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Compound Chain Drive Transmission System for Automotive Vehicles

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Abstract – *In the transmission system chain drive is considered as the most robust and efficient mode of power transmission because of its highest transmission efficiency. Transmission system mostly consist of Chain and sprocket combination with 2 sprockets which maintains the TR of 3 which is basically required to propel the vehicle i.e. to overcome the frictional resistance WRT to road[2]. The changes were made such, within the given CD between the sprockets we can achieve the TR above 3 or even above 4 by using the concept of compounding. Using the compounding in the chain is possible but using it in 2wheeled vehicle is difficult because of the constant cyclic fluctuations and polygonal effect[3]. First trial was taken in ATV vehicle like Quad bike which has space as well as CD constrains. After the use of the compounding arrangement, it shows the drastic improvement in GR and SR with which we have increased the efficiency as well as speed of the vehicle.1st trial was used in Quad bike which is basically All-Terrain Vehicle which basically used in heavy Terrain.*

Key Words: Gear ratio(GR), Speed Ration(SR), compounding, Fictional resistance,

1. INTRODUCTION

All-Terrain Vehicle (ATV) is the one which is capable to clear all the terrains like muddy-hills-off read tracks. For this, an ATV always required and robust drive train system which can work under several conditions as well as in fatigue loading. Mostly in all the ATV's, chain drive is used for transmitting the power because of its advantages over other drive. Chain drive is mostly preferred because it is easy to adjust the speed ratio and the gear ratio as per the requirement and it is simple in maintenance. Compound drive is the one of the innovations that being used in our ATV. By using the compound arrangement, we can modify the gear ratio and speed ratio within the minimum center distance and achieve the maximum torque and speed than the rated one. Basic requirement of TR is 3 in order to propel vehicle by overcoming the FR offered by road. We can achieve above 4 by changing the pair of sprockets that being used.

2. Literature Review

Niels Fuglede And Jon Juel Thomson[1] (Kinematics and Dynamic Modelling and Approximate Analysis of Roller Chain Drive), in this research paper they told about the best method for transmitting the power in vehicle. Roller chain drives are applied for power transmission in many mechanical systems due to high energy efficiency, large power capacities, timing capabilities, flexibility in choosing shaft centre distance and ease of installation and maintenance. The undesirable noise and vibrations present in the roller chain drive is the ongoing study for use of the chain drive.

C. Pereira, J. Ambrosis and A. Ramalho[2] (Dynamics of Chain Drive Using Generalised Revolute Clearance Joint Formulation), in this research paper they told about the roller chain drive and the positive power transmitting capacity of the roller chain and sprocket. Due to the positive power transmitting capacity of the chain it is mostly selected for transmission of power. In this research paper they also told about the dynamic behaviour of the roller chain and manufacturing of the roller chain.

S. Mahalingam[5] (Polygonal Action of The Chain Drive), in this research paper they told us about what the polygonal effect is exactly and why it must be considered during the manufacturing or selection of the chain and sprocket. The detailed calculation about the polygonal effect is shown in this research paper.

Yong Wand, Desheng Ji and Kai Zhan[3] (Modified Sprocket Tooth Profile of Roller Chain Drive), in this research paper they told us about polygonal action and meshing impact form the non-conjugated mashing features damages the tooth profile. This research paper is based on the developing the new tooth profile with reduced polygonal effect and meshing impact under high speed.

3. OBJECTIVE

- Minimization of Weight: Using Aluminium alloys in place of steels can drastically reduce the weight of components for the same size for about 60-65%.
- Achieve Safer Design: Selection of specific Aluminium alloy is very difficult but we selected Tempered grade

Al-alloys which have strength and hardness closer to steel with good modulus of elasticity.

- Achieve Higher Gear Ratio in Minimum Space: As we have space constraints, we selected to use compound drive to achieve higher gear ratio without hampering other geometry.
- Minimize Inertia: It is reduced by using optimized design and Aluminum alloys to take care of excessive dynamic forces acting and gyroscopic couples too.

4. METHODOLOGY

Design of compound drive is carried out in systematic way. The detailed analysis are as follows-

1. Input Study-

   This is the first step and it involves gathering and analyzing the equivalent information. The main source of information is current market and future trends. Correct, complete and accurate data allows designer to identify and finalized the specific requirement of end product.

2. Deciding the geometry and material-

   The compound hub carrying sprocket is designed in such way that it forms compact structure with sufficient strength and withstand dynamic load in running condition.

3. Selection of material-

   Aluminium 7075-T6 which is basically aerospace grade is selected by considered on the basis of 2 main factors i.e. weight and strength. We want our hubs having less weight and can withstand internal stresses which might develop while working and OEM sprockets as well as customized sprockets were manufactured.

4. Making cad model of vehicle-

   Using the above collected and calculated data, a CAD model is prepared of the proposed vehicle.

5. Structural analysis of cad model-

6. The final CAD model of the vehicle is structurally analyzed using ANSYS for failure of parts.

7. Thermal analysis of hubs and sprockets-

   Thermal analysis is carried out to check the internal heat developed because of continuous operation of the drive.

8. Manufacturing phase-

   The finalized design is used for manufacturing of vehicle.

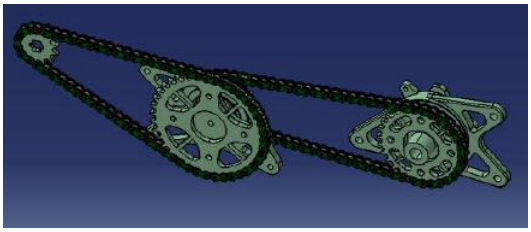

Fig.1 Proposed Design

Table 1 Assumptions

Designation	Parameters to achieve
Center distance	**528mm**
Overall speed ratio	**4.57**
Speed ratio distribution in each stage	**1st stage=3** **2nd stage=1.57**
Torque at wheel	**680N.m.**

5. PROPOSED DESIGN

By the dimensional constrains and to achieve the GR of 4.57 in given space we used the combination of sprockets which as follows[8]-

Table 2 Gear pair

13	39	19	29
3		1.57	

For the same pair of gears and for the 2 different CD we have 2 different chain lengths which are as follows[8]-

Table 3 Chain length w.r.t center distance

Gear Pair	13	39	19	29
Chain length	419.1mm		431.8mm	

After the calculation has been carried out final results were shown in below table-

Table 4 Actual Parameters achieved

Parameters	Calculated Specification
Approx. center distance in 2 stages	1st stage=250mm 2nd stage=278mm
Overall speed ratio	4.57
Speed ratio distribution in each stage	1st stage=3 2nd stage=1.57
Torque at wheel	680N.m.

6. FINITE ANALYSIS

The compound hub Is designed by considering the dimensions of assembling components which are bearing and sprockets. The compound hub was meshed with tetrahedral elements. The loads were applied and the resulting stress acting on the compound hub will be obtained.

During the Ansys of compound hub, it has been designed for lower weight by considering the required fatigue strength. Material selected for the compound hub is AL7075-T6 which is Aerospace grade material from tempered series. Specification of the material is it has the Syt of 503Mpa.

The material for wheel hub has been selected by considering yield stress, availability, machinability and material cost

By applying the torque of 431N.m on middle hub and 680N.m torque on rear hub.

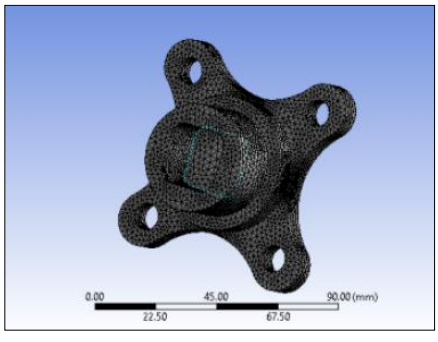

Fig.2 Tetrahedral Meshing

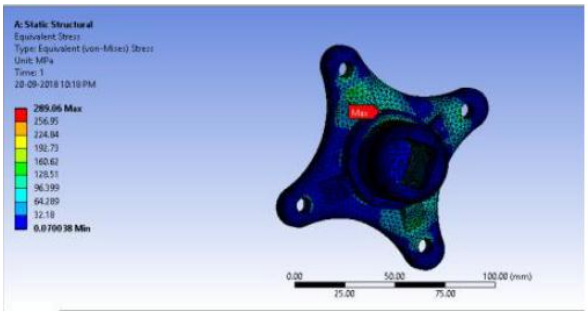

Fig.3 Equivalent Stress at Middle hub

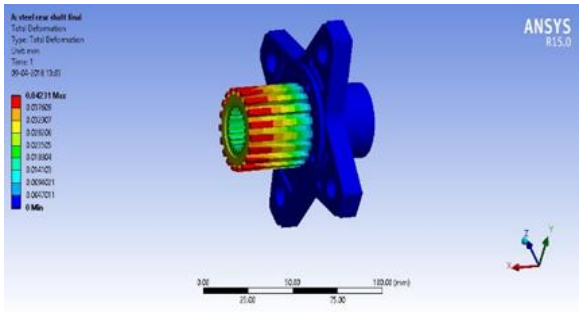

Fig.4 Equivalent Stress at rear hub

Material	Hub location	Stress
AL_7075-T6	Middle	148.56
AL_7075-T6	Rear	148.56

7. CONCLUSION

After designing whole transmission system in All-terrain vehicle, it is seen that the design for off-road vehicles is more dynamic than the on-road vehicles. Some excessive factors need to be considered while designing of power transmitting components. Also, material selection is very crucial step in designing and decides impact of design on performance of a vehicle. The design includes design for manufacturability (DFM) as well as design for Performance (DFP). The power-train used in the design offers easy operation and maintenance. Multiple unique design features provide easy adjustability that give the owner more control over the vehicle

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