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FATIGUE STRENGTH AND STRUCTURAL CHARACTERISTICS OF SINTERED STEEL DISTALOY AE+0,5%C

DINAMIČKA ČVRSTOĆA I STRUKTURNE KARAKTERISTIKE ČELIKA DISTALOY AE+0,5%C

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ABSTRACT

In this paper examined to research on the fatigue strength and distribution of elements sintered steel of Distaloy AE+0,5%C. Specimens were prepared from diffusion alloyed Distaloy AE (Fe-4wt.-%Ni-1,5wt-%Cu-0,5wt.-%Mo) mixed with graphite (0,5wt.-%). The materials were sintered under industrial conditions at 1120 °C for 30 min. Fatigue tests with stress levels above the endurance limit have been carried out to determine Woehler curves.

1. INTRODUCTION

A few data from rotating and plane bending are available for elemental blends of Fe-Cu-Ni-C steels in [1, 2], which resemble those of Fe-Cu-C alloys in [3, 4, 5, 6]. Assuming similar production sequence and experimental care, the negligible difference between the two would imply the nickel addition to contribute virtually nothing to the fatigue strength at normal sintering temperatures.

In [7] 2% elemental Ni were added to prealloyed 0.85% Mo steel with fine and coarse particle size. The steel with the coarse Ni particles had significantly inferior fatigue properties in comparison with the fine addition which is the industrial standard, particularly at normal sintering temperature. After high temperature sintering the effect was not so pronounced any more, but still reproducible.

The sponge iron based samples from [8] were sintered at 1200°C, all other high temperature specimens were sintered at 1280°C. The sintering temperature makes obviously a noticeable difference with this type of material. The sponge iron data from [8] coincide essentially with the results of [9] based on water atomized iron sintered at 1120°C. This can be understood as a hint that elemental Ni additions develop their full strengthening potential only at rather high sintering temperatures.

A few results from axial testing have been published [10, 11, 12], the metallic alloying elements were organically bonded to the base iron powder in [11, 12].

With the exception of some data from [13] and [14] the axial endurance limit exhibits moderate scatter with an evident trend. A weighted average from a round robin test yielded a 50 % survival probability endurance limit of 194 N/mm^2 at 7.08 g/cm^3 based on 213 specimens [15] including clearly lower results from tests with 5 Hz. With this type of steel the cooling rate plays a major role in determining the strength level and so does decarburization during sintering. For this reason only scarcely high temperature sintering is applied in producion.

New careful results from [16] document the effect of cooling rate between 800 and 500 °C. Normalizing the experimental with density of 7.08 g/cm^3, with 0.52 °C/s a plane bending fatigue strength of 227 N/mm^2 is achieved, with 1.0 °C/s 258 N/mm^2, an increase of about 15 %.

Attempts to increase the fatigue properties have also been made with steels based on blended or diffusion bonded nickel contents between 7 and 10 % [17, 18] with optional additions of up to 1 % Mo or 2 % Cu in combination with about 0.5 % C. Even though remarkable strength targets can be met this way, the market has refused acceptance because of high raw material costs and shrinkage during sintering.

Prealloyed steels with 3.5 to 4 % Mo plus ternary additions like 0.1 % Nb, 0.5 % Cr or 0.45 % P have been investigated to make use of the shrinkage to higher densities when sintering at high temperatures in the bcc α - phase. These steels have low fatigue strengths due to the missing carbon content in the as-sintered condition in spite of high densities. After case hardening the properties can become quite interesting. Axial loading and plane bending data have been generated by [19], the majority of the results are also published in [20, 21] with certain modifications.

2. EXPERIMENTAL AND RESULTS

For the higher strength range samples were manufactured from the widely used Distaloy family of steels containing 4 % Ni, 1.5 % Cu and 0.5 % Mo which are diffusion bonded to pure iron to prevent segregations and maintain highest compressibilities. The powders Distaloy AE were blended with 0.5 fine graphite and in most cases with additions, which were expected to change the pore morphology. Further the standard grade, Distaloy AE, based on water atomised iron was made from a coarse powder > 45 μm and a fine fraction < 45μm and compared with the same alloy based on sponge iron. The specimens were compacted with 600 MPa in the R & D department of Höganäs AB, Sweden, were the sintering took place in semi-industrial equipment at 1120 °C in a non-decarburizing protective atmosphere. The cooling rate between 800 and 500 °C was 1.0 °C/s. Details on the as-sintered densities and some mechanical properties are provided in Table 1.

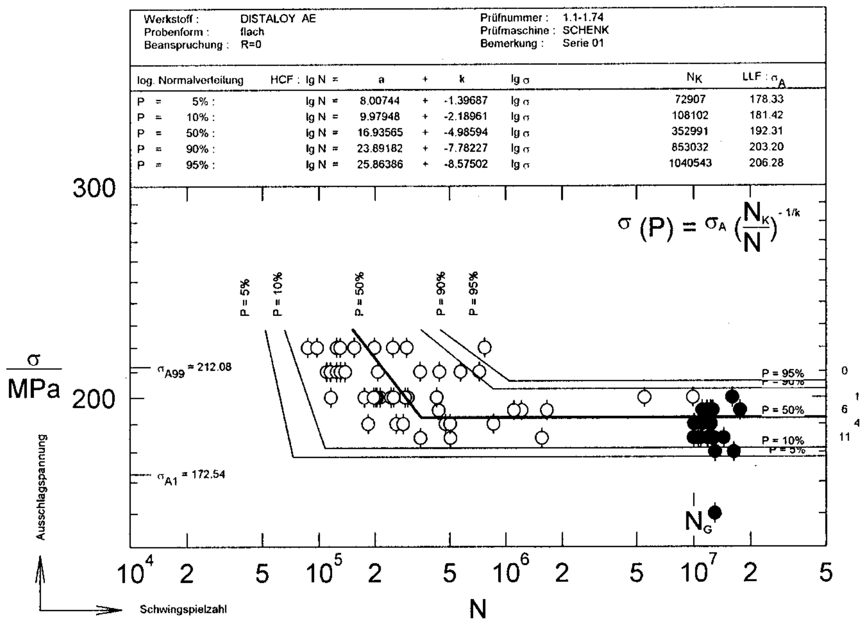

Figure 1 - Fatigue endurance limit and probability of survival of the material Distaloy AE+0,5%C

Fatigue tests with stress levels above the endurance limit have been carried out the determine Woehler curves. The obtained curves for the different series of samples are shown in Fig.1 and include the fatigue limits at 5, 10, 50, 90 and 95 probability of survival. The points in the diagrams correspond to the raw data, each open circle indicates a failure and each filled circle a run out. Plane bending fatigue tests were performed with 60 specimens in six stress levels per S-N curve, which permits to evaluate the data statistically and to determine a rather reliable endurance limit for a failure of survival probability of 50 %. Details on the as-sintered densities and some mechanical properties are provided in Table 1.

Table 1 - Materials investigated, 4 % Ni, 1.5 % Cu, 0.5 % Mo, 0.5 % C

Base powder	Addition, modification	Density, average .g/cm^3	Hardness HV 10	$R_{p0.2}$ MPa	R_m MPa	A %
Distaloy AE	-	7.105	265	423	715	2.0
Distaloy AE	< 45 μm	6.988	200	365	582	2.4
Distaloy AE	> 45 μm	7.048	218	331	538	2.4

In the figure 2 is shown the structure received in REM of the material Distaloy AE+0,5%C. And in the figure 3 is shown distribution of elements in different points sintered of the material Distaloy AE+0,5%C shown in a figure 2.

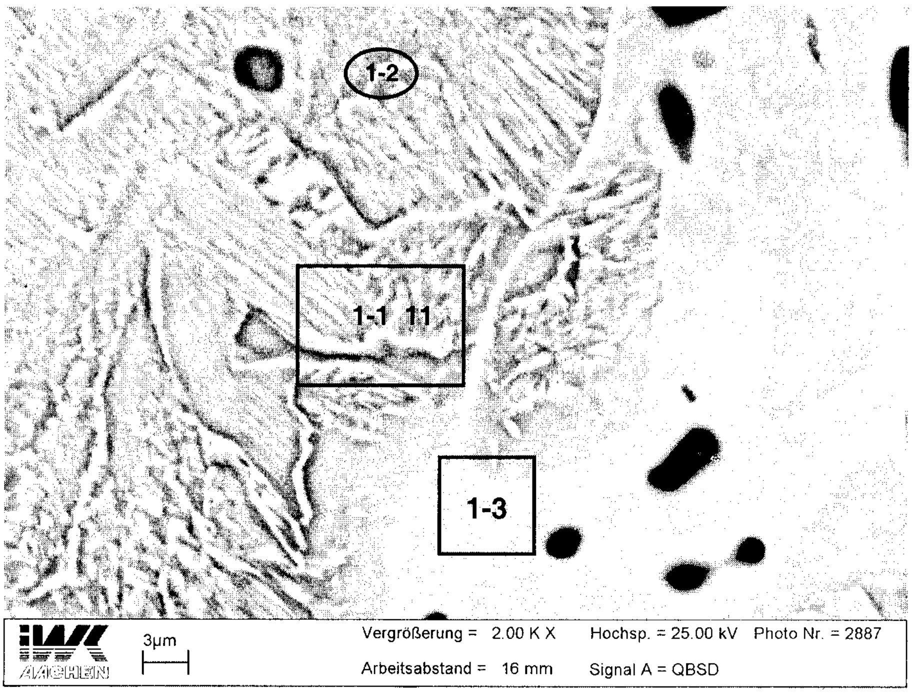

Figure 2 - Structure received in REM of the material Distaloy AE+0,5%C

3. SUMMARY

In order to improve the mechanical characteristics of sintered materials, it is increased necessary, the density to. In order to avoid an increase of the density through atrophy or a swelling preserving the sinters, but to simultaneously reach higher mechanical characteristics, is used in this work Distaloy AE as a basis powder. The improvement of the stability level of sintered material can basically through an increase of the density, that refined alloy technologies result, through structure optimisation and through warmth treatment of or through combinations these procedures.

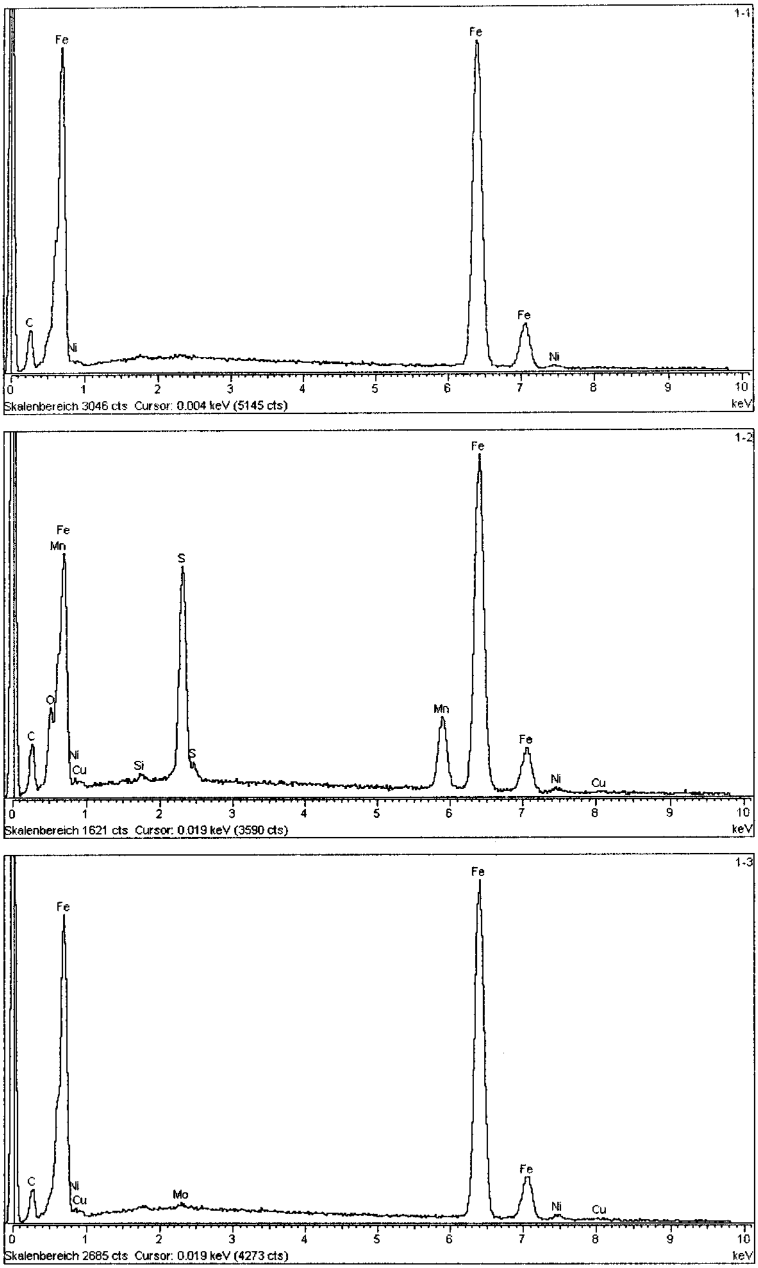

Figure 3 - Distribution of elements in different points sintered of the material Distaloy AE+0,5%C shown in a figure 2.

Fatigue tests with stress levels above the endurance limit have been carried out to determine Woehler curves. The effect of consequently on the mechanical properties was studied.

The homogenous extent the sintered material cliff of deceased parameters off. Further also particle size and oxide salary of the related powders have an influence on the homogenous extent.

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