AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 2, Issue 3, 2024 *ISSN (E): 2993-2637*

Determining the Interaction Coefficient Between Wheels and Rails

Mamaev Sh.I.
Tashkent State Transport University

Tursunov T.M.
Tashkent State Transport University

Nafasov J.H.
Tashkent State Transport University

Sh.Kh. Toshtemirov
Tashkent State Transport University

Abstract: This article delves into the determination of the coefficient of friction between wheel pairs and rails, crucial components of locomotive wheel motor units, through scientific inquiry. Our research highlights that the maximum coefficient value is contingent upon both the maximum friction value and the force exerted by the wheel on the axle. Additionally, we observe that the adhesion coefficient's value varies with sliding speed, with a maximum sliding speed identified as 0.5. Experimental findings reveal that mixing coefficients range between 80% and 90% of the maximum value.

Keywords: wheel pair, rail, sliding, speed, coupling coefficient, locomotive.

INTRODUCTION. To enhance locomotive reliability and efficiency, it's imperative to optimize and maintain a constant coupling coefficient between wheel pairs and rails. This coefficient is determined based on sliding speed and vertical forces acting on the rail. Through dynamic process analysis, we establish a functional relationship between the wheel-rail contact coefficient and sliding speed v, alongside the vertical load R. The maximum friction coefficient, which remains stable amid slight sliding speed changes, is termed the potential coefficient of friction. Notably, the ps0 value marginally decreases with increasing movement speed v, attributed to reduced stationary contact duration.

We call the maximum value of the coefficient of friction, which remains constant during small changes in the sliding speed, the potential value of the coefficient of friction [1, 3], in this case $\psi_0 = \psi_{мак.уст.}$.

Theoretical groundwork for functional relationships between wheel and rail characteristics was laid by Russian scientist V.I. Naumov, who considered the given normal force R as the maximum coupling value, leading to stresses within the wheel and rail bodies per material strength limits.

In this scenario,

$$\psi_0 = \frac{S_{max}}{P}$$

it is imperative to expand the contact surface area to enhance the coefficient value. According to research [11], this expansion can be achieved by increasing the wheel's rolling circle diameter, the rail head surface radius, and utilizing tires with specialized profiles. Moreover, boosting the strength limit of wheel tires and rails by employing materials with higher Poisson's coefficients and lower moduli of elasticity is essential.

Laboratory experiments [2] and torque tests conducted during locomotive operation [3] corroborate these conclusions and principles. However, it's noted that the coefficient value diminishes due to rail pollution from mineral dust and oil stains, as well as moisture accumulation from dew, light rain, or melted snow. Conversely, heavy rain cleanses the rails, restoring the coefficient to its peak, which experimental data suggests can reach 0.5 [4].

To stabilize the coefficient ψ_0 , the application of fine quartz sand, with minimal moisture content (not exceeding 1%), is advocated. This sand, when continuously dispensed beneath the wheels during challenging terrain or adverse weather conditions, facilitates automation through a tripping relay mechanism or an operator-initiated button press. Crushed quartz sand serves to dislodge dirt and oxide films from the wheel's rolling surface, thereby augmenting the actual contact area.

It's crucial to differentiate this practical approach from the calculated speed coefficient, which is contingent upon speed and detailed in the rules governing train operation calculations.

Fundamental research [6] focused on examining the characteristics of mainline locomotives. Among these studies, the scientific investigation conducted by N. N. Menshutin [7] holds significant importance for our purposes. The nominal load from the wheel pair of the VL22 series locomotive on the rails is $P_0 = 22m$ with a wheel diameter of $d = 1{,}22$ Tests were conducted using both conical and cylindrical bandages, with and without sand..

Measurement of slip was achieved utilizing frequency induction sensors, with one sensor positioned on the axle of the active engine wheel pair responsible for torque development, and the other on a stationary axle (control). These sensors' measuring coils were connected to a single vibrator, facilitating the detection of slip-induced vibrations on the recording film. By analyzing the distance between film nodes and reference wheel revolutions, the ratio of sliding speed to rolling speed was determined: $\alpha = \frac{u}{v}$.

For the initial ascending region of the connection description network, a relatively more accurate yet labor-intensive method involving separate pulse recording was employed. This method enabled the determination of sliding speed through pulse movement.

This approach allowed for the measurement of relative sliding speeds ranging from 0.1% to 100%, with approximately 2000 data points collected during testing to establish the desired relationship.

Overall, wheel sliding speed comprises two components: longitudinal, perpendicular to the wheel pair axis, and transverse, parallel to it. While it may seem convenient to analyze longitudinal and transverse slips separately, it's crucial to recognize that these forces are interdependent, originating from force projections. Similarly, longitudinal and transverse sliding speed components exhibit this relationship. However, in practical problem-solving, due to limited experimental data, adopting a unified engagement description representing wheel operation on straight road sections remains feasible for various scenarios.

Economic assessments are essential to determine the optimal relative sliding speeds on both straight and curved rail sections, where wheel axles conform to calculated gradients. It's important to note that a portion of the locomotive's energy, proportional to the coefficient a=u/v, is not solely utilized for traction but is also expended on maintaining the rolling surfaces of wheels and rails.

Professor G. M. Shakhunyans [58; 421-428-b] suggests, based on extensive experimental data processing regarding rail wear, that comparative wear follows an approximate law expressed as:

$$\varepsilon = K\frac{P}{\Phi}(1+9\alpha\%)$$

Here, the parameter alpha takes into account track construction effects and rail steel quality. It's observed that increasing sliding speed from 0.8% to 2% results in 2.3 times more wear on the rails.

Considering this and the nature of slip characteristics, the recommended average slip value for the limiting wheel pair on straight sections corresponding to predominant inclines, under normal conditions, is approximately $\alpha_{S\text{рук}} = 0{,}65 - 0{,}7\%$ This value is suitable for mainline locomotives as it achieves a sufficiently high coefficient of engagement during calculated climbs (approximately ranging from 0,8ψ_0 to 0,9ψ_0), while also providing a margin of engagement to prevent differential creep.

References

1. Biryukov, I.V. et al. Mechanical Part of the Rolling Stock: Textbook for Higher Education Institutions in Railway Transport. Edited by I.V. Biryukov. Moscow: Transport, 1992. 440 pages.
2. Schreiber, R. "The Optimization Coefficient of Electric Generator Series is 12x." In: Railways of the World, Issue 6, 2000. pp. 29-34.
3. Kikichev, Sh.V. "Enhancing the Efficiency of Coupling Activators by Improving Their Adhesive Characteristics." Abstract of Dissertation for Candidate of Technical Sciences, Rostov-on-Don, 2009.
4. Engel, B. "Regulation of Traction with High Utilization of Coupling Forces." In: Railways of the World, Issue 2, 1999. pp. 39-45.
5. Minov, D.K. Enhancing the Traction Properties of Electric and Diesel Locomotives with Electric Transmission. Moscow: Transport, 1965. 267 pages.
6. Frenkel, E.M. "On the Issue of Wheel-Rail Coupling." In: Proceedings of the XII Congress, Issue 23. Moscow: Transjeldorizdat, 1953.
7. Naumov, V.I. "Influence of the Contact Strength between Metal and Steel Connection of Wheel and Rail." In: Proceedings of the All-Union Scientific Research Institute of Railway Transport, Issue 255. Moscow: Transjeldorizdat, 1963.