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The Application of FE Parametric Quadratic Programming Method to Problems of Wheel-Rail Relation

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Summary

At the present day world railways are developing towards high speed trains and heavy haulage. In order to increase the running speed of the train and hauling tonnage rating, it is necessary to ascertain the mechanism between the wheel-rail transmitting forces and make a precise analysis. This is a multi-nonlinear, frictional elasto-plastic contact problem. Nowadays the theory used for calculating wheel-rail contact forces is based on the Hertz's hypothesis and elastic semi-space assumption and is unable to accurately study the complicated problem of wheel-rail relation. In this paper, the elasto-plastic wheel-rail contact problem is solved by using FE parametric quadratic programming method combined with multi-level, multi-branch substructure technique, precisely modeling wheel-rail contact relation. Consequently, the Hertz's hypothesis and elastic semi-space assumption are avoided. As for convergence of contact computation, the convergent speed is ensured owing to adopting the mathematical programming method and avoiding iteration. Four examples of computation are discussed in this paper. (1) Comparison between the two computations of elastic contact model and elasto-plastic contact model for problem of wheel-rail relation. The computed results show that there are important differences between the distribution laws not only of normal but also of longitudinal tangential forces computed by two models. The distribution of adhesion and creep regions in contact spot between wheel and rail obtained by elasto-plastic computation is entirely rational and coincides with practice good. (2) Research on the reason of better wear resistance of worn-tread. In order to make comparison both the contact computations of wheel-rail relation for cone-tread and worn-tread are conducted. The computed results show that the area of the worn-tread contact spot will be about 1/3 greater than that of the cone-tread one while the maximum value of normal forces and longitudinal tangential forces will decrease. That is the reason why the worn-tread has better wear resistance than the cone-tread. (3) Contact analysis of wheel-rail relation when locomotive negotiates curves. The computation of negotiation of curves was made by means of theory of rigid body mechanics before. Using substructure technique the computational model of a wheel set in contact situation with inner and outer rails is constructed when a Chinese domestic diesel locomotive negotiates curves, and the problem is solved by FE parametric quadratic programming method. Since almost every part

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of wheel-rail system is included in model, the computed results correspond with test. (4) Investigation on the influence of functionally gradient material upon the wheel-rail contact performance. The precise model is constructed for the situation when the wearresistant gradient material is used in rail top and the accurate computation is made. The research shows that the application of gradient material will result in reduction of stress level produced under the contact spot between wheel and rail, consequently, the gradient material has the best future in 21^{st} century.