

INVESTIGATION OF FRACTURED PIN PRODUCED OF 42CrMo4 Q&T STEEL

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Abstract:

In this research work were analyzed the reasons for fracture of pin machined from 42CrMo44 steel. One pine build in TBU (Tread Brake Unit) of railway wagon breaking system was broken in exploratory condition. Reclamation from purchaser was sent to the producer concerning occurred fracture of pin. Producer sent request to the team of the Faculty of Technology and Metallurgy to perform investigations and to determine the reason of fracture (failure analysis). It was decided to perform the following investigations: visual inspection, determination of chemical composition, hardness measurement, metallographic investigations which include analysis of microstructure and quantitate determination of nonmetallic inclusions. For comparison of results, raw material for pin production i.e. solid bars $\phi 50$, and new none used bar from the same steel was investigated too.

Performed investigations showed that the main reason for the fracture of pin is the quality of the raw material more concretely segregation of chemical elements and increased concentration of nonmetallic inclusions.

KEYWORDS: 42CrMo4 steel, Metallography, Non metallic inclusions, Microstructure, segregation, quenching and tempering Q&T

1. Introduction

Investigated material (steel) has designation 42CrMo44 according EN10083-2. Material number is W.NR 1.7225. It is low allowed Cr-Mo steel [1-4]. Main application of this steel is in quenched and tempered (Q&T) or annealed condition. In such condition it characterizes with very good machinability [5-8]. Molybdenum additions improve temper brittleness. It belongs to the group of steels intended for surface hardening. According chemical compositions it is low alloyed steel [9-11].

42CrMo4 steel is multipurpose material. Its main application is automotive industry, transportation and mechanical engineering. It is mainly used for production of parts which possess very good impact toughness, wear resistance and fatigue. It is ultrahigh strength steel and in the same time enables production of high stressed components. The most often produced components are crankshafts, gears and similar parts [12,13].

As was formerly said 42CrMo44 steel is used for production of very responsible parts which are used in different industrial sectors. One of them is railway sector. Because of that properties of raw material must be keeping at very high level as prescribed with appropriate standard. So fracture which appeared of the pin was analyzed very in this research work,

2. Material and investigation

Fractured pin is machined from the solid bar ($\phi 50$) of 42CrMo44 steel in quenched and tempered condition Q&T. For comparison the results of investigation, besides broken pin, raw material and one new unused pin was investigated. Both pins are produced from the same raw material (Figure 1(a and b)).



Figure 1(a and) b a.) Raw material b. new, unused pin

2.1 Determination of chemical composition

Chemical composition of the raw material, broken pin and unused pin is given in the table 1. Obtained values are compared with the values prescribed by appropriate standard DIN EN 10083-1 [].

Spectrometer type Spectro was used for determination chemical composition.

Table 1 Chemical composition of the investigated parts

Element	Raw material	Broken pin	New pin	42CrMo4 (standard)
C	0.39	0.38	0.408	0.38-0.45
Si	0.25	0.29	0.296	0.4
Mn	0.73	0.79	0.798	0.6-0.9
S	0.026	0.027	0.0311	0.035
P	0.011	0.010	0.01	0.025
Cr	1.09	0.95	0.94	0.9-1.2
Mo	0.2	0.19	0.209	0.15-0.30
Ni	0.16	0.18		
Cu	0.019	0.20	0.18	
Ca	-	0.026	0.024	

2.2 Visual inspection

Visual inspection of the broken pin surface was performed by naked eye and and lens. It was that there is large white area i.e. area of segregation where fracture of pin start (Figure 2).



Figure 2 (a and b) fractured pin b broken surface of pin

2.3 Hardness measurement

Hardness measurement was performed on metallographic specimens (Figure 3). Rockwell method was implemented (HRC), and AVERY hardness tester was used to perform measurement.

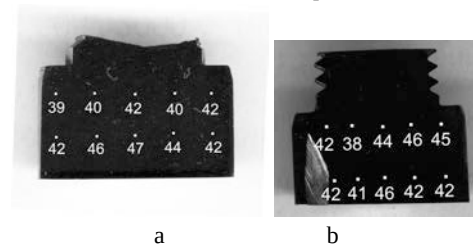


Figure 3 Hardness value of fractured and new pin

2.4 Metallographic investigations

Metallographic preparation of specimens consists of mechanical grinding on abrasive papers with different granulation of particles. After that specimens were polished using Al_2O_3 suspension. Polished specimens were used for analysis of nonmetallic inclusions using magnification $\times 100$. Finally, specimens were chemically etched with Nital and Villela reagents for revealing microstructure of the parts. For metallographic investigation was used optical microscope MELJI Techno. The microscope is equipped with softer for qualitative and quantitative analysis of nonmetallic inclusions VideoTestMetal 1.2. Microstructures of the raw material, fractured and unused pin are presented in the figure 4 (a-c).

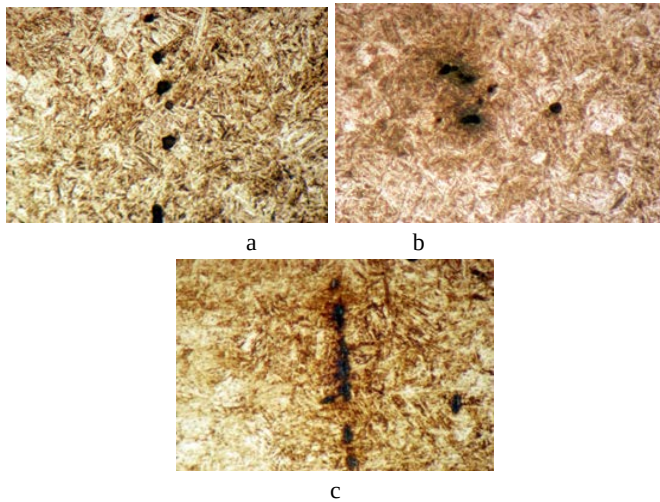


Figure 4 (a-c) Microstructure of investigated parts
a. raw material b. fractured pin c. new pin

In the figure 5 (a-b) is given microstructure of raw material (Villela) and fractured pin (Nital). Traces of segregation in specimens and nonmetallic inclusion can be clearly seen.

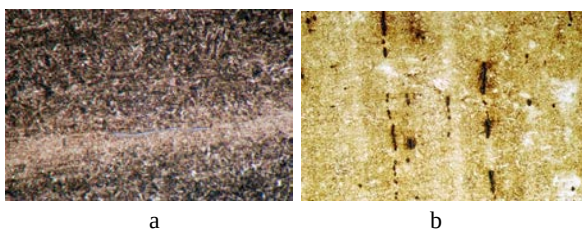


Figure 5 (a-b) Microstructure of raw material and fractured pin

Non metallic inclusions present in the investigated parts are given in figure 6 (a-c).

Quantitative analysis of nonmetallic inclusions was performed using comparative chart JK scale (Figure 7) [14] and automatic analysis softer. This softer is based on ISO 4967 standard [15]. Results of automatic analysis in table 2 and figure 8. Extremely inclusion presented in the fractured pin is given in the figure 9.

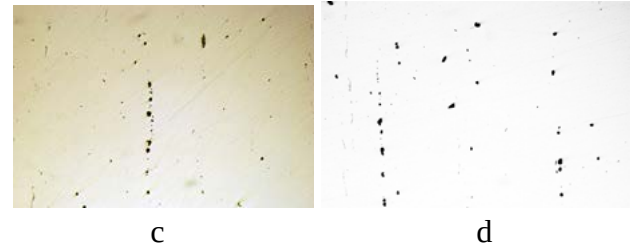
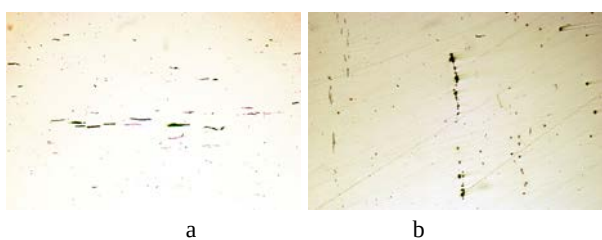


Figure 6(a-d) Nonmetallic inclusions a and b raw material, c fractured pin, d new pin

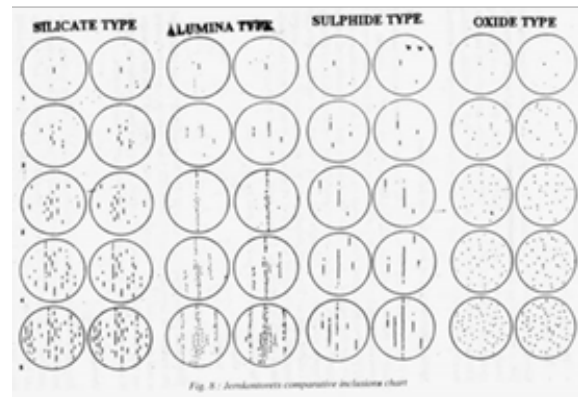
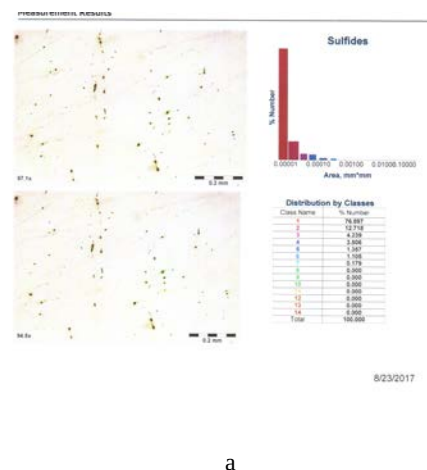
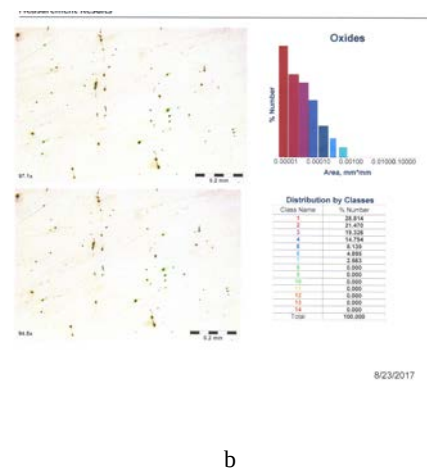


Figure 7 JK comparison chart for determination of nonmetallic inclusions



a



b

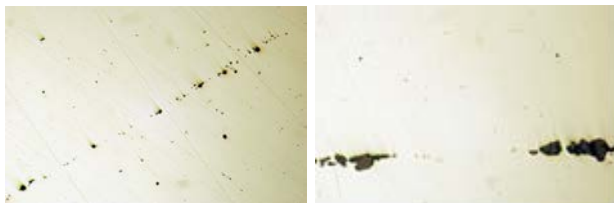
Figure 8 Automatic analysis of nonmetallic inclusions - type and size

Table 2 Results of automatic analysis of nonmetallic inclusions

	A	Ae	B	Be	C	Ce	D	De	DS	DSs
1			1.5		2	2.5	4	3	1.5	2
2			0.5		2		3	3.5		2
3	0.5		1	0.5e	2.5		3	2.5	2.5	2.5

1 Raw material, 2 New pin, 3 Fractured pin

Figure 8 Automatic analyses of nonmetallic inclusions



Extremely non metallic inclusions

1. 3 Discussion

- General conclusion from the performed investigation is that chemical composition of the investigated part is in accordance with standard requirement. Microstructure of all parts is tempered martensite. It is confirmed by hardness measurement. Visual inspection showed that there is area of segregation in the fractured surface. Analysis of nonmetallic inclusions confirmed that steel bar for production of pin is very unclean concerning presence of nonmetallic inclusions. Inclusions are mainly concentrated in the core of the bar and propagate parallel with longitudinal axis of the pin. Some of the inclusions like sulfides are elongated while oxides are mainly globular but all of them propagate parallel with the rolling direction. As was previously mentioned 42CrMo steel is used for production of very responsible parts subjected to different types of stresses. So presence of inclusions could cause fracture of the parts. Because of that, it is prescribed in standard 10083-1 that presence of nonmetallic inclusion should result of special contract between producer and purchaser.

4 Conclusions

Performed investigation clearly showed that chemical composition, microstructure and hardness are in accordance with standard requirement. As was shown by microstructural investigations the main reason for the fracture of pin is segregation of chemical elements like sulphur, carbon and manganese.

3. 5 Literature

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