Review of a Dissertation Thesis

Degradation Processes of Materials Due to Contact-Fatigue Loading

Ing. Utku KAYA

Description

The submitted work has been elaborated in accordance with Study and Exam Regulations of the University of Pardubice. The dissertation thesis investigates mechanical changes in the surface layers of railway steels due to contact of a railway wheel with rail. Two materials were investigated: austenitic Hadfield steel and steel R 260 with pearlitic structure.

The thesis is divided into an introduction plus eight chapters. The situation is outlined briefly in the introduction. The first chapter explains the mechanisms of the rail-wheel contact. The second chapter discusses the mechanical processes in the contacting materials and explains various mechanisms of wear and creation of defects in the surface layers. Chapter 3 is devoted to the rail materials, pearlitic steels, bainitic steels and austenitic steel Hadfield, including the variant with explosion-hardened surface. Chapter 4 outlines the problems to be solved and the aim of the research, such as finding of the suitable way for evaluation of the contact-induced heterogeneity in the surface layers. Chapter 5 analyses degradation of the investigated steels after operational loading (material composition, formation of cracks, and appearance of microstructure). The information is mostly presented in the form of photographs. Chapter 6 investigates the degradation after tests done on a special stand for rolling contact. In addition to metallographic analysis, also mechanical properties and wear rate were measured. Chapter 7 is devoted to the determination of mechanical properties by instrumented indentation. This method enables measurement of hardness and components of energies involved in the process of indentation. The dissertant tested Hadfield steel using three kinds of indenters (Vickers, cylindrical and spherical) and investigated elastic-plastic response of the surface region before and after rolling contact and without and after explosion hardening. Chapter 8 summarizes and discusses the results. After Conclusions, a list of 74 references is given, plus five own publications of the author.

Evaluation

a) The task of the work, enhancement of the knowledge about the contact "wheel–rail", is topical – with respect to the general effort to develop railway steels with high resistance to contact fatigue. For this purpose also methods for better characterisation of the situation and changes in the surface layer are needed, and this was also one task of the dissertation.

b) The text of the thesis is understandable and the individual chapters are arranged in a logical way. The works done are described carefully, though some critique can be expressed to the grammar (see later).

c) The dissertation work fulfils the objectives formulated in Chapter 4.

d) Ing. Kaya has oriented his work to various aspects of the contact and the related changes in the material. Nevertheless, he devoted perhaps the main effort to the characterisation of indentation process. He has proposed a new quantity for it, called "P", which can be determined from load-displacement indentation curves. This is his original contribution. It can

be recommended to continue with this research and to combine the findings with the current (rich) knowledge on instrumented indentation.

e) The thesis brings new information and some of the findings can help in the improvement of the materials for rails and wheels.

f) The extent and quality of the submitted thesis (73 pages including figures, tables and references, plus the list of figures and abbreviations) and the five published works of the applicant (related to the dissertation) are adequate.

g) The dissertation thesis meets the general requirements for awarding the title Ph.D.

Therefore, I recommend that this dissertation thesis is defended, and - in positive case - the applicant is awarded the title Ph.D. Nevertheless, I also want that he answers my comments and questions written at the bottom of this page.

20th July 2016

Prof. Ing. Jaroslav Menčík, CSc.
reviewer

Notes and questions:

The dissertant should have devoted more care to the quality of writing. It is too obvious from the text that the author is not from an English speaking country. He should have asked somebody good in English to read his text and check the grammar. At several places words are missing and/or it is difficult to understand the text. Errors are also in the list of references, e.g. [71, 72] and [1, 2] of author´s works.

p. 38: Why Figure 34 expresses the changes as a function of driven track, and Figure 34 as a function of number of cycles? The relationship between them would be useful.

p. 39, Figure 36: The description of axes is insufficient; also in Fig. 44 (p. 51), Fig. 45 (p. 52).

p. 44, line11 from top: What is As(h) in: "test force F divided by As(h) the surface area…"?

p. 60: What is P and what is its dimension? "Each P value determines the variation of indentation depth…". Compare with p. 65: "contact pressure Pmax=…", also with P written by the same font. Would it be possible to compare the P values from page 60 with similar values obtained under different loads? What about using some non-dimensional expression; this is always useful - see, for example, the quantity η_{IT} [%] in Table 5.

What the dissertant considers as his biggest achievement?