Quality Improvement in Heat Treatment Based on Necessary Information Exchange

Arnold Horsch

Overview

• Who is AWT
• Main tasks of the AWT research committee (RC 25)
• Motivation and targets of presentation
• Influencing factors of successful heat treatment
• Reasons for necessary information
• Knowledge System
• Conclusion and outlook

Source: SFB 570 AWT FA25 001
Who is AWT?

- German Association for Heat Treatment and Materials Technology
- Founded 1948
- Is a scientific technical association with the aim to advance the theoretical and practical knowledge on material science especially on heat treatment of materials
- The AWT is a member of the
  AiF, the "Joint Venture for Industrial Research Associations"
- Together with the German State of Bremen the AWT is founder of the Institute for Materials Science (IWT), an interdisciplinary research institute for materials science, process engineering and manufacturing technologies
- AWT has at the moment
  - actually 267 company members
  - more than 500 personal members.

Who is AWT?

- At the moment 25 research committees of the AWT in cooperation with the Institute of Materials Science (IWT) are working on the
  - current scientific and technological problems of heat treatment
  - materials science
  - process engineering
  - manufacturing technologies
- Currently, 15 local heat treatment chapters provide ample opportunity to exchange information and experience, and also plenty of scope for training
- The chapters meet periodically at various regional locations in Germany
Main tasks of the AWT research committee (RC 25)

- Elaboration of general acceptable technically as well as organizationally possible quality assurance criteria for the heat treatment
- External and internal heat treat shops should obtain more understanding and certainty for their work
- The results should be summarized in a (online) knowledge catalog for heat treatment

Quality assurance criteria discussed in this presentation:
- Consideration of material information, process information and information about the change of parameters

Motivation

Insufficient information exchange can lead to avoidable costs for heat treatment:

Costs at the beginning of an order / process:
- Ask for necessary information

Costs during and after heat treatment:
- Surprising results and failures in production
- Parts which will fail before reaching lifetime end
- Find out reasons, prove if heat treat shop is responsible for the failures
Goals of presentation

Better understanding of the problems of insufficient or missing information for heat treated components mainly in the area of

- Necessary raw material information
- Necessary delivery information
- Necessary information if processes were changed before delivery

• Presenting two examples and reasons for necessary information
• Introducing a knowledge system to collect necessary information and their reasons

Influencing factors of successful heat treatment

- No scrap parts
- No cracks
- Less reconditioning
- Hardness reached
- Strength reached
- Surface state reached
- Tolerances kept
Reasons for necessary information

Material data - 51CrV4 (SAE 6150)

Example:
51CrV4

Information:
No availability of necessary material data information

What is shown:
How much different information and interpretations are possible about chemical composition, hardenability and tempering behavior

Rationales for necessary material information – chemical composition SAE 6150 (51CrV4)

No information about chemical composition, no information about using
Reasons for necessary Material information – hardenability, tempering behavior - 51CrV4

<table>
<thead>
<tr>
<th>51CrV4/1.8159</th>
<th>1,5</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
<th>11</th>
<th>13</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50 mm</th>
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<tr>
<td>HH max</td>
<td>HH max</td>
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<td>58 HRC</td>
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<td>HH min</td>
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<td>50 HRC</td>
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<td>37</td>
<td>35</td>
<td>34</td>
<td>33 HRC</td>
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<tr>
<td>HH max - HL min</td>
<td>$\Delta$</td>
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<td>9</td>
<td>8</td>
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<td>10</td>
<td>11</td>
<td>13</td>
<td>14</td>
<td>18</td>
<td>21</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>26 HRC</td>
</tr>
</tbody>
</table>

Reasons for necessary Material information – different material numbers – SAE 6150

<table>
<thead>
<tr>
<th>SAE 6150 / 1.8159 Tempered/Spring Steel</th>
<th>SAE 6150 / 1.2241 Toolsteel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tempering diagram</td>
<td>Tempering diagram</td>
</tr>
<tr>
<td>Source: Dörrenberg</td>
<td>Source: StahlWissen NaviMat</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>°C</th>
<th>$R_m$</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>430</td>
<td>1490</td>
<td>48</td>
</tr>
<tr>
<td>460</td>
<td>1391</td>
<td>44</td>
</tr>
</tbody>
</table>

Source: Dörrenberg
Reasons for necessary information

Process changes – 50CrMo4 (SAE 4150)

Example: 50CrMo4

Information: No information about process changes

Customer specification: Hardness > 700 HV

Problem: Hardness is not reached

Process description:
- Customer changed delivery state – former tempered – now +AC (annealed on globular cementite)
- Superfine carbides from hardening and tempering (only 500°C) have changed into thick balls of carbides

What is shown:
- New state is softer than the older one
- If reaching the same hardness, more energy for the new state is needed

Reasons for necessary information

Process changes – SAE 4150 (50CrMo4 / 1.7228)

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Quench hardness [HV]</th>
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</thead>
<tbody>
<tr>
<td>1000°C/300°C/s</td>
<td>ca. 820 HV</td>
</tr>
<tr>
<td>1000°C/820HV1</td>
<td>Tempered microstructure</td>
</tr>
<tr>
<td>1000°C/600HV1</td>
<td>Soft annealed microstructure</td>
</tr>
</tbody>
</table>

To reach 820HV by 300°C/s, 1260°C is needed. + 260°C to get the same hardness.

Source: Atlas zur Wärmebehandlung der Stähle Band 3
Conclusion

• Point out the necessity of information exchange
• Argue for a better understanding to reach a win-win situation
• Present influencing factors of successful heat treatment
• Illustrate two examples and reasons of necessary information exchange
• Introduce a knowledge system to collect necessary information and their reasons
Outlook and Future work

- Publish and disseminate the need of useful information exchange in further publications and on further conferences
- Extend the knowledge system by further examples and reasons for necessary information
- Prepare the knowledge system to open it for the public

References

- N.N., Steels for quenching and tempering - Part 3: Technical delivery conditions for alloyed steels; German version EN 10083-3:2006, Beuth Verlag (Berlin, 2006).
- N.N., „Dr. Sommer Datenbank Stahlwissen NaviMat 1.0,” 2002.
- N.N., Steels for quenching and tempering - Part 2: Technical delivery conditions for non alloyed steels; German version EN 10083-2:2006, Beuth Verlag (Berlin, 2006).
Thanks for your attention