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EXPERIMENTAL AND THEORETICAL ANALYSIS OF FREIGHT WAGON LINK SUSPENSION

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Summary In an ongoing study of freight wagons with link suspension, measurement of link and end bearing characteristics are performed. Normal load, amplitude and frequency of excitation are altered. Different maintenance conditions of link and end bearing are tested. The observed behaviour is discussed. A model to describe the observed behaviour is proposed.

INTRODUCTION

In an ongoing project at KTH the running behaviour of freight wagons is studied. The background to the project includes plans to increase axle load, loading gauge and speed of freight trains in Sweden to make freight traffic more competitive. Simulation models for freight wagons with different types of running gear are developed. Prediction of running behaviour for wagons with link suspension is found to bee very difficult. One cause for that is the strongly non-linear characteristic of the link suspension and the fact that the vehicle behaviour is very sensitive to the horizontal suspension characteristics. Another reason is that the characteristics vary with maintenance status of the link suspension and climate conditions [1-3]. The link suspension, shown in Figure 1, is the most common suspension design for freight wagons in Europe today and is used both on two-axle as well as bogie wagons [4]. Even though the design has existed more than 100 years, they are still, in our opinion not fully understood today. The rather simple model used for the link suspension today is not regarded to be sufficient.

The study of the link suspension characteristics is divided into two parts. In the first part a link-bearing system is investigated. Measurements of the characteristics of the link-bearing system are performed and a model based on contact mechanics is developed. In the second part the influence of link suspension characteristics on the running behaviour of a freight wagon is investigated. The present paper covers laboratory measurements and mathematical modelling of a pendulum link.

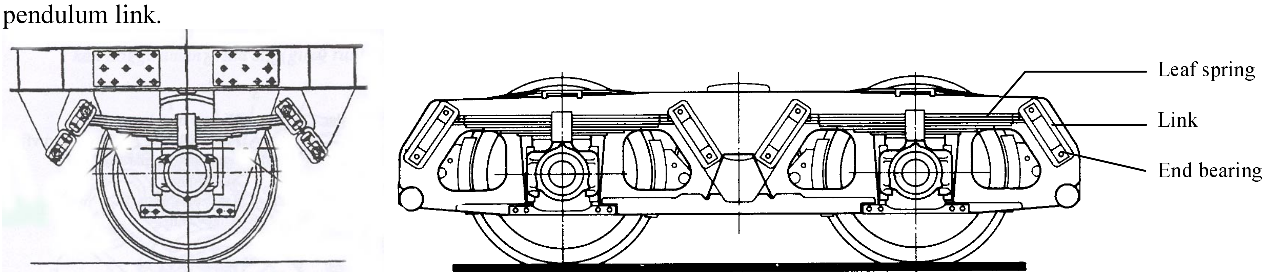

Figure 1: Running gear with link suspension.

LABORATORY MEASUREMENTS

To study the contact between link and end bearing a test rig, shown in Figure 2, is designed. A pendulum mass is hanging in a frame via link and end bearings. The upper end bearing is connected to the frame and the lower to the mass. A hydraulic cylinder applies a horizontal force on the lower part of the link and lateral force-displacement characteristics are measured. The mass is varied between 660, 1380 and 2200 kg. The amplitude and frequency of the applied force is varied. New as well as components worn in service are tested.

Figure 2: Test rig.

Figure 3 shows force-displacement characteristics for different links. The first observation is the significant hysteresis. Another observation is that the hysteresis curves differ from each other.

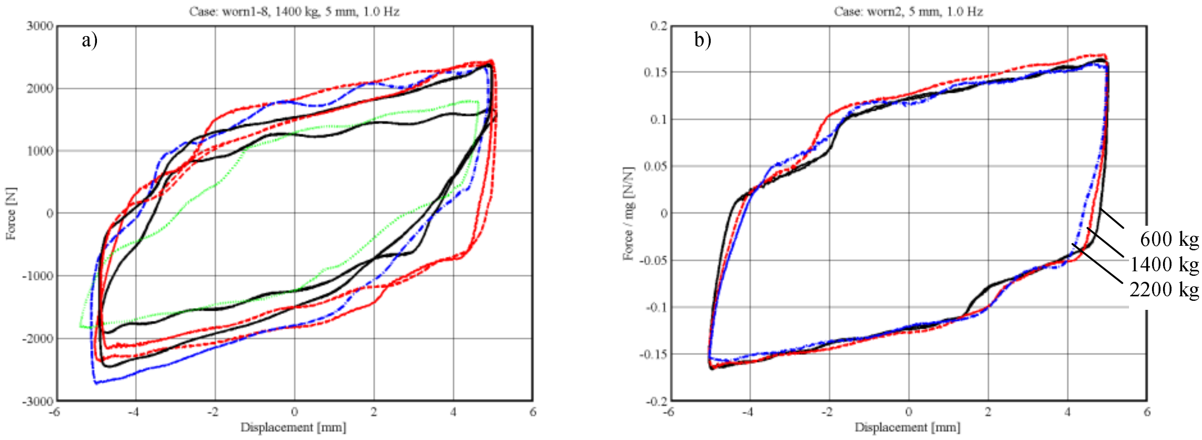

Figure 3: Force-displacement characteristics:
a) Scatter for different worn links.
b) Load dependence.

In Figure 3 b) is the force from the excitation normalized with the normal load. It is observed that in the transition zone between rolling and sliding the behaviour is not proportional to the normal load.

MATHEMATICAL MODELLING

The principle of the link suspension is that of a pendulum. When applying a lateral force on the link, it will start to roll in the bearing. When a certain tangential force is reached between the links and bearing, the link starts to slide. In the rolling case the suspension is stiffer than in the sliding case. The proposed model is using contact mechanics between rolling cylinders [5]. With a given geometry and contact environment the characteristics can be simulated. The motion for centre of gravity of the link pendulum system is described by the vector **q=A+B+C-D-E+F**, as shown in Figure 4. The equation of motion for the link pendulum system is written as $\mathbf{F}=\mathbf{M}*\ddot{\mathbf{q}}$. The tangential force in the contact points between link and end bearings, P_1 and P_2, is given as a function of the creep ratio and normal force in the contact.

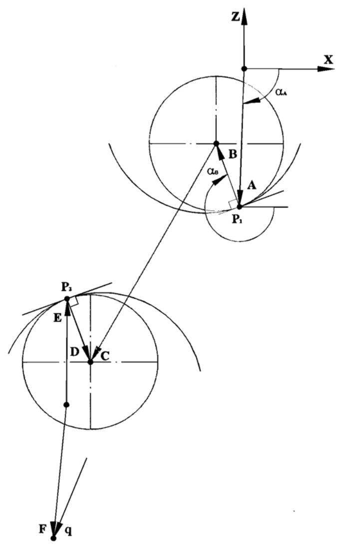

Figure 4: Link model.

CONCLUSIONS

Links worn in service show a significant amount of hysteresis. Links are thus not only providing stiffness but also damping to the vehicle. The characteristics vary with the maintenance status of the components. The results are independent of frequency, in the range 0 – 5 Hz. The rolling stiffness is independent of the amplitude of the displacement. The result is not proportional to the normal load in the transition zone between rolling and sliding.

References

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