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Reduction of Noise in Chain Drive Mechanism of Motorcycles

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Abstract – This paper investigates chain drive, chain adjustment mechanism and wheel alignment of 160cc sports motorcycle to find root causes of chain noise. Chain noise occurs in vehicles due to friction between chain links and sprocket teeth, specially when slackness varies from its standard range. A swingarm design modification is proposed as of to reduce chain noise problems and rear wheel axle alignment issues.

Keywords – *Chain Drive, Root Cause Analysis, Chain Slackness, Chain Noise, Roller Chain, O-Ring Chain*

1. INTRODUCTION

This paper investigates chain drive and chain adjustment mechanism of a 160cc sports motorcycle to find root causes of chain noise. A detailed study is conducted on TVS Apache RTR 160 4V which is one of the leading motorcycles in 160cc segment, to analyze root causes of chain noise. Chain drive is used in most of the motorcycles as it is positive drive and highly efficient for power transmission Chain used in this motorcycle is O-Ring type roller chain. It has rubber O-rings between plates. It has vacuum filled grease, which provides continuous lubrication and reduces friction between links. Chain material used in these chains is processed medium carbon steel. Standard chain slackness range for Apache RTR 160 4V is 20-25mm. Chain specification for all four TVS Apache series vehicles is given in the following table.

	RTR 160 4V	RTR 200 4V	RTR 160 2V	RTR 180 2V
Chain Type	O-Ring type Roller Chain	O-Ring type Roller Chain	Standard Roller Chain	Standard Roller Chain
No. of Teeth in front sprocket	13	13	13	14
No. of Teeth in rear sprocket	44	43	44	46
No. of Links in Chain	138	116	124	130

Table 1.1 – Chain Specifications of RTR series vehicles

2. LITERATURE REVIEW

Noise produced by a chain drive mechanism is considerably reduced by providing rubber rings on the faces of a sprocket, with the rubber rings dimensioned so that they are not contacted by the chain as it approaches into engagement with the sprocket. The sprocket vibration are absorbed by this rubber rings and are as effective in reducing noise as are conventional rubber rings which are contacted by link plates of a chain to alleviate the effects of collision shocks.

Stuart Burgess and Chris Lodge (2004) have discussed on optimization of the chain drive system on sports motorcycles. The new model can be accustomed to predict the efficiency of a 600cc sports motorcycle at different speeds. The efficiency of power transmission is estimated to be between 96 and 99% for speeds less than 75 miles/h. Between 120 and 240 Km/h, the efficiency of power transmission can be as low as 85% due to inertial tension. The transmission efficiency model presented in this paper enables the optimization of sprocket and chain sizes. In general, large sprockets are better at low speeds and smaller sprockets are better at high speeds. The optimum chain size is the chain with the smallest pitch that can meet the torque and power requirement. The sprocket center distance also has a big effect on efficiency and it is important to use an effective installation procedure. In particular, it is important to set a chain up when the rear wheel axle, front crank, and swing arm bearing are all in-line.

3. PROBLEM DEFINITION

3.1. DIFFERENT CAUSES OF CHAIN NOISE FOUND BY ROOT CAUSE ANALYSIS

Different causes of chain noise are:

Chain loose – Chain is considered loose if chain slackness is more than 25mm, which is the upper limit of recommended standard slackness range, in this case, chain noise can be observed.

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Chain tight – Chain is considered tight if chain slackness is less than 20mm, which is the lower limit of recommended standard slackness range, also in this case chain noise is observed.

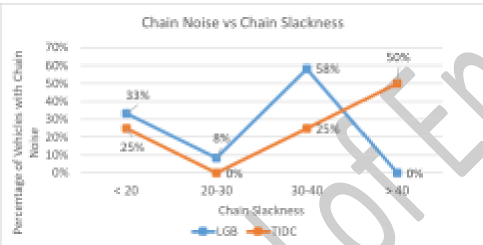
The chain is dirty, dry, and not lubricated. The chain makes noise.

Chain-sprocket is worn out.

Rear-wheel alignment is not adjusted properly i.e. axle is slightly tilted and not perfectly aligned, so on using the vehicle in this condition the rear sprocket pulls the chain slightly sideways which causes the chain to bend and the sprocket wears out quickly. This leads to fluctuation of chain slackness i.e. at a particular wheel orientation chain becomes very tight, on a further rotating wheel and on changing orientation there comes a point where chain becomes very loose. In this condition, the chain-sprocket is permanently damaged and cannot be adjusted properly and thus need to replace it.

3.2. CHAIN SLACKNESS AND WHEEL ALIGNMENT WITH CHAIN NOISE

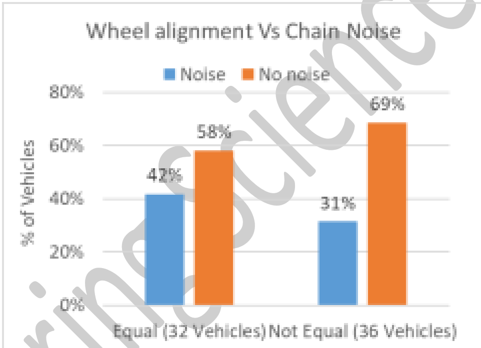
Study was conducted on Apache RTR 160 4V vehicles.



The above graph represents trends of chain noise complaints by vehicle owners, with variation in chain slackness. Chains observed in these motorcycles were of two different chain manufacturers. Here, the blue line represents LGB chain in which 33% of chain complaints were recorded below 20mm chain slackness i.e. in chain tight condition. 58% of chain complaints about LGB chain were recorded in 30-40mm slackness range and 8% of complaints were recorded with vehicle chain slackness in the standard range between 20-30mm. No complaints were recorded for the slackness of more than 40mm in the LGB chain.

Redline represents trends of TIDC chain, in which 25% of chain complaints were recorded below 20mm chain slackness i.e. when the chain is tight. 25% of chain complaints about the TIDC chain were reported between the 30-40mm slackness ranges. 50% of chain complaints about the TIDC chain were observed for slackness higher than 40mm, where the chain is considered extremely loose. No complaints were recorded between standard slackness ranges of 20-30mm in the TIDC chain.

So, chain complaints are observed specifically when chain slackness varies from standard slackness range of 20-30mm. Whereas, complaints are very less/negligible when chain slackness is in the standard range.



From this graph, we can see that there is no direct co-relation of wheel alignment to chain noise during this study, but wheel alignment plays a major role in chain wear. If the wheel is misaligned, rear sprocket is also misaligned which pulls drive chain sideways, resulting in premature wear of chain-sprocket and fluctuating chain slackness at the different orientation of the wheel.

4. PROPOSED SOLUTION ARRANGEMENT

It was found that it is difficult to adjust wheel alignment every time while adjusting chain slackness. Wheel and axle misalignment lead to misalignment of rear sprocket because of which chain is pulled sideways and on further using the vehicle in this condition, eventually, chain elongates and chain-sprocket wears out prematurely. This can cause chain noise, fluctuation in chain slackness on the different orientation of the wheel, and also affects power transmission. To overcome this axle misalignment issue and making chain slackness adjustment method less complicated, the design of a new chain adjustment mechanism is proposed in which there is no need to adjust axle alignment.

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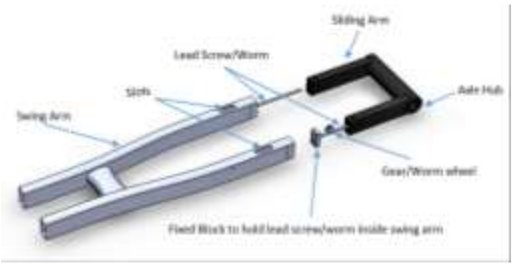

Figure 4.1 - Exploded View of design

The previous figure is a 3-dimensional exploded view of the rectified modification concept of swingarm design. This modification consists of original swing arm design followed by an additional component called a sliding arm and its adjustable slider mechanism. The sliding arm includes a fixed hub for mounting rear axle.

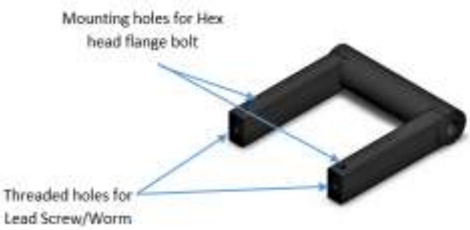

Figure 4.2 - Sliding Arm

4.1 SLIDING ARM:

Sliding Arm is designed such that it has a fixed hub for mounting rear axle. Arms are designed to slide inside the hollow swingarm in back and forth motion. Both arms have an inner threaded fixed block in its cross-section which will make this component slide with the help of a lead screw. Also, two holes are provided on the top of both arms in which hex head flange bolt will be fitted in such a way that it restricts sliding motion in the desired range with the help of slots on the top of the swing arm.

4.2 LEAD SCREW/WORM AND HOLDING BLOCK:

Lead screw/worm is used for the sliding mechanism of the slider arm. Holding block will be fixed inside a hollow swing arm and will hold lead screw from one end such that lead screw/worm will rotate in its place without any linear motion. Another end of lead screw/worm will be inside the threaded holes of slider arm and on rotation, it will provide linear motion to slider arm.

Figure 4.3 - Lead Screw/worm and holding block

4.3 GEAR/WORM WHEEL:

Gear/worm wheel is used to rotate lead screw/worm. This will be mounted inside the swing arm such that its pitch matches the pitch of lead screw/worm. This gear/worm can be rotated with the help of a lock nut mechanism outside the swing arm.

Figure 4.4 - Gear/worm wheel

4.4 SWING ARM:

Swing arm design will be similar to existing swing arm design with slight modification. Slots will be provided on the top side of the swing arm to restrict the sliding range of sliding arm. Hex head flange bolt will be fixed on the sliding arm through these slots.

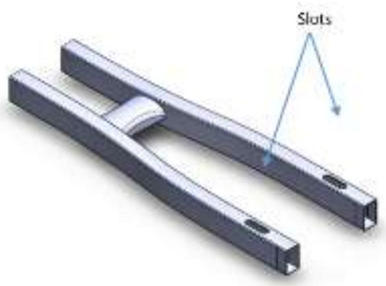

Figure 4.5 - Swing Arm

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Figure 7.6 - Assembled View

Figure 7.7 - Exploded Side view

Figure 7.8 - Exploded Top view

5. CONCLUSION

The proposed concept design can resolve axle misalignment issue, which indirectly leads to chain noise. Chain slackness adjustment can be easily done.

Any other minor causes of chain noise can be reduced by regular lubrication and maintenance of chain.

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