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LUBRICATION MODELS IN RAILWAY CURVES

Ali Samet Ayvaz
Samsun Metropolitan Municipality, Department of Transportation
* alisametayvaz@samsun.bel.tr

Mohammad Alalou
Ondokuz Mayıs University, Faculty of Engineering, Department of Civil Engineering
* mohamadalou93@live.com

ABSTRACT
One of the most important problems of the Railway Operations is the wear problems that occur in the rails under load and momentum. Many businesses in the world have developed different solution methods on this issue and the same methods are still applied. Noise is also the bleeding wound of many railway operators, regardless of or dependent on wear and fatigue problems. Noise, especially in the curves, adversely affects human and environmental health. In this report, we will examine the factors caused by these 2 problems and examine the solution methods with their costs.

INTRODUCTION
With the completion of the 2nd Stage of Samsun HRS line, our Main Line consists of 28 + 700 m double track rails. The section between the Warehouse Fields, level crossings and Büyük Cami-Kılıçdede stations consists of Ri60 grooved rails. The remaining part of the line consists of S49 mushroom rails.

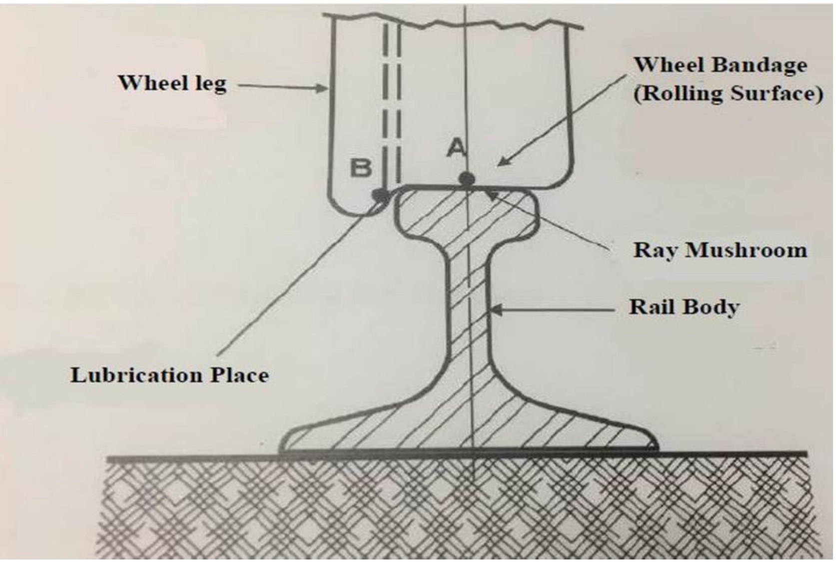

Figure 1: S49 Rail-Wheel Relationship

Wear and Fatigue Tolerances
Fatigue is the gradual decrease in the mechanical strength of a material when the stress caused by the effect of continuous loads reaches the fatigue limit. This does not happen with stresses below the fatigue limit. The material, whose strength decreases over time, breaks at lower strengths than the breaking stresses corresponding to the initial loading. In the fatigue test, the rail or weld is continuously loaded up to a fatigue stress of at least 2 million times and no cracks are required.
The cause of fatigue in metals is the spaces between the crystals that have been found from the beginning. When stresses and loads reach the fatigue limit, voids spread, expand, and cause the material to deteriorate without visible deformations.
Visible deformations in the rail profile are examples of wear. Apart from this, invisible wear between 0.10-2.00 mm can be read with Line Maintenance Tools or laser-optical equipment.

The maximum vertical wear tolerance depends on the maximum train speed and line traffic load.

Table 1. Maximum vertical rail wear values according to British Railways;

Above 160 km/h	9 mm
120-160 km/h	12 mm
80-120 km/h	15 mm
Below 80 km / h	18 mm

Table 2. Maximum vertical rail wear values according to German Railways;

19 MGT - 25000 tons – above 140 km / h	12 mm
1.75-7.5 MGT - 20000 tons – below 140 km / h	20 mm
0-1.75 MGT	26 mm

According to the BoStrab standard, the vertical wear tolerance of the S49 rail is 25mm'. Vertical rail wear is proportional to total tonnage. The vertical wear rate for 900A rails is 1mm / 100MGT if there is buden lubrication.

According to British Railways, the point that makes an angle of 26 degrees with the rail axis 3mm above the lowest point of the rail cork is used as the reference point in lateral wear tolerance.

The total vertical and lateral wear of the rail cork should not reach 25mm.

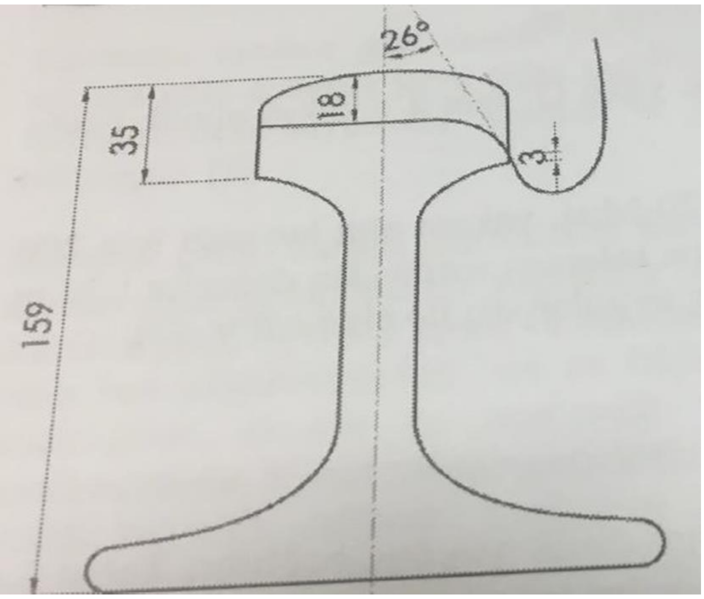

Figure 2: Lateral and Vertical Wear Criteria According to British Railways

In our main line, we do not have a zone where the total lateral-vertical wear reaches 25 mm. Although we do not have a wear measuring device or vehicle, periodic control of the pulleys is carried out in the scissors and curve areas.

Wheel - Rail Contact

Our S49 and Ri60 rails in the main line and warehouse area are of R260 - 900A quality. In other words, they have 260 BHN Brinell Hardness.

There are 3 different tram models serving in our business. Of these models,

- Wheel Budeni 290 BHN on Ansaldo Breda tram
- Wheel Budeni 305-320 BHN on CNR tram
- Wheel Budeni 305-320 BHN on Durmazlar Panorama tram they have their hardness.

The fact that the rail is harder than the wheel causes more wear of the wheel, and the harder the wheel than the rail causes more wear of the rail. In the enterprises, the desired rail is also the least level of wear on the wheel. It is useful to pay attention to these rail wheel stiffness criteria in line manufacturing and when choosing the vehicle to work on the line.

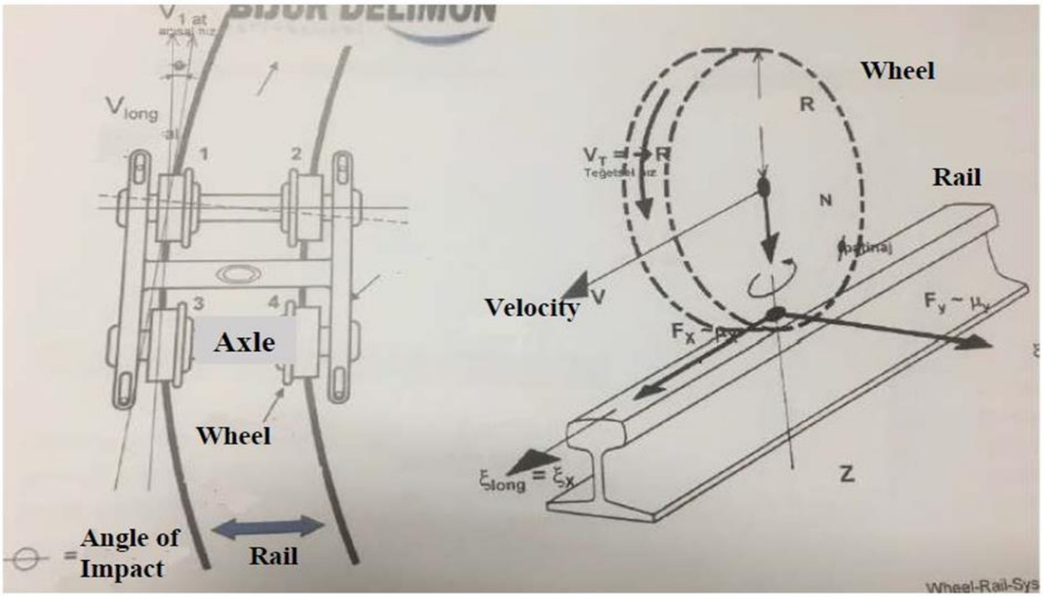

Figure 3: Bogie Team Movement on the Cross

As seen in the figure above, the Bogie team oscillates on the curve. There can be many reasons for the abrasion and squeaking noise that occurs on the curve. These;

- Speed difference of wheels on inner and outer tracks
- The swing of the wagon on the track
- Skid
- Sudden Braking
- Laterally controlled or uncontrolled sliding
- Geometric error on the screen
- Exceeding Speed Limits
- It can be listed as the absence of the Transition Curve.

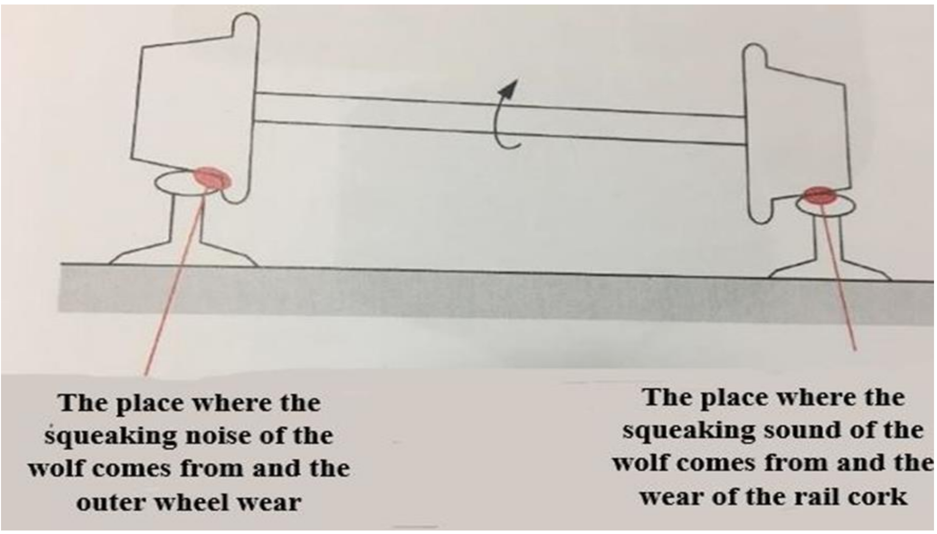

Figure 4: Points of Wear and Noise

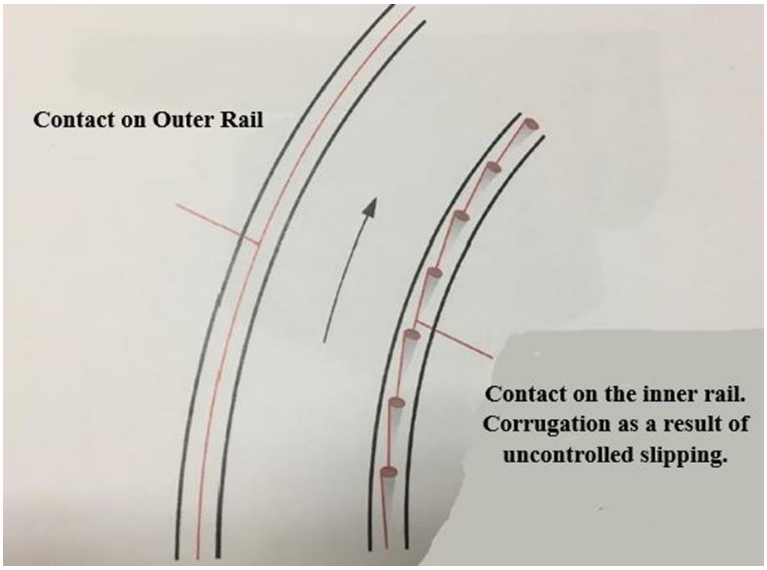

Figure 5: Corrugation points

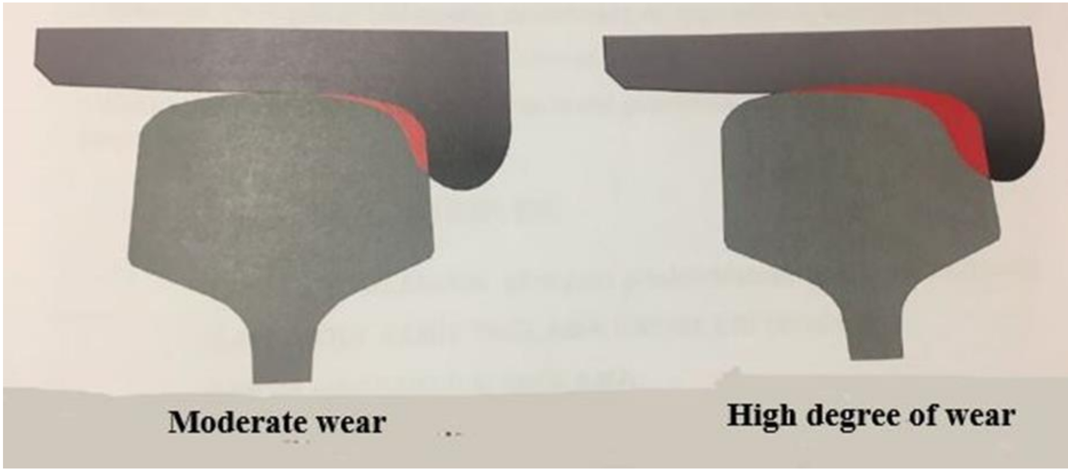

Figure 6: Wear Points on Rail and Wheel

Wheel Wear

Boden has passed from English as a term to our language and technique. In English, "Flange" means prominence in Turkish. If we explain it as a technical term, Boden is the protrusion part of the wheel that allows the train to move without derailment. The height and thickness of each wheel can vary within the standard limits (UIC 810-UIC 510).

Boden is the most worn part of the wheel. Especially in the curves, the entire load of the train rests on the rail over the basement. Fattening of the body is a very important issue. The better the body is lubricated, the longer the life of the wheel. During the turning of a wheel whose body is worn, approximately 3 times more sawdust is removed compared to normal turning.

To give an example numerically; Let us assume that a wheel whose rudder thickness should be 32 mm decreases to 28 mm as a result of wear in the measurement. To increase the thickness of the body back to 32 mm, you need to decrease approximately 12 mm from the diameter. For a wheel that wears 1mm per month, this means. The life of the wheel is shortened by 12 months as a result of the thinning of the body.

- Wheel Wear Tolerances
- Ansaldo Breda / Lucchini OIC810 st. 610/656 mm
- CNR / GHH EN13749 st. 540/600 mm
- Durmazlar Panorama / GHH EN13749 st. 570/650 mm

Because the wear is on the flanges rather than the rolling surface of the wheel, therefore, more chips are removed from the wheel diameter in each turning cycle in order to maintain the thickness of the flange. Wearing flange and required flange thicknesses are shown in Picture-5 and Picture-6 below.

Figure 7: CNR profile defective flange thinning

Figure 8: CNR profile smooth wheel bandage

Tram number 5522 can be given as an example of flange thinning.

Turned at 120500 km and the P Bogi wheel flange thickness is 17.36 mm. The next lathe was made after 41000 km, that is 161400 km, and as seen in the preliminary measurement data, the flange thickness of the same wheel was seen to be thinner by 15.08 mm. In order to correct the profile, 20 mm of sawdust was removed from the diameter.

Importance of Lubrication

Until recently, rail wear, especially in narrow curves and under load, was the most important problem to be avoided for railway engineers. Nowadays, railway noise has been added to this. The primary cause of railway noise is the wear between the outer rail on the curve and the knuckle, and the second is the so-called snap-slip movement. This stick-slip movement is due to the slippage of the inner wheel in order to compensate the difference between the inner wheel and the outer wheel in curves.

What needs to be done to reduce this wear and noise on the rails is to cut the contact between the wheel and the outer rail on the curve with tribological methods, in other words, to lubricate. A layer should be placed between the inner rail on the curve and the wheel to prevent the noise caused by slipping.

This layer is provided with high viscosity lubricants and friction modifiers applied independently from each other and automatically.

As the main line railways are exposed to a much higher load compared to the tram, it is not possible to drill holes in the rail in practice. For this reason, lubricants and friction modifiers are transported to the application points (rail side and rail) by various equipment.

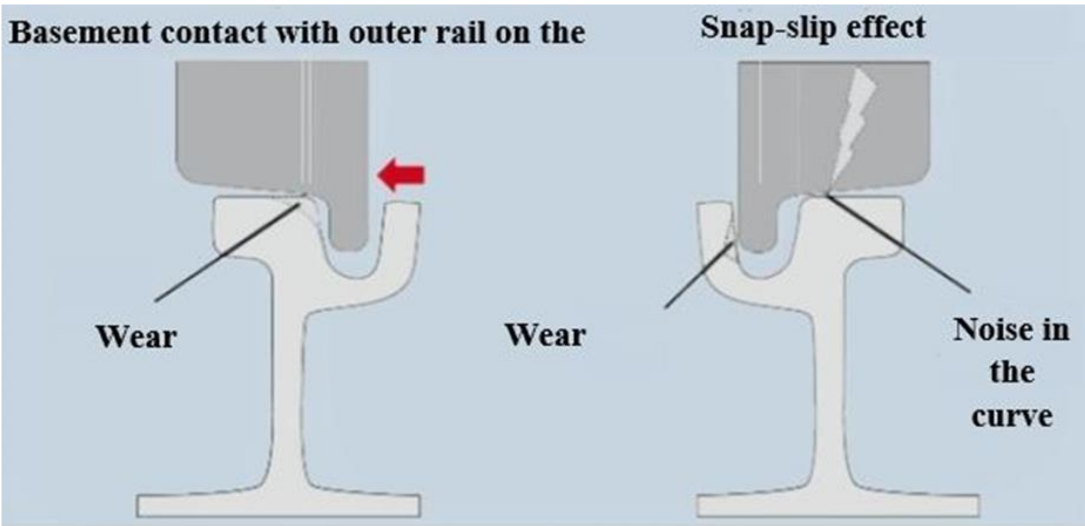

Figure 9: Abrasion and Snap-slip effect

Lubrication reduces friction between the rail-wheel and reduces lateral loads. In this way, the risk of wheel climbing and the widening of the gauge is reduced. With friction modifiers (grease, solid oil, etc.) on the rail, the friction coefficient is required to be between 0.2-0.4. In this way, rolling resistance, corrugation and wheel squeal noise in curves is reduced.

The friction coefficient is measured by a hand-driven car (Crab etc.) or vehicle-mounted tribometer device. The friction coefficient is between 0.3-0.7 in dry track and is considered to be 0.5 on average. The friction coefficient increases with the turned wheel or the ground rail. It is between 0.2-0.4 in lubricated rail. While it is desired to be between 0.2-0.4 on the rail with lubrication, it is desired to be below 0.1 at the edge of the rail.

CONCLUSION AND EVALUATION

Considering the cost of the automatic lubrication system, it is the ideal method for tram companies like us to continue to apply fixed flange lubrication from the vehicle and manual (with brush) lubrication systems together. Because there is no wear on the rails in the main line and our warehouse area above the tolerance values yet. In addition, the continuity of the line and tramway flanges with minimum wear can be ensured with the grinding and lubrication trainings that the Line Maintenance Team personnel will receive continuously.

Kayseray, Ankaray and Antalya Transportation companies have recently started to use the Automatic Lubrication System in their lines. When the data obtained from these plants were analyzed, it was seen that, for example, 1/6 of the oil consumption of the automatic lubrication system in a curve of R150 was consumed in 1 curve of similar radius in our line. In other words, it has been observed that our Line Maintenance Team consumes an average of 15% of the oil consumed by the Automatic Lubrication System with Manual Lubrication. This is because they have known how much oil to apply for many years and even where.

The Line Maintenance Team does not only focus on this job while lubricating the line on a curve, but also checks whether there are any adverse situations around the curve and the line (drainage channels - scissor motor and zone - scissor sliding pads). In other words, it always keeps the Maintenance and Repair Directorate up-to-date on whether there is a malfunction or a negative situation.

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