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THE METHODOLOGY OF FATIGUE TEST SIMPLIFICATION

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Abstract: *The contribution is focused on the issues of experimental determination of fatigue characteristics of structural nodes of rail vehicle parts on a dynamic test stand. The aim of the contribution is to describe a methodology allowing simplifying the experiments. The proposed methodology uses FEM computation, correlation analysis and estimation based on specific stress response. In order to validate the methodology, an experiment with a physical specimen was performed.*

Keywords: ***Rail vehicle, structural node, fatigue testing, FEM analysis, dynamic test stand.***

1. Introduction

The aim of this contribution is to describe a methodology which allowing simplify experimental testing of fatigue strength of structural nodes of rail vehicle bogie frames. The purpose of the proposed methodology is to reduce the number of cylinders (and thus also other equipment) necessary for fatigue testing for determining the fatigue properties of structural nodes, especially structural nodes of rail vehicle constructions. The methodology was validating by FEM analysis and testing on real specimens at an electrohydraulic stand.

2. The proposed methodology

The method assumes that the loaded assembly is linear. Further assumption is that the sample, subjected to the applied loading, has one critical point. The aim is to reach the same number of cycles to failure, but another requirement has still to be fulfilled, that the same mode of failure occurs at the same point as with the original loading set. In an extreme case it may also happen that the specimen is loaded in a completely different way but the failure occurs at the same (almost the same) number of cycles. Based on the aforementioned information, several assessment methods were proposed (which does not exclude other methods):

One-parameter methods

a) The value of σ_1 – only the magnitude of the principal stress is evaluated, its direction is not taken into account!

b) The value of τ_{max} - only the magnitude of the maximum tangential stress is evaluated, its direction is not taken into account!

c) The value of σ_{HMH} – the directions and relation of the shear and tensile components are not taken into account; negative values of stress are not taken into account either.

d) Reference stress σ – one or more strain gauges are positioned at a suitable place of the construction. The assumption may be made that there is a relationship between this stress and the maximum stress in the notch. The value of the stress in the direction of the strain gauge is evaluated and subsequently transformed to the stress in the notch (critical point).

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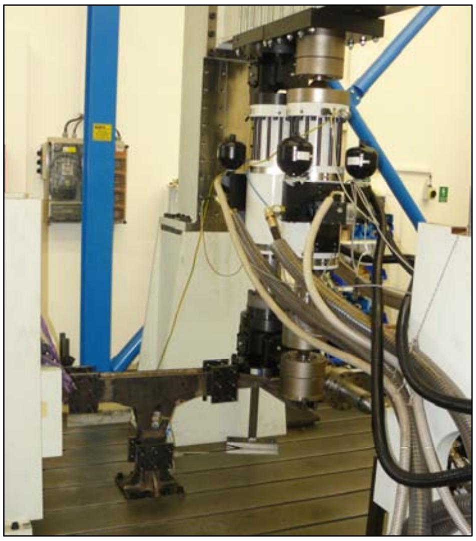
Two-parameter methods

e) The values of σ_1 and τ_{max} – Magnitudes of both stresses are evaluated, with regard to the fatigue limit ellipse in the σ–τ diagram. The direction in relation to the critical point is not taken into account.

f) The values of σ and τ – The values of tensile stress and shear stress in a selected reference direction are evaluated. The direction must be chosen with regards to the supposed direction of the crack. The direction in relation to the critical point is thus taken into account.

3. Achieved results

The methodology was applied on an actual specimen. A steel weldment was constructed, representing the structural node of connection of a sideframe and a transom (Fig. 1). It was loaded by three EH cylinders; the simplified assembly was loaded by two EH cylinders. There are two potential critical points on the specimen (CP1, CP2) but with regard to load system only one of them is critical.



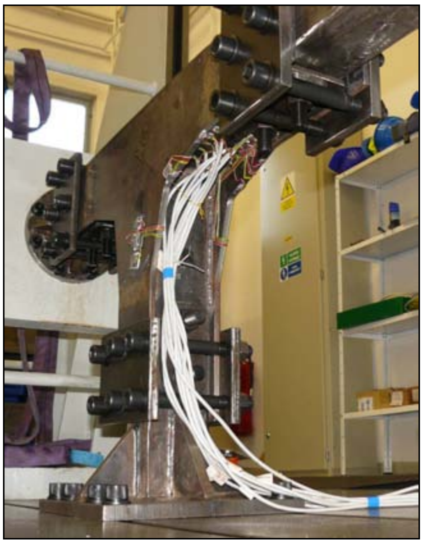


Fig. 1: The experimental assembly and the specimen with strain gages.

Five variants of load were proposed. Results of stress responses are listed in Tab. 1.

Tab. 1: Stress response (two-parameter simplification).

Variants	F1 [kN]	F2 [kN]	F3 [kN]	CP1 [MPa]		CP2 [MPa]	
				σ	τ	σ	τ
Original	+/- 4.3	-/+ 1.3	8.5 +/- 2.10	64.9	28.4	49.7	28.6
A	+/- 3.5	0	7.1 +/- 1.75	64.8	30.7	40.8	30.9
B	+/- 2.9	0	5.8 +/- 2.90	65.0	31.0	33.5	31.1
C	0	0	19.3 +/- 4.80	64.7	28.3	-1.0	28.3
C1	0	0	10.6 +/- 6.40	64.4	30.0	-1.3	30.0
D	+/- 5.5	0	0	64.9	31.6	64.9	31.9

4. Conclusions

The described methodology allows simplifying the loading of a structural node of a rail vehicle for the purpose of simulation of its operational loading at a dynamical test stand. However, the methodology should be taken only as a starting point of further research, since it still has many limitations in the present stage. For simple structural nodes loaded by external loading components with the same phase it is applicable, though. It is also difficult to use for tests, which are conclusively defined by standards.

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