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EXPERIMENTAL APPROACH FOR CHAIN PERFORMANCE THROUGH RECURDYN SOFTWARE

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Abstract- This paper presents the results from a recent experimental investigation into the dynamic changes in the values of chain velocity and chain tension of roller chain drives with or without idler. While the idler is used as chain tensioner, it brings some positive changes in the chain sprocket assembly. This changes are observed and studied by performing a multi-body dynamic simulations.

Keywords – Recurdyn software, chain, initial tension, velocity, multi-body dynamic simulation

I. INTRODUCTION

Chain drive is used to transmit mechanical power from one place to another. The chain transmission has many advantages, such as simple structure, large transmission force, high efficiency and adaptability, durable and easy to repair and maintain. This structure is widely used form of mechanical transmission, which can be used as power transmission, material handling, traction, elevation and so on. It combines some features of both the gear drive and belt drive. Compared with the friction drive belt, chain transmission has not elastic sliding and slipping, so it can maintain accurate average transmission and high transmission efficiency, at the same time this structure is relatively compact. Compared with the gear drive, its accuracy requirement for manufacturing and installation is low and the cost is cheap.

The chain can be divided into single row chain and double row chain. According to the structure, single row chain can be divided into roller chain, sleeve chain and sealing chain. In this paper, a single row roller chain of designation 10B is used. Sprockets are selected from ISO 606 library using various considerations. A material used for both the chain and sprocket is high quality steel.

Due to the continuous driving of chain, friction is developed between the sprocket tooth and a roller chain which causes elongation in the chain. This increased length of a chain produces oscillations at the slack side. It causes unnecessary vibrations [4]. To overcome this problem, researchers evolved with the solution of using an idler sprocket as a chain tensioner [1]. By using the idler sprocket, chain drive undergoes a smooth operation. The use of idler brings some changes in the assembly; as the chain gets tightened it effects on the chain velocity and chain tension. According to the James work, tension in a chain link increases very rapidly as the link exits the driven sprocket [1]. Also, Huo concluded in his previous research that the external impulsive loads cause relatively moderate effect on the chain tension of meshing area of the chain links. However, the effect of impulsive load on chain tension in tight-side chain is significant [5]. In the past research of Spicer, concluded that the increase of chain tension results in the increase of efficiency of a chain drive [9]. Hence, the use of idler sprocket can be considered as an extra-advantage.

This research paper involves the study of velocity and tension of the chain under the different conditions of with and without idler. Here the results are calculated based on the multi-body dynamics software 'Recurdyn'.

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II. Experimentations & Methodology

In this study, Chain drive model is designed and simulated using different conditions as shown in the figure 1 and figure 2.

The number of teeth on driving and driven sprockets are taken as 13 and 52 respectively, considering the gear ratio of 4:1. The minimum centre distance has to be taken in between the range of 500-550 mm. It is strongly recommended to take the even number of links[14]. So, the numbers of links are taken as 100 with a fixed centre distance of 526.56 mm. The value of input rpm is taken as 2200 rpm for the high-speed application purpose. A chain with the pitch of 15.875 mm and the designation number 10B is selected. The roller diameter is taken as 10.16 mm. The teeth width of a sprocket is 6.1 mm. The above parameters are taken as inputs for the designing of the chain-sprocket model.

The rotary motion of a sprocket is obtained by adding a revolute joint at the centre of sprocket. The input angular velocity is given to the driving sprocket using an expression 230.38346*STEP(TIME,0,0,1,1). A Tension sensor is fixed on the tight side of a chain with a range of 100 mm. This sensor is used to measure the tension of chain link that pass the range of tension sensor and is the nearest to tension sensor. The symbol of tension sensor is "T" and the circle around it shows the range of tension sensor as per shown in the figure 1 and figure 2.

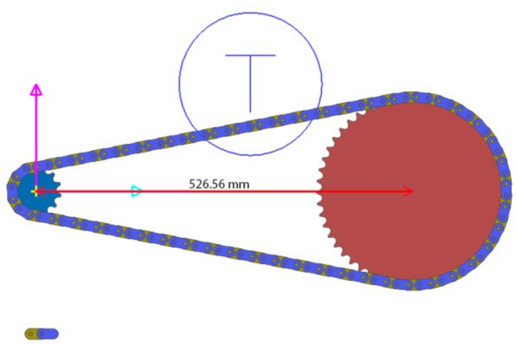


Figure 1. Arrangement of chain drive in Recurdyn

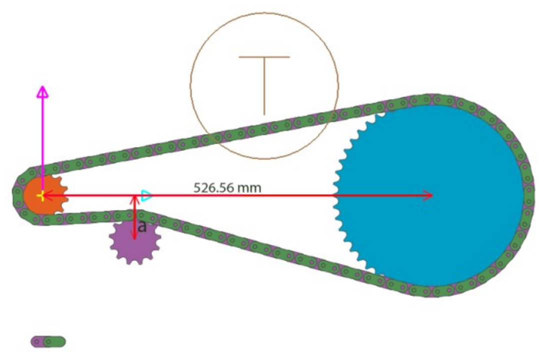


Figure 2. Chain drive with an idler at a=70,65,60 mm

In figure 1, two sprockets are designed with the number of tooth 13 and 52 respectively. The driving sprocket is placed at a position (0,0,0) and the driven sprocket is placed at position (526.56,0,0). A roller chain is aligned on both the sprockets. Also, the revolute joints are added at the sprocket centers. A tension sensor is placed at the position (300,150,0) on the upper side of the chain.

While simulating it is observed that the continuous friction between the sprocket tooth and the chain links leads to the wear and elongation of the chain. To compensate the gap, we used an idler sprocket on the slack side at the position nearer to the driving sprocket.

In figure 2, an idler is placed at a distance 'a' from the line joining the centers of driving and driven sprockets. The chain is aligned on the sprockets such that idler is kept outside of it. The tension sensor is fixed at the same position (300,150,0).

The position of idler changes according to the value of 'a' which is varied as 70 mm, 65 mm and 60 mm respectively. So, the center points of an idler sprocket are (125,-70,0), (125,-65,0) and (125,-60,0). As the chain gets tighten more and more in every condition; the number of chain links remains the same.

III. Results & Discussion

To analyse the effect of different conditions, a simulation is performed for 2 seconds with the number of steps as 100.

After simulating for the condition of chain drive without an idler sprocket, the graphs of the chain velocity and chain tension are obtained. The graph of chain velocity is plotted as velocity (mm/s) to time (sec). Also, the graph of the chain tension is plotted as force (N) to time (sec).

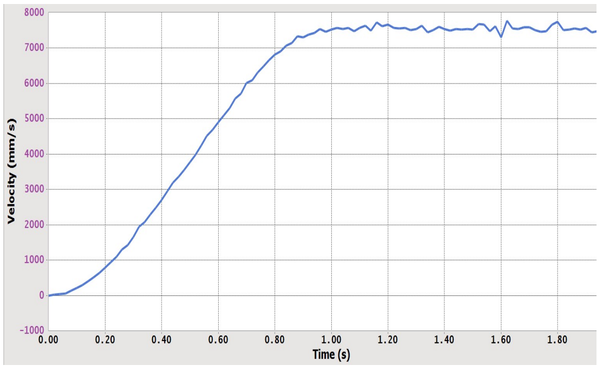


Figure 3. Chain velocity (without Idler sprocket)

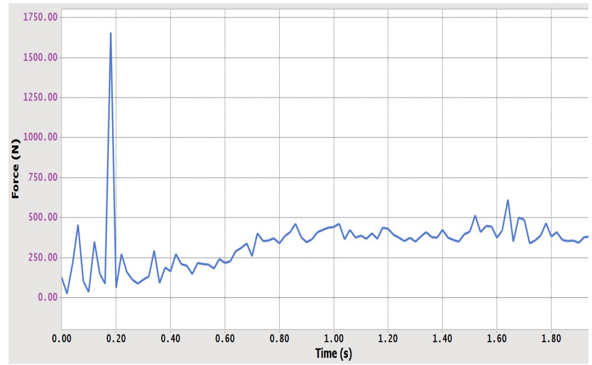


Figure 4. Chain tension (without Idler sprocket)

In figure 3, the value of chain velocity is linearly increasing with respect to time up to the 1 second. After that, curve is approximately horizontal where the value of a chain velocity varies in the range of 7.305 to 7.77 m/s.

In figure 4, it is observed that the value of chain tension reaches to the peak (T =1657 N) at starting. Further its value is fluctuating. The chain tension is varying between the range of 300 to 500 N approximately.

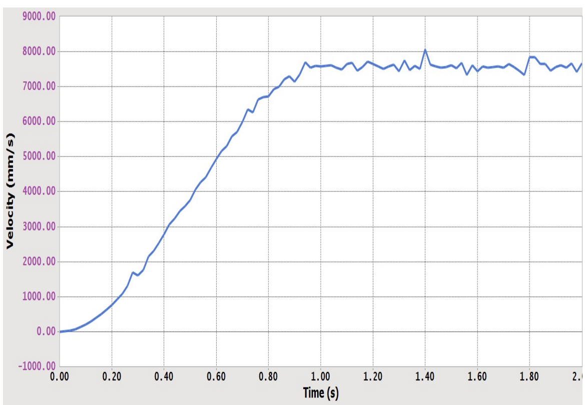


Figure 5. Chain velocity with the idler at a=70mm

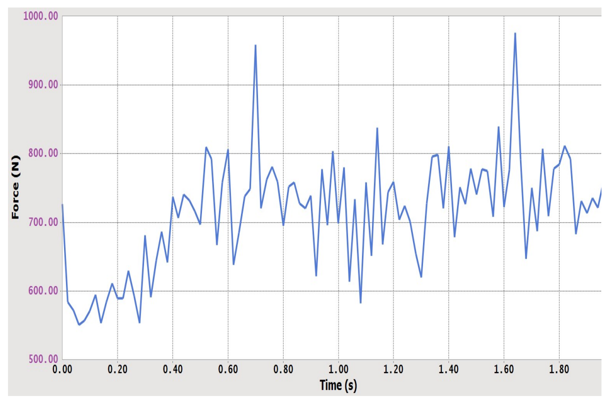
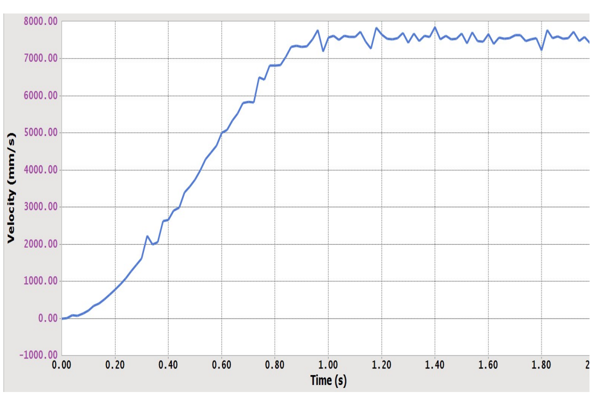


Figure 6. Chain Tension with the idler at a=70mm

Though an idler sprocket is added in the chain assembly at a distance a=70 mm, the graphs of chain velocity and chain tension can be observed in figure 5 and figure 6. The chain velocity is increasing linearly for a certain interval of time. Then its value is varying in the range of 7.33 to 8.07 m/s. The value of chain tension is continuously fluctuating between the range 600 to 800 N(approx).



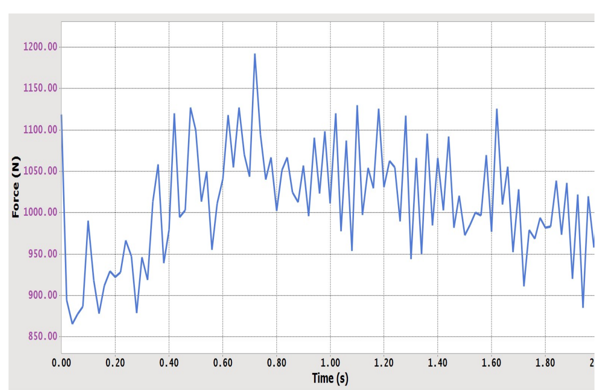


Figure 7. Chain velocity with the idler at a=65mm

Figure 8. Chain Tension with the idler at a=65mm

When the idler is displaced upward by 5 mm i.e.(a=65 mm), the chain velocity starts increasing initially and then it varies in the range of 7.231 to 7.864 m/s. The chain tension continuously increases and decreases in the range 900 to 1100 N approximately.

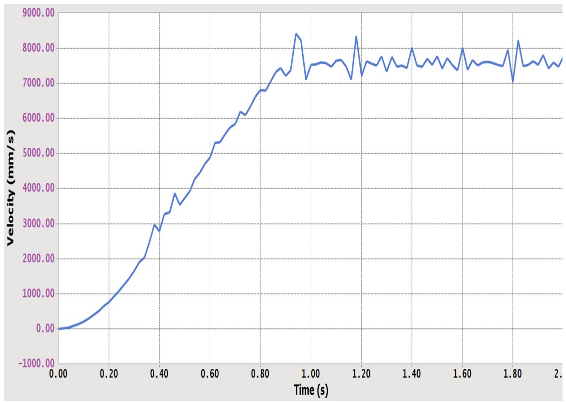


Figure 9. Chain velocity with the idler at a=60mm

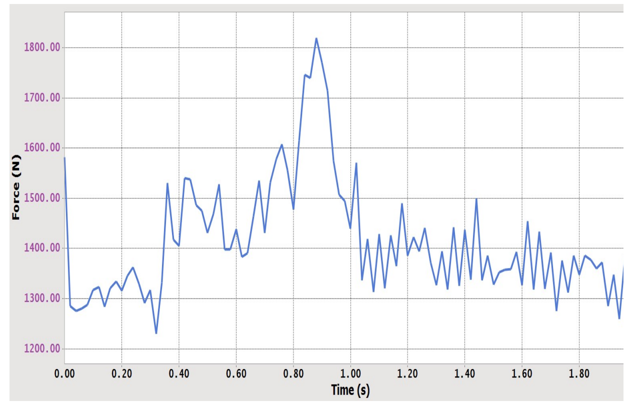


Figure 10. Chain Tension with the idler at a=60mm

After the simulation of chain model where an idler is placed at a distance a=60 mm, the graphs are plotted as shown in figure 9 & figure 10. The value of chain velocity obtained is in the range of 7.034 to 8.428 m/s. The chain tension value is fluctuating continuously in the range of 1300 to 1600 N approximately.

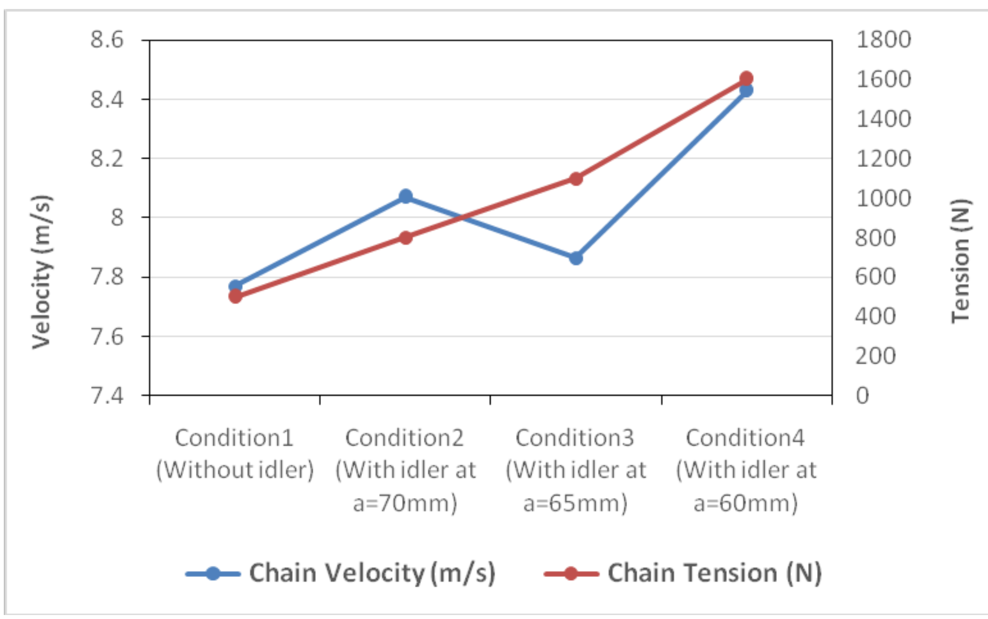


Figure 11.

The values of chain velocity and chain tension for different conditions are plotted together in figure 11. It can be observed that the value of chain velocity as well as chain tension goes on increasing except at condition 3. The value of chain velocity is 7.864 m/s at condition 3 which is less than the previous condition. Hence, position of idler at a=65 mm should be avoided.

IV. CONCLUSION

A software study was undertaken to study the effect of chain tension on the performance of chain. The following parameters were studied based on the results:

- Chain velocity
- Chain tension

The following are the conclusions from the study:

1. The values of chain velocity and chain tension are minimum for the condition of without idler and the values are maximum for the condition where the idler is used and placed at a 60 mm. Hence, it can be concluded that the values of chain velocity and chain tension increases gradually as the chain gets more tightened by using the idler sprocket. So, it is the additional benefit of using idler along as the chain tensioner.
2. Recurdyn software is beneficial for selecting the chain for industrial as well as automobile application and adjusting the chain tension.
3. It is also observed that the value of chain velocity is directly proportional to the value of chain tension during the experimental software result.

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