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The Quantitative Analysis of the Influence of the Superficial Abrasion on the Lifetime of the Frog Rail

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Abstract : Turnout is the essential equipment on the railway, which also belongs to one of the strongest demanded infrastructural facilities of railway on account of the more seriously frog rail failures. In cooperation with Germany Company (DB Systemtechnik AG), our research team focuses on the quantitative analysis about the frog rails to predict their lifetimes. Moreover, the suggestions for the timely and effective maintenances are made to improve the economy of the frog rails. The lifetime of the frog rail depends strongly on the internal damage of the running surface until the breakages occur. On the basis of Hertzian theory of the contact mechanics, the dynamic loads of the running surface are calculated in form of the contact pressures on the running surface and the equivalent tensile stress inside the running surface. According to material mechanics, the strength of the frog rail is determined quantitatively in form of the Stress-cycle (S-N) curve. Under the interaction between the dynamic loads and the strength, the internal damage of the running surface is calculated by means of the linear damage hypothesis of the Miner's rule. The emergence of the first Breakage on the running surface is to be defined as the failure criterion that the damage degree equals 1.0. From the microscopic perspective, the running surface of the frog rail is divided into numerous segments for the detailed analysis. The internal damage of the segment grows slowly in the beginning and disproportionately quickly in the end until the emergence of the breakage. From the macroscopic perspective, the internal damage of the running surface develops simply always linear along the lifetime. With this linear growth of the internal damages, the lifetime of the frog rail could be predicted simply through the immediate introduction of the slope of the linearity. However, the superficial abrasion plays an essential role in the results of the internal damages from the both perspectives. The influences of the superficial abrasion on the lifetime are described in form of the abrasion rate. It has two contradictory effects. On the one hand, the insufficient abrasion rate causes the concentration of the damage accumulation on the same position below the running surface to accelerate the rail failure. On the other hand, the excessive abrasion rate advances the disappearance of the head hardened surface of the frog rail to result in the untimely breakage on the surface. Thus, the relationship between the abrasion rate and the lifetime is subdivided into an initial phase of the increased lifetime and a subsequent phase of the more rapid decreasing lifetime with the continuous growth of the abrasion rate. Through the compensation of these two effects, the critical abrasion rate is discussed to reach the optimal lifetime.

Keywords : breakage, critical abrasion rate, frog rail, internal damage, optimal lifetime
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