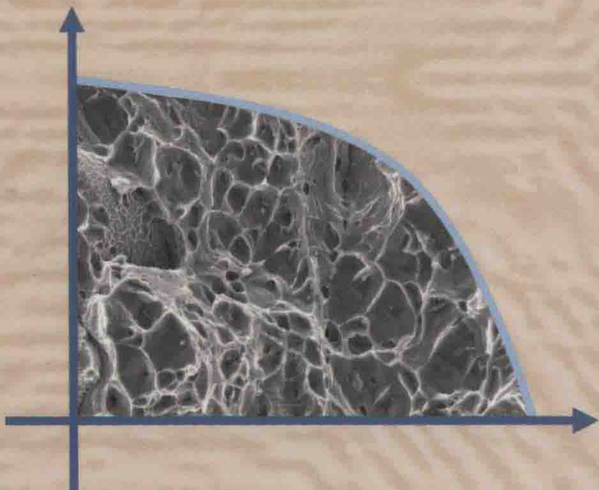
Fatigue and Fracture Mechanics XXV



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Fatigue and Fracture Mechanics XXV

Selected, peer reviewed papers from the
25th Polish National Conference on
„Fatigue and Fracture Mechanics",
May 20-23, 2014, Fojutowo, Poland

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Dariusz Skibicki

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Preface

25th Polish National Conference on „Fatigue and Fracture Mechanics" was held in Fojutowo near Bydgoszcz on 20-23 May'2014. It was organized by Committe of Machinery Design of Polish Academy of Science end Institut of Mechanics and Mechinery Design of University of Technology and Life Sciences in Bydgoszcz.

The „Fatigue and Fracture Mechanics" conferance is hold every second year and is a form of integration of researches and scientist from polish universities, research institutes and industry.The works presented are the result of work over the past two years and allow us to assess the studies of the problem from the fatigue and fracture mechanics in Poland.

This year, in the conference were approximately 100 participants. The selection of works to be submitted to the conference materials by representatives of the scientific committee of the conference. The selection criterion was the scientific novelty and originality of the results.

Janusz Sempruch

chairman of organisation committee

of the conference

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The influence of the ferrite and pearlite grain size on the S-N fatigue characteristics of steel

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Keywords: ferrite, pearlite, metallographic, monothonic stretching test

Abstract: In this work an investigation of internal structure influence on mechanical and fatigue properties of ferritic- pearlitic steels is shown. Ferrite grain size and phase volume fraction of three grades of structural steel with similar chemical composition, but different mechanical properties, were examined. Afterwards, samples of the materials were subjected to cyclic bending tests. The results and conclusions are presented in this paper

Introduction

The problems of static and fatigue durability of machine components and engineering constructions are inseparably associated with the structure of materials used to make them. The grain size is one of the factors having the greatest influence on the strength properties of the polycrystalline materials. The general form of relation between yield stress and grain size is described by the Hall–Petch equation. It is a basic equation in the literature showing the relationship [2]. As a result of grain refinement, the material strengthening occurs to the grain boundary, and the temperature of steel changing to brittle state lowers. In reference [7] it is assumed that structure refinement enhances strength of materials when subjected to both static and fatigue load stress. This paper attempts to verify the above statement by subjecting the samples to cyclic bending tests.

Materials Tested

The materials chosen for tests were 12 mm thick hot rolled sheet metals, made of three steel grades included in references [4,5], described as S235 JRG2, S355 J2+N, P460 NH. Their chemical composition is shown in Table 1. These are welded low-carbon steels characterized by the value of required minimum yield strength R_e at a level of 235, 355 and 460 MPa respectively [6]. The S235JRG2 grade is a widely used non-alloy structural steel, designed for machine parts and constructions. The S355J2+N grade is a low-alloy structural steel with enhanced strength, and P460NH is a low-alloy, fine grain special steel for pressure equipment. The static strength properties of tested metallurgical products are shown in Table 2.

Table 1. Chemical composition of tested materials based on smelting analysis.

The mass fraction of selected elements in [%]														
Stal	C	Mn	Si	P	S	Cr	Ni	Cu	Al.	Mo	N	Ti	V	Nb
S235	0,14	0,72	0,22	0,01	0,011	0,02	0,02	0,05	0,047	0,002	0,005	0,001	0,00	0,002
S355	0,17	1,46	0,27	0,016	0,008	0,02	0,01	0,02	0,053	0,001	0,004	0,002	0,00	0,011
P460	0,2	1,69	0,47	0,015	0,01	0,04	0,019	0,013	0,018	0,004	0,025	0,001	0,11	0,002

Table 2. Static strength properties of tested steels.

Steel	R_e [MPa]	R_m [MPa]	A [%]	R_e/R_m	Hardness HV5
S235	291	424,5	30	0,69	132
S355	391	516	33	0,76	160
P460	616,5	717	24,6	0,86	212

Metallographic Tests

From the tested materials samples, the metallographic specimens were prepared as shown on Fig. 1.

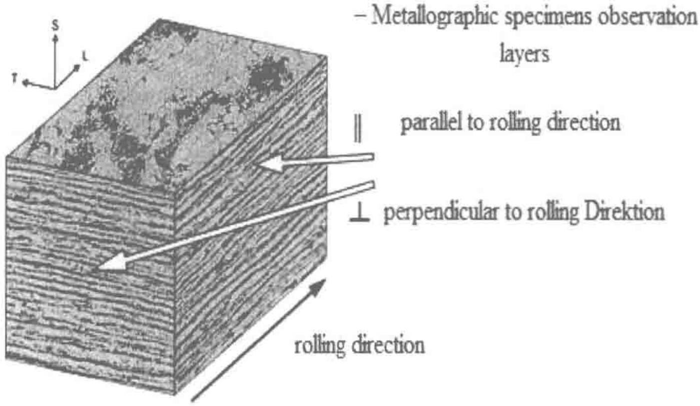

Fig. 1. Metallographic specimen layer orientation relative to the rolling direction [3].

The specimens were pickled and then observed under optical microscope. The obtained pictures of the structures are shown on Fig.2. The tested specimens were characterized by two-phase structure comprised of ferrite and pearlite in different volume proportions. A substantial banding structure was observed in the P460 steel sample. No fundamental differences were observed in structures in parallel and perpendicular layers relative to rolling direction. The use of image processing software allowed determining the volume fraction of ferrite and pearlite in the composition of tested steel samples. The ferrite grain size was measured as well. The analysis was performed using Metilo software at the Institute of Iron Metallurgy in Gliwice, Poland. The analysis was performed for a series of ten samples of each specimen. The results are presented in table 3.

Table 3. Grain size of tested specimens and volume fractions of phases.

Material	Ferrite grain diameter [μm]				Volume fraction [%]	
	Minimum	Maximum	Average	Variability index [%]	Ferrite	Pearlite
S235	1,38	124,83	22,96	71,58	84,3	15,7
S355	0,67	38,32	6,97	72,92	70,4	29,6
P460	0,67	21,01	4,54	60,12	62,1	37,9

A substantial scatter of measured values was noticed. Besides the inhomogeneity of structure, the cause of the scatter should include the difficulties in evaluation and interpretation of observed contours that represents the grain boundary.

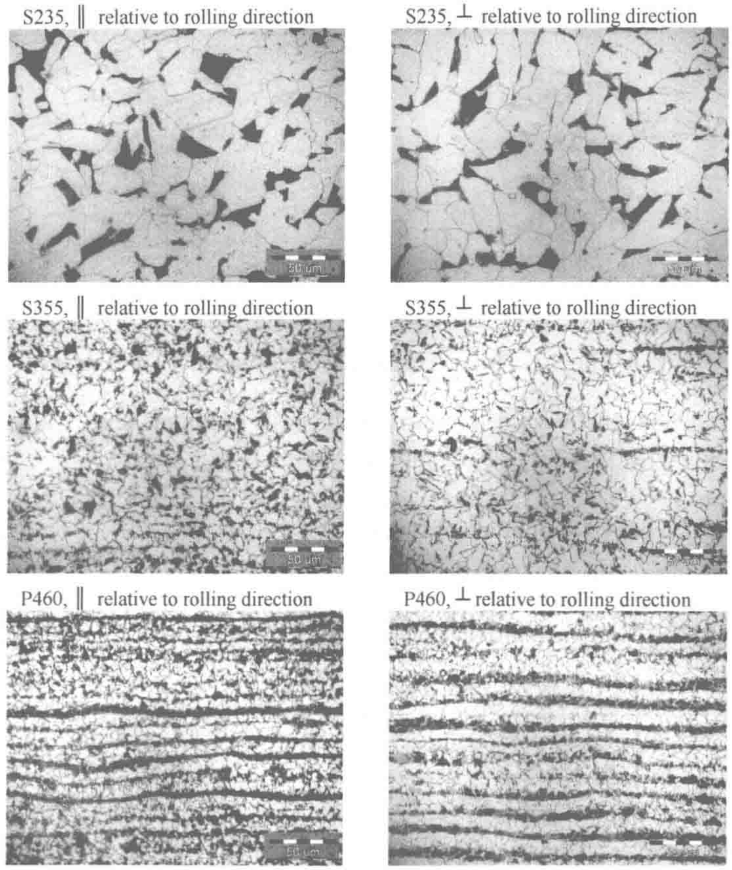

Fig. 2. Pictures of structures obtained during observations of metallographic specimens in parallel and perpendicular layers relative to rolling direction.

Fatigue Tests

The form of the samples for fatigue tests were modeled on MZGS-100 test stand. Fig. 3 shows the geometry and dimensions of the samples.

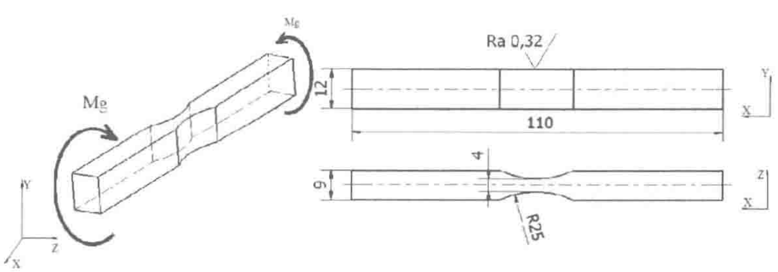

Fig. 3. A sample for fatigue tests.

The results of performed fatigue tests are presented in S-N chart form in Fig. 4 according to Basquin model [8,9]. The stress amplitudes were determined from the formula for the cross-sectional bending stress strength for perfectly elastic body [1].