Research on Application of heat quenching and tempering after connecting rod of 40Cr diesel engine

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Abstract: 40Cr steel diesel engine connecting rod were quenching and tempering by waste hate after forging and its mechanical properties were studied. The results showed that comparing with traditional technology, the forging-remnant-heat quenching and tempering technology route for 40Cr connecting rod of diesel engine not only meet the performance requirements of a stable product, grain refinement, as well as improve the forging of strength, hardness and toughness, but also shorten the production cycle, energy conservation, and improve labor productivity.

Introduction

40Cr steel belongs to the typical alloy quenched and tempered steel, the quenching and tempering process for the quenching temperature is 850 DEG C, quenching medium for mineral oil; tempering temperature for 520 DEG C, tempering medium is water or mineral oil, mainly for manufacturing automotive gears, spline shaft, rear axle shaft, a connecting rod, a main shaft of machine parts, but as a result of the steel containing alloying elements less, quenching is poor, often appear unstable quality, production efficiency low problem. In this research, the heat quenching and tempering treatment of 40Cr forging is studied, and the strength, hardness, toughness, microstructure and so on are studied. After the use of heat quenching and tempering treatment process, it can save two heating process, with obvious energy saving effect. For example: a 180kW car furnace, each furnace can save energy H - 1100kW, processing time from 15h to 7h.

Mechanism of quenching and tempering after forging

Heat quenching after forging is a comprehensive process of plastic deformation in the austenite state, which is a combination of deformation and heat treatment.

High temperature austenite plastic deformation grain boundary deformation, and change the precipitation of brittle precipitates. Therefore, deformation heat treatment can improve the impact toughness and reduce the sensitivity of the reversible and irreversible temper embrittlement. In addition, in the high temperature, the uniform infiltration of trace elements is one of the factors which can improve the material properties of the forging heat quenching technology. The practice has proved that the quenching process can be greatly improved by the quenching of the waste heat, which can be used to quench the cooling water, so that the thermal stress can be reduced greatly, and the risk of the cracking of the forging can be avoided.

Test materials and technology

Diesel engine connecting rod for 40Cr (its chemical composition, see Table 1), according to the performance requirements of processing technology for forging, quenching and tempering treatment, etc..

Table 1 40Cr chemical composition (%)

C	Mn	Ni	Si	P	S	Cr	Cu
0.37~0.44	0.50~0.80	≦0.030	0.17~0.37	≦0.030	≦0.030	0.80~1.10	≦0.030

Forging processing

40Cr diesel engine connecting rod forging process: cutting (cutting machine) induction heating (medium frequency induction heating furnace, forging, upsetting - forging blind hole piercing). The equipment has a round cut machine, intermediate frequency furnace WH-V3-JV, high temperature infrared temperature measurement instrument (the highest test temperature up to 1200 DEG C), upsetting forging machine, punching, forging machine and so on.

Heat treatment

Conventional quenching and tempering treatment process: the quenching temperature of 40Cr is taken at 850, 30 minutes or so, the quenching medium is water, which can be completely quenched. Tempering temperature of 560 degrees, about 30 minutes, water medium cooling.

Heat quenching and tempering process after forging, the core of the process is to use the quenching of the forging heat. Control of quenching temperature by using constant temperature furnace or infrared temperature measuring instrument, the quenching temperature is about 850, and the quenching medium is water.

Sample processing

40 Cr materials will impact tensile samples and sample each 5 groups, a total of 10 artifacts. One of tensile samples taken is Lo = 5 do short scale standard sample; Impact specimen is 10 mm x 10 mm x 55 mm standard specimen, a u-shaped groove .

Mechanical property analysis

Quenching and tempering hardness analysis.

The hardness value of the work piece in the process of quenching and tempering after quenching and tempering was measured by HR-150A. Each sample was taken from the five groups of data, and then the average, as seen in Table 2, 3.

Table 2 hardness of conventional quenching and tempering treatment (HRC)

Sample number	Hardness value（HRC）	Mean value（HRC）
1	29.5 31.0 29.0 30.0 30.0	29.9
2	29.5 29.5 29.0 29.0 30.0	29.4
3	31.5 30.0 30.0 29.0 32.0	30.7
4	32.0 33.0 32.0 30.0 31.0	30.6
5	33.0 31.0 30.0 31.0 31.0	30.4
Combined mean value		30.4

Table 3 hardness of waste heat quenching and tempering treatment (HRC)

Sample number	Hardness value（HRC）	Mean value(HRC)
1	35.0 32.0 30.0 32.0 33.0	31.8
2	32.0 31.0 33.0 31.0 31.0	31.0
3	31.5 32.5 31.5 32.0 32.0	32.1
4	32.5 33.0 33.0 32.0 33.5	32.8
5	34.5 35.0 35.0 34.5 35.0	34.8
Combined mean value		32.5

From the table we can see that after forging heat quenching and tempering of the work piece, the hardness value than the conventional quenching and tempering treatment to high, indicating that after forging waste heat hardening and tempering, the hardness of the work piece to is superior to the conventional mode of production; and after forging heat quenching and tempering process can not only save energy and time, the processing of the work piece performance can also be reached and even exceeded the work piece requirements.

Tensile test data and analysis

The processed forgings are made into a tensile specimen, and the tensile test results are shown in Table 4 and 5.

Table 4 tensile test of 40Cr conventional quenching and tempering treatment

Sample number	Maximum forceFm /KN	Tensile strengthRm/ MPa	Yield strength/ MPa	Section shrinkage ratio （%）	Elongation （%）
1	21.94	1120	988	45.1	11.5
2	21.93	1017	985	46.5	10.2
3	21.57	1100	945	45.8	11.7
Mean value	21.8	1079	979	45.8	11.0

Table 5 tensile test of 40Cr waste heat after heat quenching and tempering

Sample number	Maximum forceFm/ KM	Tensile strengthRm/ MPa	Yield strength/MPa	Section shrinkage ratio （%）	Elongation （%）
1	23.4	1190	987	61.0	13.6
2	23.6	1200	1054	58.5	13.4
3	24.5	1250	1120	59.2	13.0
Mean value	23.8	1213	1057	59.1	13.3

From the above data show that 40Cr steel after forging waste heat hardening and tempering than conventional quenching and tempering treatment the largest tensile stress increased by 8.7%, the tensile strength increased 8.7%, the elongation increased 15.6%. Thus 40Cr forging residual heat quenching and tempering in tensile strength, elongation than conventional heat treatment significantly increased.

Impact test analysis

The treated forgings are made into impact samples, the impact test results are shown in Table 6, 7.

Table 6 impact test after conventional quenching and tempering treatment of 40Cr

Conventional conditioning treatment	Absorption power(Ak/J)	Impact toughnessak/J/cm^2
Sample1	154.442	193.048
Sample2	128.075	160.090
Sample3	132.412	165.511
Sample4	133.946	167.429
Sample5	130.861	163.572
Combined mean value	135.947	169.930

Table 7 impact test of waste heat after quenching in 40Cr

Heat quenching after forging	Absorption powerAk/J	Impact toughnessak/J/cm^2
Sample1	168.353	210.436
Sample2	167.532	210.673
Sample3	160.156	200.190
Sample4	154.518	190.643
Sample5	159.308	199.130
Combined mean value	161.973	202.214

40Cr steel after forging quenching and tempering heat treatment impact toughness for 202.214 J above test data display, and traditional hardening and tempering treatment impact toughness value 169.93 J, the impact toughness increased by 19%; after forging quenching and tempering heat treatment process in the saving energy and technology at the same time, the impact toughness has also been strengthened.

Conclusion

After forging-remnant-heat quenching and tempering, this technology not only saved energy, shortened the production process, and improved mechanical properties.

The optimum scheme after forging heat quenching and tempering treatment: forging, quenching of heat (infrared control of quenching temperature at 850 DEG C, or a constant temperature furnace insulation to 850 DEG C) -- high temperature tempering machine processing.

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