T because MATLAB data's of all these arrangement looks effective, safe and genuine for conventional cycle's point of view.

Fabrication Outcome

1. Fabricate with 44 teeth chain ring and 18 teeth rear COG drive arrangement and outcomes has mention below.

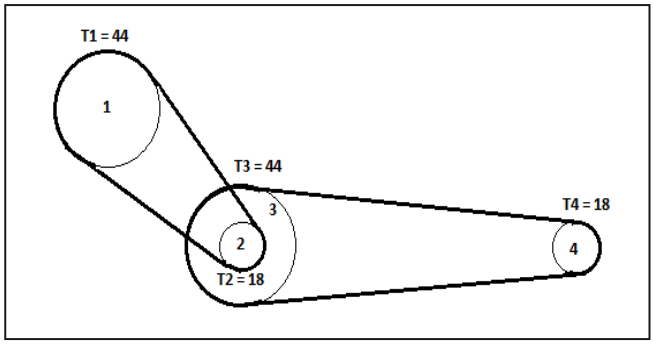

Figure 2: Drive Arrangement with 44T Chain Ring and 18T Rear COG

Table 3: Speeds of 44 and 18 Teeth Drive Arrangement According to MATLAB.

For Chain Ring (T1) = 44												
Rear COG	110RPM		100RPM		90RPM		80RPM		70RPM		60RPM	
18	78.67339	53.67339	71.52127	46.52127	64.36914	39.36914	57.21701	32.21701	50.06489	25.06489	42.91276	17.91276

According to the above table, drive ratio is better than economic range but unable to get this for normal human. With this arrangement, we had to apply more effort to get this speed range. So, it was not suitable for Hybrid EMT.

2. 38 teeth chain ring and 18 teeth rear COG drive arrangement and outcomes has mention below.

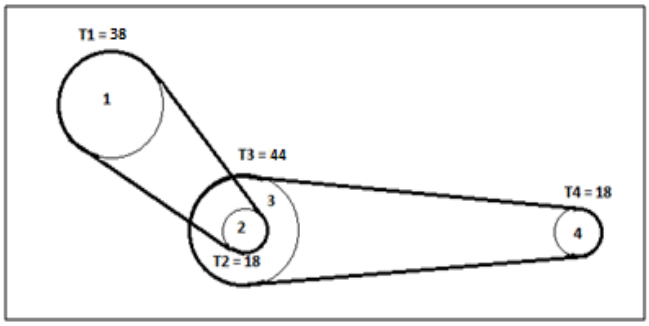

Figure 3: EMT preferred drive arrangement of 2 sets of 44T & 18T sprockets, 32T & 18T sprockets.

Table 3: Speeds of 38 and 18 Teeth Drive Arrangement According to MATLAB

For Chain Ring (T1) = 38													
Rear COG	110RPM		100RPM		90RPM		80RPM		70RPM		60RPM	
18	67.9452	42.9452	61.76837	36.76837	55.59153	30.59153	49.41469	24.41469	43.23786	18.23786	37.06102	12.06102

Result of this arrangement creates an issue in terms of chain misalignment. With this arrangement misalignment of chain drive occurs at every cadence during pedaling and which is undesirable for movement of sprocket and vehicle too.

3. 32 teeth chain ring and 18 teeth rear COG drive arrangement and outcomes has mention below.

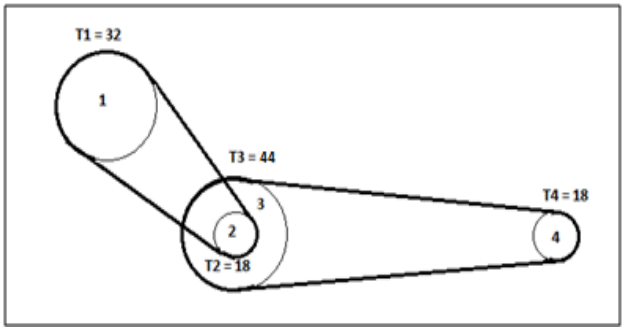

Figure 4: Drive Arrangement with 32T Chain Ring and 18T Rear COG

Table 4: Speeds of 32 and 18 Teeth Drive Arrangement According to MATLAB.

For Chain Ring (T1) = 32												
Rear COG	110RPM		100RPM		90RPM		80RPM		70RPM		60RPM	
18	57.21701	32.21701	52.01547	27.01547	46.81392	21.81392	41.61237	16.61237	36.41083	11.41083	31.20928	6.20928

According to the above table, speeds are in good range and able to get this for normal human. This arrangement is better in drive and speed ratio. So, it was suitable for Hybrid EMT and desirable for safety purpose.

Out of all combination we had finalized the drive train arrangement for Hybrid EMT has 32T – 18T with 44T – 18T sprockets arrangement with two chain drive. This is beneficial in terms of speed and ride comfort both. Outcome of this speed is more than economical speed without an exertion.

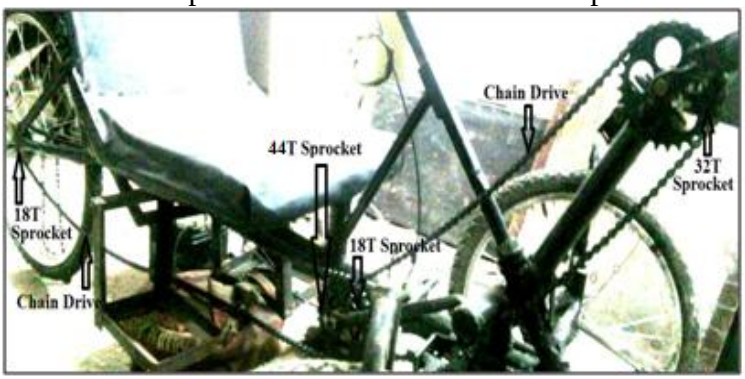

Figure 5: Fabricated and Practical drive system of Hybrid EMT with 32T chain ring and 18T rear COG

RESULT AND DISCUSSION

Comparative outcomes and Calculation of speed for different values of cadence with respect to 32T chain ring and 18T rear COG under MATLAB and Implemented condition of Hybrid EMT with regenerative braking system are mention in below table.

Table 5 : Comparative Outcomes of Speed between MATLAB Report and model of Hybrid EMT

S.N	Comparative Analysis	Overall (Mechanical + Electrical Drive) Speed Calculation Km/hr.	
	Pedal in Minu (Cadence)	According to MATLAB	According to Practical Model
1	110	57.21701	51.81
2	100	52.01547	47.45
3	90	46.81392	41.39
4	80	41.61237	36.06
5	70	36.41083	31.01
6	60	31.20928	25.72

Comparative outcome of table 5 shows that speed of practical creation at every cadence is little-bit lesser than the speed of MATLAB report because of some frictional and weight losses.

Discussion of Manual Drive Arrangement

1.) Drive geometry of Hybrid EMT is tightened; reason while two separate chain drive are used. 2.) Weight factor of Hybrid EMT drive geometry is getting small as compared to derailleur drive; reason while final tricycle have only four sprocket and two chain drive are used except 30 speed gear system. 3.) Speed enhancement of Hybrid EMT is definitely occur; reason while arrangement is simpler than market readymade gear sets, gear ratios are stable at every cadence; gear ratio from initial to final gears is 1.8. This shows 1.8 times enhancement of speed in single cadence without over effort.

CONCLUSION

By this Paper study I had tried to collect those data and information which can be helpful for building a hybrid vehicle which is ecological as well as economical in the field of automobile. Now days the greatest concern in the field of automobile is to develop those vehicles which are environment friendly and can give a handful amount of energy to transport the things. I had tried to develop a machine which can run with the help of electric power as well as human power, both forms of energy are eco-friendly and easily available. The auto world is changing gradually which defines a rise of new era, an era which ruled by these hybrid monsters. These Papers are just a little involvement in the developing of drive train and reduce the weight and complexity of pedal assistance. Final design of manufactured vehicle is an efficient and it could safely and effectively be used for everyday transportation. So as to I tried to develop a cheaper but effective way of transport which helps a special group of people who are unemployed as well as facing economic problems and convenient for physically challenged person who want to travel a large distance with cycle without more effort. In the end I just want to say that this Paper is not just a Paper, it's a one step forward towards the era of hybrid vehicle, an era which is dominated and influenced by the "GO

GREEN" concept and that is also our prime concern to develop a machine which fulfills the GO GREEN requirements.

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