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Experimental Validation of Carbon Fiber Sprocket

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Abstract: A sprocket or sprocket-wheel is a profiled wheel with teeth, cogs or even sprockets that mesh with a Chain. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

Generally sprockets are made of mild steel. They exist in various dimensions, teeth number and are made of different materials. Sometimes faulty chains quickly wear the sprocket. Possible causes of this problem are significant overload, breakage, high impact pressure, excessive chain wear far beyond replacement level, combination of worn chain with new sprockets etc. To ensure efficient power transmission chain sprocket should be properly designed and manufactured. There is a possibility of weight reduction 0in chain drive sprocket. During this work, a study of designing optimization of sprocket using different processes and techniques will be studied. During this work the designing of chain sprocket, analysis will be done by using FEA.

***Index Terms* - Sprocket, mild steel, carbon fiber, CAD, FEA, stress and deformation.**

I. INTRODUCTION

Sprockets are used in bicycle, motorcycle, car tracked wheel, and other machinery either to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track, tape etc. Perhaps the most common form of sprocket may be found in the bicycle, in which the pedal shaft carries a large sprocket-wheel, which drives a chain, which, in turn, drives a small sprocket on the axle of the rear wheel. Early automobiles were also largely driven by sprocket and chain mechanism, a practice largely copied from bicycles. Fig.1.1 shows the sprocket chain mechanism used in bike.

Fig.1.1: Sprocket chain mechanism

Sprockets are of various designs, a maximum of efficiency being claimed for each by its originator. Sprockets typically do not have a Flange. Some sprockets used with timing belt have flanges to keep the timing belt centered. Sprockets and chains are also used for power transmission from one shaft to another where slippage is not admissible, sprocket chains being used instead of belts or ropes and sprocket-wheels instead of pulleys. They can be run at high speed and some forms of chain are so constructed as to be noiseless even at high speed.

The sprocket chain when used for long term faces problems such as pins or bushes wear-out, broken plates and pins, wearing of sprocket etc. also chain sprockets works in very dirty environment which lowers its life. Normally sprocket chain is made up of alloy steel.

So the objectives of this study are,

- To increase strength of a sprocket so that it can be used for long time.
- To reduce the weight of sprocket.
- To select an alternative material for the sprocket.
- To analyses the sprocket with existing as well as alternating material.
- To validate the results for better output.

II. PROBLEM DEFINITION

From the literature review it is seen that the limited research is conducted on the Design, Development and Analysis with the use of composite material. Hence it is need to work on the Design, Development and Analysis of carbon fiber sprocket for weight reduction, increase in strength, to find and replace existing material.

III. EXPERIMENTAL ANALYSIS

The experimental investigation is performed on fabricated prototype on universal testing machine at Praj Metallurgical Lab, Kothrud, Pune. Test has been performed on the prototype produced. The input conditions are recreated in the lab while the component is being tested. The loading and the boundary conditions are matching the practical working conditions in which the vehicle is expected to perform. An equivalent maximum torque of 383N-m is applied on the prototype for testing purpose.

Fig. 1 : Prototype of carbon fiber sprocket

3.1 EXPERIMENTAL SET UP:

Fig. 2: Experimental set up

The experimental set up is shown in fig 5.12 which consists of following components.

- Test component – Prototype of carbon fiber composite chain sprocket prepared from composite as shown in fig 5.13.

Fig. 3: Test specimen

- Load frame - Usually consisting of two strong supports for the machine.
- Load cell - A force transducer or other means of measuring the load.
- Cross head - A movable cross head (crosshead) is controlled to move up or down. Usually this is at a constant speed: sometimes called a constant rate of extension (CRE) machine.
- Means of measuring extension or deformation - Many tests require a measure of the response of the test specimen to the movement of the cross head. Extensometers are sometimes used.
- Output device - A means of providing the test result is needed. Some older machines have dial or digital displays and chart recorders. Many newer machines have a computer interface for analysis and printing.
- Conditioning - Many tests require controlled conditioning (temperature, humidity, pressure, etc.). The machine can be in a controlled room or a special environmental chamber can be placed around the test specimen for the test.
- Test fixtures, specimen holding jaws, and related sample making equipment.

3.2 TESTING PROCEDURE:

- The prototype is placed in the machine between the grips. The machine itself records the displacement between its cross heads on which the specimen is held.
- Adjust the load cell to read zero on the computer up to peak load 4.5 KN. Once the machine is started it begins to apply an increasing load on specimen.
- Throughout the tests the control system and its associated software record the load and displacement of the specimen.
- Plot the variation of displacement with load.

3.3 Experimental results:

Experimental results of mild steel sprocket:

- Load vs deformation plot is obtained from experimental results.
- Displacement is measured for the prototype from the test and a load vs deformation graph is obtained.
- Here are experimental results are shown in fig.5.14 which is load vs deformation for steel.

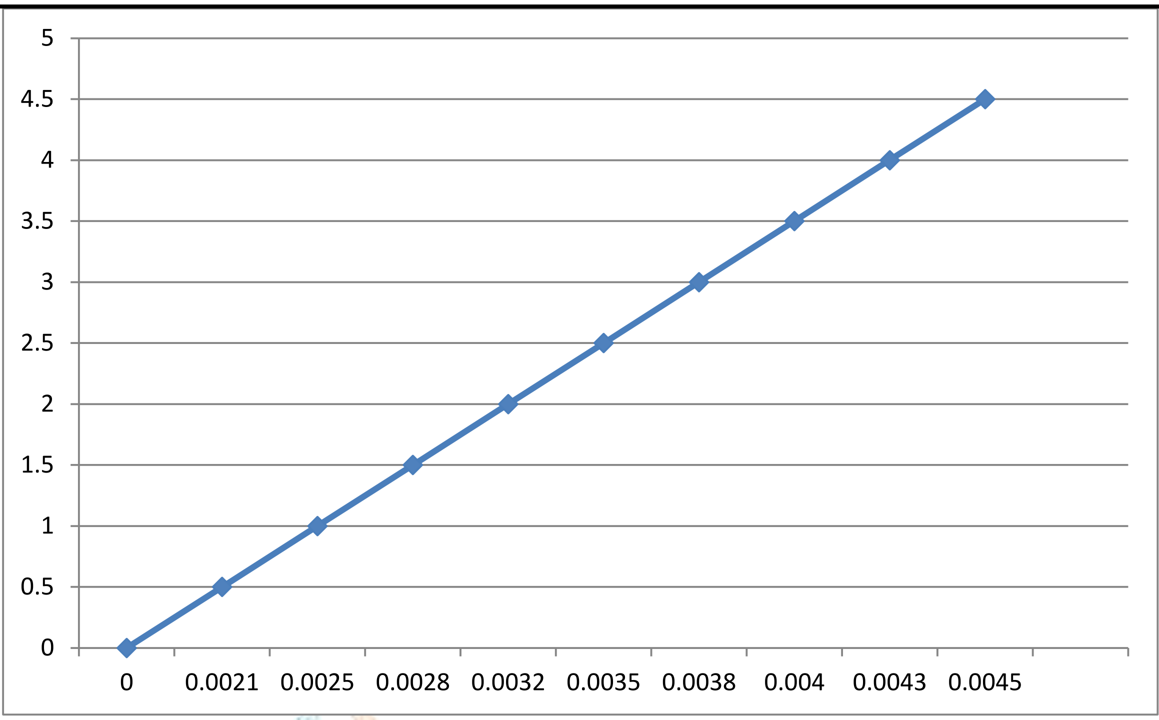

Fig. 4: Graph of load Vs deformation for mild steel

The experimental result is 0.0045 m for 4.5 KN but we have to compare the FEA results and with experimental result.

- **Experimental results of carbon fiber sprocket:**
- Load vs deformation plot is obtained from experimental results.

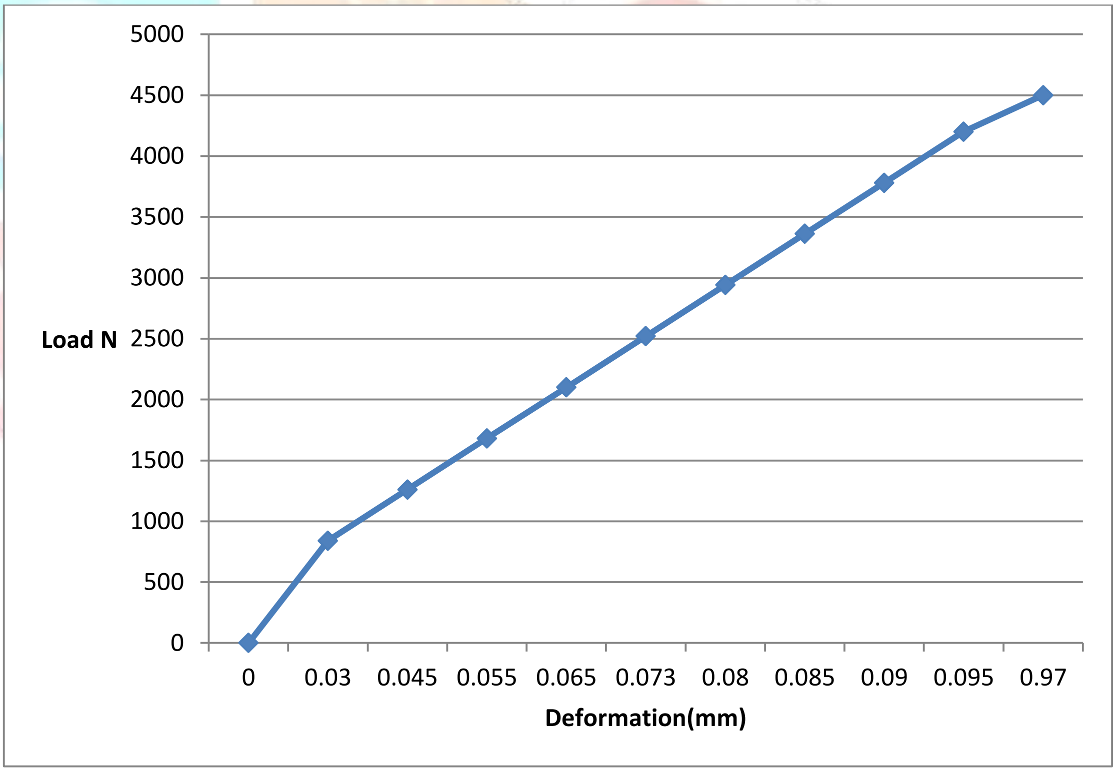

Fig. 5: Graph of load Vs deformation for carbon fiber sprocket

The maximum deformation found was 0.097 at load of 4.5 KN but we have to compare the FEA results and with experimental result.

IV. Results and Discussion

4.1 Results for Mild Steel (IS 2062):

FEA Results:

Maximum deformation found was 0.0049mm

Mass of sprocket was 0.847 Kg

Experimental result:

Maximum deformation found was 0.0045mm

Mass of sprocket was 0.850 Kg

4.2 Results for Carbon Fiber:

FEA Results:

Maximum deformation found was 0.091mm

Mass of sprocket was 0.173 Kg

Experimental result:

Maximum deformation found was 0.097mm

Mass of sprocket was 0.210 Kg

4.3 Comparison between Experimental and FEA results:

	Deformation (mm)		Mass (Kg)	
	Mild Steel	Carbon Fiber	Mild Steel	Carbon Fiber
FEA Results	0.0049	0.00091	0.847	0.173
Experimental Results	0.0045	0.00097	0.850	0.210
Percentage Error	**8.10 %**	**6.18 %**	**0.35 %**	**17.61 %**

Table 1: Comparison between Experimental and FEA

From results of finite element analysis it is observed that stresses are maximum at joint locations. It is also observed that both the materials have stress values less than their respective permissible yield stress values. So the design is safe.

From analysis results and comparison of properties of all the materials, it is found that carbon fiber is the material which is having the least density; also it is easily available and cheap as compared to other alternate materials. Also machining cost for carbon fiber is less. Hence it is the best suited alternate material for sprocket and is expected to perform better with satisfying amount of weight reduction.

V. Conclusion

From results of finite element analysis it is observed that stresses are maximum at joint locations. It is also observed that both the materials have stress values less than their respective permissible yield stress values. Hence the design is safe.

Mass of carbon fiber sprocket is reduced by 75.29% comparative to mild steel sprocket.

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Hence carbon fiber is the best suited alternate material for sprocket and is expected to perform better with satisfying amount of weight reduction.

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