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ANISOTROPY EXAMINATION OF MATERIALS USED IN VEHICLES CONSTRUCTION

P. BERKE, G. GALAMBOSI, and P. MICHELBERGER

Department of Transport Engineering Mechanics
Technical University of Budapest

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Abstract

Deformation of metals has an effect — among others — on their mechanical properties, however at the same time, it also renders these properties direction-dependent.

The stress calculation of vehicles takes place for dynamic and fatigue loads, therefore it is advisable to determine for what loads and to what extent the direction-dependence is to be taken into consideration.

Keywords: material testing, fatigue, anisotropy

1. Introduction

The anisotropy caused by deformation of metals is well-known, however to settle the question whether it is generally advisable to take it into consideration and reckon with it in the course of calculations depends, on the one hand, on the values of the strength characteristics measurable in deformation direction and perpendicularly to it, while on the other hand, it depends on the fact to what extent the properties caused by anisotropy are influenced by the production technolgy used for the building of structures. From among the items of technical literature dealing with the effect of anisotropy on the mechanical and fatigue properties, the following ones are connected most closely with this article: [1], [2], [3], [4].

Vehicles are compex structures in which the structural elements can be connected to each other mostly by welding. It is known that welding eliminates the former structural composition due to the formation of welding- bead, or crystallization is induced, respectively, corresponding to the heat dissipation of the solidification process. With the proper layout of the cross-sectional areas, the elimination of the proper structural composition due to welding can be compensated, however it remains doubtful how far and to what extent the widening of the cross-sectional area should take place in relation to the welding seam. With certain examinations, temperature-dependence can easily be controlled. In our case, the extension of the examination into such a direction is justified by the factthat there are countries in which the vehicles are operated under very extreme weather conditions.

Examination of Deformation Anisotropy

Anisotropy — if there exists at all — can be detected in all the three dimensions of the material or product, but on the other hand, according to our experiences with the sheets of the quality and size used in vehicles manufacturing, it can often be detected only with the help of metallographic methods in the direction of thickness apart from such extreme cases when, e. g. a laminated sheet is loaded by shearstress, too [5].

With the sheets of the quality and thickness used in vehicles manufacturing, it is difficult to make distinction between them with respect to the values measurable in the thickness of sheets, too, because whenn finished products are subject to examination, the standard deviation exceeds the accuracy required by these examinations even if the standard deviation of the strengthh properties remains within the permissible limits. Our examinations performed so far have justified the observation that the large-scale anisotropy in transversal direction can be traced back — in most cases — to a cause detectable by metallographic methods, e. g. to a local segregation of contaminants.

Therefore, with those sheet products it will be suficciet to characterize the anisotropy — independently from the place the specimen was taken from — by drawing a comparison between the peoperties measured in deformation direction and in the direction perpendicular to it.

In the case of static loads, anisotropy can be scarcely characterized by the values of tensile strength, yield point and strain. This is backed by the values measured on the specimens worked out in deformation direction and in the direction perpendicular to it, as plotted as a function of temperature. Cf. *Fig. 1.* (The data are related to the specimens worked out of material 37D).

If for any reason, we should like to characterize anisotropy on the basis of the values associated with the tensile tests, then the measure of contraction should be suitably subject to examination. However, it cannot be measured with due accuracy with the sheet-shaped specimens. The inaccuracy mentioned above was eliminated in a way that the amounts of energy measurable on the contraction section of the tensile diagrams were compared to each other with the specimens worked out in different directions. The values measured on the specimens similarly made of material 37D are shown in *Fig. 2.* The use of temperature as an independent

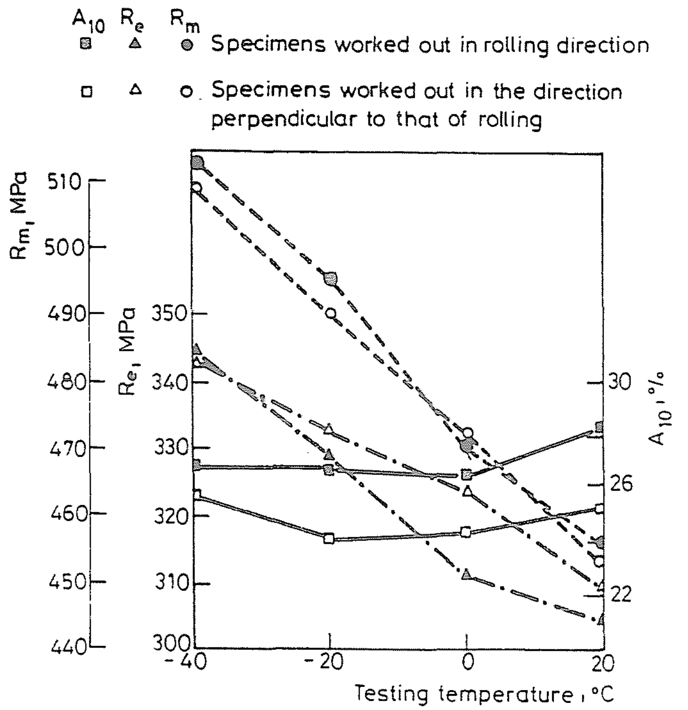

Fig. 1. Tensile-test results of specimens worked out in different directions — in the direction of deformation and perpendicular to it as a function of temperature

variable served — similarly to the previous case — the possibility of the numerical expression of embrittlement.

To examine the relations between the effect of deformation direction and the resistance to dynamic load, the Charpy impact-test feasible in the simplest way was chosen, the specimens were subject to impact load in deformation direction and in the direction perpendicular to it. (The specimens were made of material 37D, and they were micro impact-test specimens due to the profile dimensions available). The measured values can be seen in *Fig. 3.*

For the same purpose, i. e. for the detecting the effect of deformation direction, fatigue tests were carried out with asymmetry factors: 0.1 and 0.4. The results of those tests are shown in *Fig. 4.*

As it is well-known, certain technologies, among them welding, take an influence on the deformation direction effect. Therefore, our examinations were extended also to the specimens joined by welding.

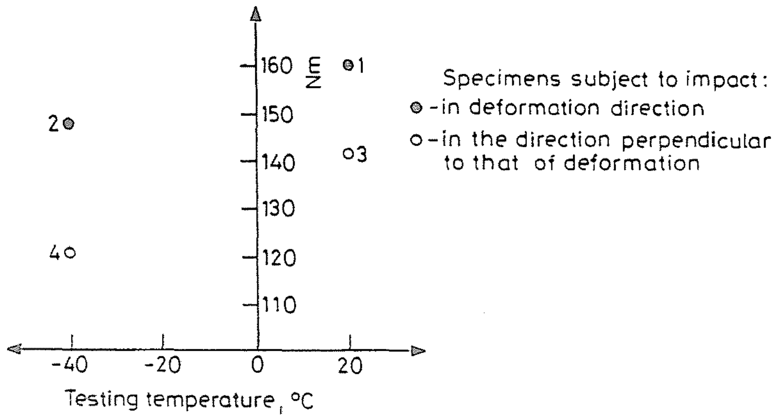

Fig. 2. Deformation energy measured in the contraction phase of the tensile test as a function of temperature

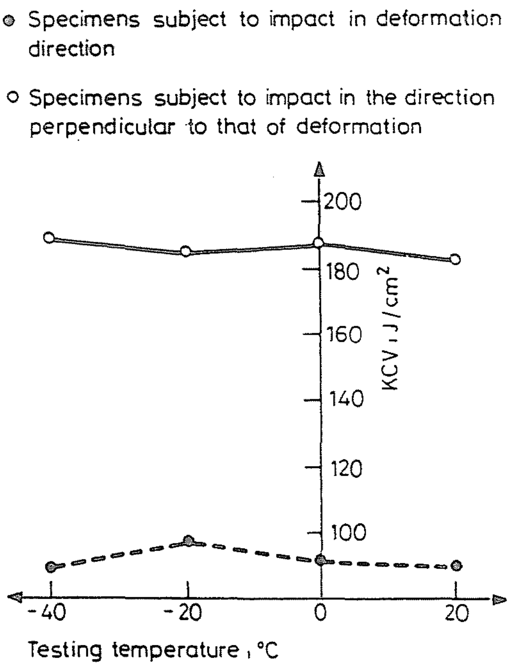

Fig. 3. Values of impact energy measured on the specimens tested in different directions — in the direction of deformation and perpendicular to it as a function of temperature

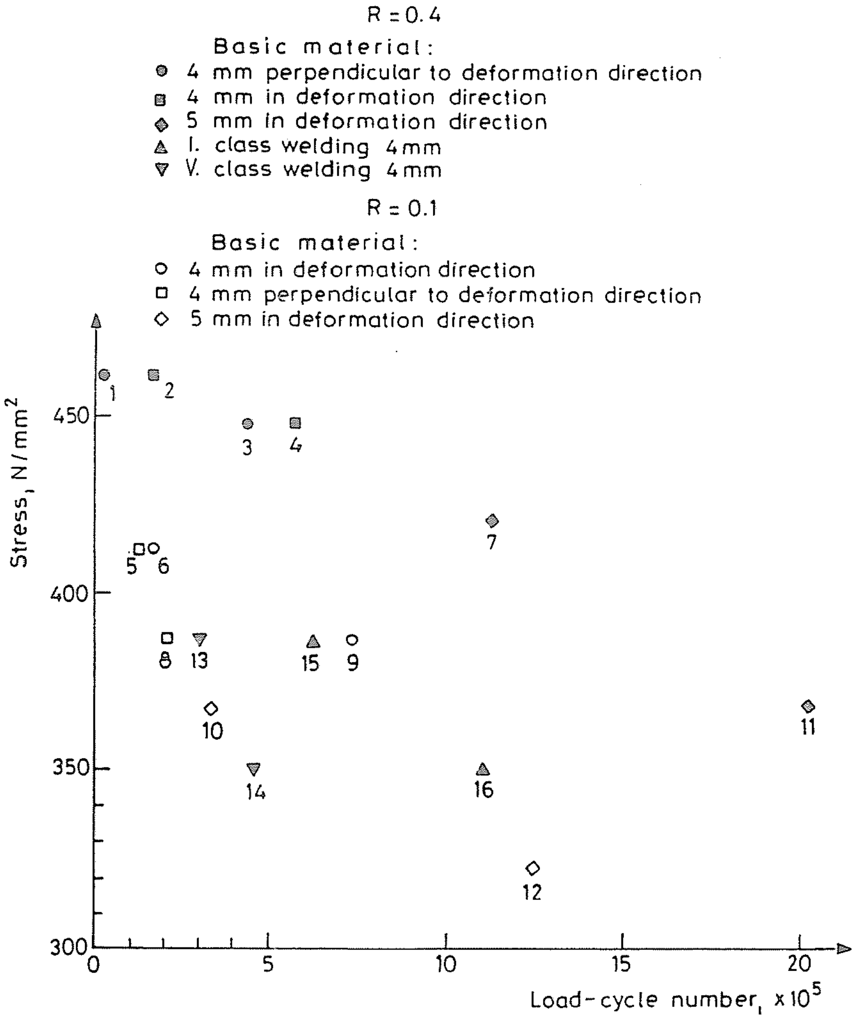

Fig. 4. The endurance-life data of the speciments subject to fatigue load in different directions — in the direction of deformation and perpendicular to it, with asymmetry factors $R=0.4$ and $R=0.1$

The results of the tensile tests performed on the welded specimens reffered to the elimination of the deformation direction effect.

In order to characterize theh direction-dependence of dynamic loads, after welding together the sections of the specimens worked out in deformation direction and those worked out in the direction and those worked out in the direction perpendicular to it, respectively, the impact-test specimens were worked out at an identical distance from the centre of the weld-seam in a way that the notches were spaced out by 2 mm steps moving away from the centre of the weld. The values of the impact energy are shown in *Fig. 5.*

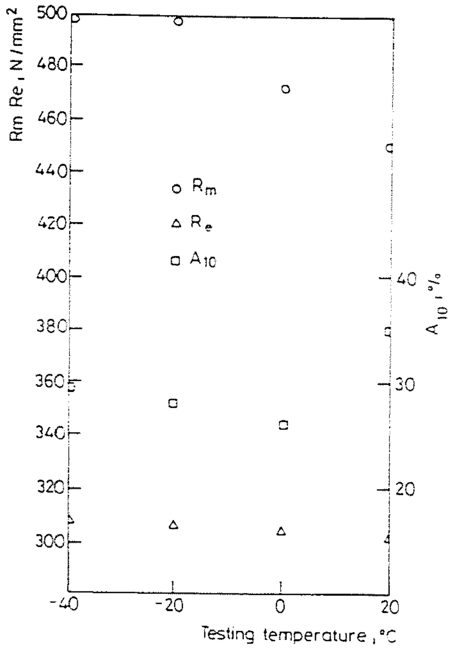

Fig. 5. The values of impact energy measured on the specimens worked out both in deformation direction and perpendicular to it at different distances from the welding seam at a testing temperature of −40°C

In spite of the fact that — according to expectations — the neutralization effect of the welding bead in deformation direction was demonstrated in the course of the tensile test of welded specimens, they were subject to fatigue load as arranged in pairs according to deformation direction, with the restriction that — in case it is justified — the test specimens welded together from the specimen parts worked out in deformation direction and and in the direction perpendicular to it will be treated as separated sets. With regard to the fact that the separation was not justified — again, according to expectations — by the results obtained, the results were treated as a uniform, coherent set. The asymmetery factors were again 0.1 and 0.4, nevertheless the maximum load had to be reduced necessarily so that a load-cycle number could be reached for evaluation.

In *Fig. 4,* the endurance-life results of both the welded specimens qualified by I class radiographic (X-ray) test, and those qualified by the V class test are equally enlisted.

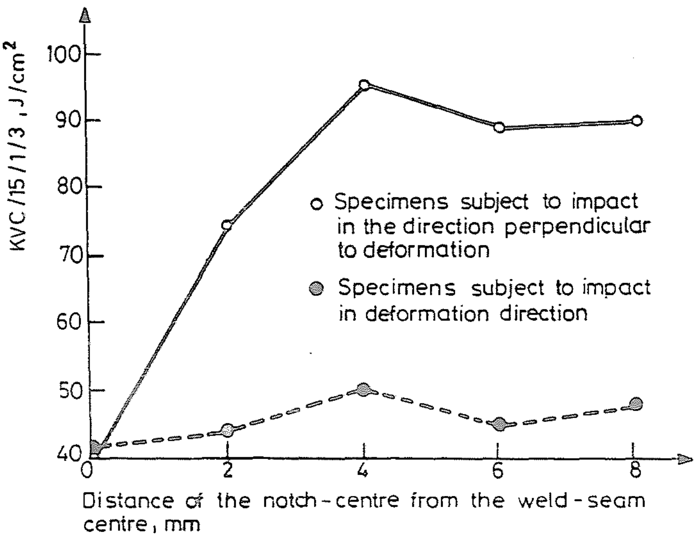

Fig. 6.

Summary

We should like to emphasize that the question raised in the Introduction about whether it is advisable to take into consideration the effect of anisotropy caused by deformation altering the mechanical properties in the case of certain loads, can — of course — be answered from many aspects, and as a consequence, the standpoint can be criticized only from the given aspect.

Our test results are — in certain cases — corresponding to the expected ones, and in this case their serviceability is given by the fact that their nomerical value can be considered as the basic design data of the given material with the temperature changes taken into consideration.

It can be established that:

- with the sheets subject to static load — tension — due to the uncertainty of contraction measurement, the amount of work measureable during the contraction phase of the deformation of specimens can be utilized for the detection of deformation direction effect, emphasizing that the consideration of the deformation direction effect will provide, in certain cases, only negligible advantages.
- in case of dynamic loads, such possibilities of the constructional layout should be looked for which reckon with the deformation direction,

especially because the effect of deformation direction is considerable even in the close neighbourhood of the welding bead: i. e. with the help of a proper layout of nodal joints, the structural element will be more resistant to dynamic loads;

- the resistance to fatigue loads — whose possible parameter is the endurance life — shows a deformation-direction dependence, consequently, in the case of such loads, too, such a constructional layout should be aimed at, which reckons with the deformation direction.

Though our result have been obtained from testing a sheet of a given quality manufactured with given production technology, nevertheless we think that the publication of the results exceeds the simple drawing of attention.

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Address:

Dr. Pál BERKE
Dr. Ferenc GALAMBOSI
Prof. Dr. Pál MICHELBERGER
Department Transport Engineering Mechanics
H–1521 Budapest, Hungary