INVESTIGATION OF HIGH SPEED STEEL (R18)

Dr.KhidhairJasim Mohammed

Mustaqbal University College, Babylon, Iraq

E-mail: Khidhair_ Aljuboury@yahoo.com, Mobil: 00964(0)7707836997

Abstract

As the high carbon high speed steel type R18 is a very abrasion resistant material due to its high hardness resulting from hard carbides and martensitic matrix .In this work we had tested , the spectra chemical composition, hardness , of that steel before and after heat treatment , and determination of phase transformation points by dilatometer during heating and cooling at the rates of 10 and 20 C˚/min. .Mechanical properties after different temperatures of heat treatments were tested. Valuable results were achieved .All results were shown in the tables (1-6) in the text, which could be considered as the continuation of many authors works, who tried other methods , in their investigations ..The main goal is to has high abrasion resistanse at high temperature during high speed machining

Keyword:R18, phase transformations points, heat treatments, mechanical properties.

Introduction

Metallurgical definition of any various steels that retained their hardness at high temperatures and are used for making tools on lathes and other high speed machines,i.e it is high alloyed steels remain hard at a red temperatures CITE-[1]2014.The steels used as cutting tools which reach red hardness during cutting (about 600 C˚), called high speed steel H[2]2016 . Direct relation between chemical composition and properties requiredRe.[3]2010 . The first alloy was introduced in 1910 R.[4]2010 and it is classified as (HSS) and known by (AISI) as T.Bo.[5]2001,Me.[6]1977 tool steel T1 (R18) alloy that gain their properties from either W or MO. They belong to the (Fe-C-X) multi component alloy . X component is presents in excess of 7% , W ,Cr , MO , V or Co with more than 0.6%C . Tungsten – type grade (e.g.T1,T15) are assigned as T12001$_{xxRe.}$[7]2010. The addition of high W content (about 18%) maximizes the hardness and toughness and maintend those properties at high temperatures during cutting metal .H.S.S. with high C% steels are very abrasion – resistant .Different mechanical properties and microstructures were obtained after quenching and tempering T1[8]2008,H.Springer [9]2008 , that due phase transformations occurred or due carbides redistributions.

Previous works dealing with phase transformations such as by using constant temperature transformation (TTT) ,Hi. [10]1976 , and transformation of eutectoid to austenite at 850 C˚ during heating W.G.H[11]1958 .Higgens- also stated that tempering is required after hardening to decrease retained austenite , the temperature used was (beyond 520C˚) . W improves red hardness , retention of hardness and high temperature strength of matrix from special carbides of high hardness BOHLER[12] .New phase transformation by dilatometric test was used in this work , using 10 and 20C˚/min. heating and cooling rates we could find transformations points and using many heat treatments and tests . Other work is required to use higher or lower heating and cooling rates in such dilatometric or other tests . This will be a task for other researchers .

Material and Methods

In the practical side of our work , we chose a rode of 2m length and 20mm diameter from HSS(R18) .From that rode, many specimens were made for testing .Chemical composition of that steel was tested by spectrometer type [ARL-34000] . The results of the test was shown in table(1), which is similar to standard AISI-T12001 .Hardness before heat treatments , (as rolled) also tested using Vickers method . The results were shown in table (2) ,which also contains the results of mechanical tests before heat treatments .Mechanical properties after quenching from temperature 920 C˚ in different cooling media with holding time 1.5hr. and then tempered at 650 C˚ with 4hrs.holding time .The results were shown in table (3) .Determination of phase transformations points – starts and ends – using dilatometer type – 402 ES-3/6- Geratebau –using 10 and 20 C˚/min heating and cooling rates . Diagrams of dilatation could be drawn as in figs . [1 and 2] . The starts and ends of phase transformations during heating and cooling at 10 and 20 C˚/min cooling rates were indicated in table (4) .In tempering at 300 C˚ and 4hrs. holding times after quenching from 920 C˚ and cooling in different media , holding time 1.5hr.the results were shown in table (5) .The heat treatments also contained quenching from 1200 C˚ , in oil and in compressed air holding 1.5hr. tempered at 560 C˚, holds 3hrs , finally second time tempered as in first tempering , the results were shown in table (6) .

Table (1) Chemical Composition of HSS- R18 by spectrometer

Chemical composition in wt%						
W	**Cr**	**V**	**C**	**Mn**	**Si**	**S**
17.5	4.8	1.1	0.8	0.4	0.22	0.005

Table (2) initial mechanical properties before heat treatment

Hardness In HV units	UTS-in Mpa	Elongation %EL	Contraction in area %
268	807.6	14.25	21.22
275	831.5	12.43	19.43

Table (3) Mechanical properties of HSS-R18 after quenching from 920C° and tempered at 650C°

Quenching Medium	Hardness HV units	UTS- Mpa	Elongation EL%	Contraction in area R%
Water	611	1078	-	7.7
Oil	561	1114	6.7	7.3
Compressed air	543	1106	5	-
Still air	527	1102	5.75	4.9

Note : holding time before quenching 1.5 hrs. and tempering 4 hrs.

Table (4) The start and end of phase transformationduring heating and cooling of HSS-R18

During cooling			During heating			Rate of heating and cooling in C°/min
Phase transformation from austenite to martensite at C°			Phase transformation from pearlite to austenite at C°			Rate of heating and cooling in C°/min
Duration – min.	End	Start	Duration –min.	End	Start	
60	50	350	4	875	841	10
50	75	350	2.2	900	850	20

Table (5) Hardness of HSS-R18 after hardening at 920 C° using different media and tempering at 300 C°

Quenching medium	Hardness after quenching -HV	Hardness after tempering -HV
Water	579	579
Oil	481	542
Compressed air	454	543
Still air	429	511

***Holding time in hardening 1.5hrs. and in tempering 4hrs.**

Table(6) Hardness of HSS-R18 after quenching from 1200 C° in oil and compressed air and tempering at 560 C°

Hardness -HV	Oil quenching	Compressed air quenching	Temperature in C°
After quenching	831	828	**Quenching at 1200 C°**
After tempering	852	883	**Hardening and tempering at 560 C°**
After second tempering	861	887	**Hardness after second tempering at 560 C°**

***Holding time in both first and second tempering was 3hrs.and heating rate was 200C°/min**

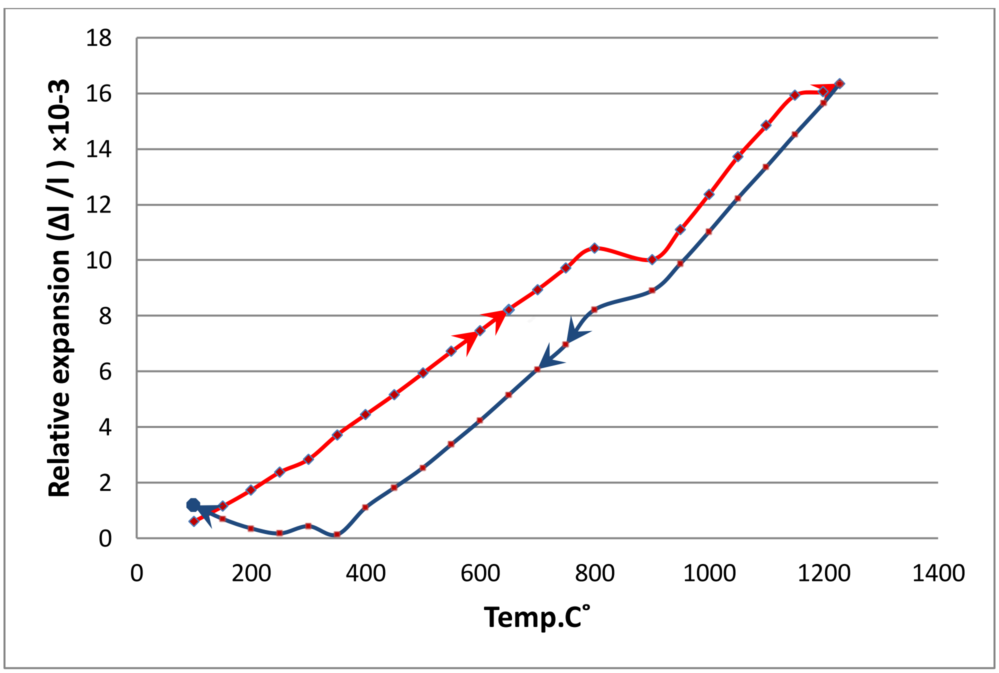

Fig.-1- Dilatation during heating and cooling at rate of 10 C°/min of HSS –R18

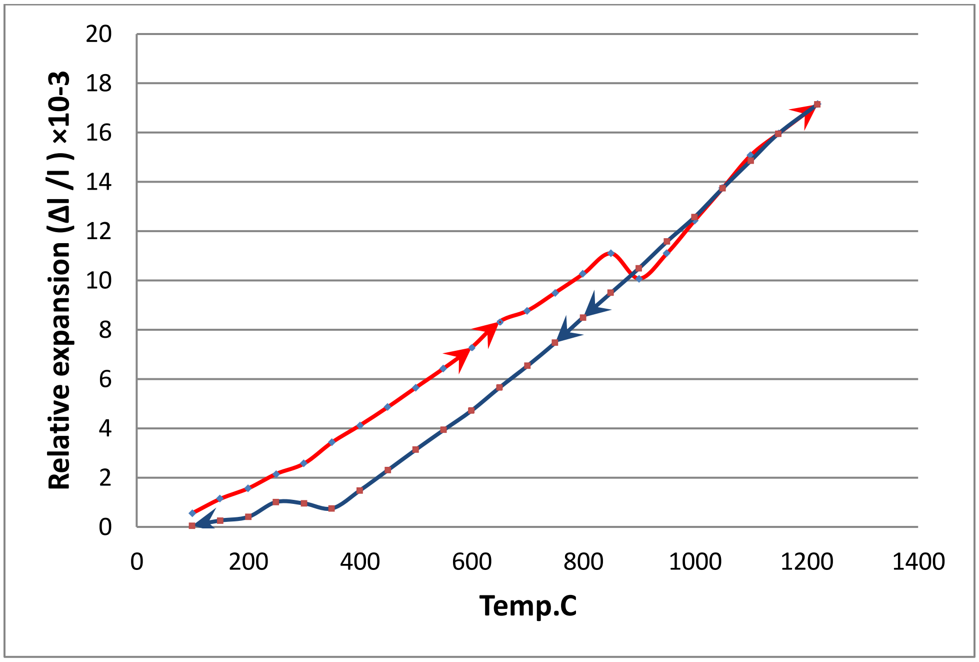

Fig.-2- Dilatation during heating and cooling at rate of 20C°/min of HSS –R18

Results

The results achieved by this work are as follow:

1- The alpha solution with carbide transformation to austenite was started at 841C°and finished at 875 C°, at 10 C°/min , heating rate that was accured during 4 mints. .The starting of that transformation was increased to 850 C° and finished at 900 C° and took only 2.2 mint. , during heating at 20 C°/min .(fig 1 and 2) .

2- The starting transformation of austenite into martensite during cooling at both 10 and 20C°/min .Cooling rate were 350 C° while the ending points were 50 C° and 75 C° respectively, the durations were 60 and 50 C° , i.e. they decreased by increasing cooling rate . (Table -4).

3- The hardness after quenching from 920 C° in different media and tempering at 650 C°, were increased relative to initial state, also UTS while, relative elongation decreased . (Tables 2and,3)

4- The hardness was increased relative to initial state by quenching from 920 C° and tempering at 300 C° , the hardness also increased by tempering at 650 C° relative to that achieved by tempering at 300 C°.(Tables 3and,5) .

5- The hardness increased rapidly after quenching from 1200 C° and continued increasing after first tempering at 560 C° (table 6), and slightly increased after second tempering at 560 C° .

6- The microstructures after oil and compressed air quenching from 1200 C° and tempering at 560 C° were martensite , carbide and retained austenite as referred to the hardness tests results (Table 6) .

Discussion of results and recommendations

1- As we know , the properties of HSS have direct relation with its structure . The structure of steel R18 after rolling is hypoeutectic alloy, consists of primary austenite , eutectic carbides (M2C and M7C3) , pearlite and martensite . With high carbon and alloying elements dissolved in the austenite, which becomes more stable after quenching .The hardness and other mechanical properties improved after quenching and tempering .The increament of quenching temperature from 920C° to 1200C° , had great effect on the hardness . Because of the more homogenous diffusion of the carbides , and the more transformation of austenite into martensite , which has high hardness and stability after full heat treatment .

2- There were small differences in the hardness after quenching in oil and compressed air because of the presence of high alloying elements such V ,Cr and W ,and[lowers the critical cooling rate , which enable obtaining microstructures nearly the same during cooling in different media .

3- The hardness increasing in case of tempering at 300C° relative to its value after quenching from 920C° , was due to transformation of part of retained austenite into martensite which increased the hardness as the hardened structure is full austenite,in addition to complex carbides .

4- The using of oil are compressed air as quenching media from 1200C° and tempering at 560C° , insured the obtaining of high hardness due to diffusion of carbides in the martensitic matrix , as a result the wear resistance was also increased enabling the use in manufacture of tools .

5- In the second tempering of that alloy access retained austenite transformed into martensite and more structure stability was achieved and hardness increment..

6- The quenching temperature 1200 C° and tempering at 560C°for 3hrs. holding time , were the best suitable to maintain the required structure and to decrease retained austenite , after full heat treatment of that steel , with less internal stresses .

ACKNOWLEDGEMENT

This publication was written at Al-mustaqbal University collage – Babylon .While the experiments were done in Nasser establishment in Taji Iraqi . I thank all peoples assisting me in this work during preparation and testing of specimens .Hopping the best regards for all of them. Also for all of your team.

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