Machinability Database for Hot-Rolled Steel

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Outline

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- Machinability Testing Method
- Using the Machinability Data Base
- Availability of Machinability Data
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Machinability Sub-committee

Steel Market Development Institute
  – Bar Applications Group
    • Machinability Sub-committee
  • Composed of representatives from automotive OEMs, academia and the steel industry, the Bar Machinability Sub-Committee develops information needed by the machining industry for material selection, process development and for improving understanding of the factors that influence the machinability of steel.
<table>
<thead>
<tr>
<th>American Iron and Steel Institute</th>
<th>General Motors Company</th>
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<tbody>
<tr>
<td>Bradley University</td>
<td>Gerdau</td>
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<td>Chrysler Group LLC</td>
<td>Materials Technologies</td>
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<td>Colorado School of Mines</td>
<td>Niagara LaSalle</td>
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<td>EMI/Michigan Technological University</td>
<td>Nucor Corporation</td>
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<td>Ferris State University</td>
<td>Sandvik Coromant</td>
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<td>Finn Metalworking and Cutting Solutions</td>
<td>Steel Market Development Institute</td>
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<td>Timken Steel Corporation</td>
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Machinability Sub-Committee - Objective

Develop machinability data on popular bar steel grades for the automotive industry

• Task 1
  – Provide access to machinability data for design selection of grades and parameters in single point turning of “autosteel” bars with uncoated tungsten carbide (WC) cutting tools

• Task 2
  – Provide access to machinability data for design selection of grades and parameters in single point turning of “autosteel” bars with coated WC cutting tools
Machinability Testing Method

- Select speed to provide 5 to 60 minute wear test
  - Feed rate of 0.010 ipr (0.254 mm/r)
  - Depth of cut of 0.100 in (2.54 mm)
  - WC cutting tool (Valenite VC-5)
  - Dry cutting
- Measure wear of flank until it reaches 0.012 inches and record time
- Repeat at different speeds (minimum of 5 tests, 2 at low, 1 at middle and 2 at high speed)
- Plot cutting tool life curves
Machinability Testing Method

Life for $V_{30}$ Value: 314 sfpm

$y = -76.908 \ln(x) + 472.45$
Using the Machinability Data Base

Steel Marketing Development Institute website: www.autosteel.org

From the Programs Tab select Bar Machinability from the drop-down menu
Using the Machinability Data Base

• Lists the $V_{30}$ Machinability Value for 36 AISI grades of bar steels used by automotive manufacturers
  
  – The $V_{30}$ Machinability Value is the maximum cutting speed for a 30 minute cutting tool life

• Include values for turning the bars steels with uncoated cutting tools

<table>
<thead>
<tr>
<th>Grade</th>
<th>$V_{30}$ ft/min</th>
<th>$V_{30}$ m/min</th>
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<tbody>
<tr>
<td>1018V</td>
<td>574</td>
<td>175</td>
</tr>
<tr>
<td>1018</td>
<td>564</td>
<td>178</td>
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<td>1038</td>
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<td>1070</td>
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<td>1070Al</td>
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<td>83</td>
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<tr>
<td>(C-70)</td>
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<td>73</td>
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<td>1080</td>
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<td>1080 Sph Ann</td>
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<td>137</td>
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Using the Machinability Data Base

- Determines the relative estimate of production cost for machining a different steel grade in a new design specification.
- Aids the selection of machining parameters for a steel grade in a new design specification.

![Graph showing machining parameters](image_url)
A machinability estimator is available on SMDI website: (www.autosteel.org/Programs/Bar Machinability)

- For steel grades not on the database list

- The estimator is based on a best fit curve of the machinability values plotted with their carbon equivalent (developed by Ito-Bessyo)
Using the Machinability Data Base

\[ y = 1493.7x^3 - 1945.6x^2 + 38.748x + 694.87 \]

\[ R^2 = 0.8 \]
The unlisted steel composition is submitted by the user in the prompts for the Estimator to obtain the Ito-Bessyo Carbon Equivalent as follows:

\[ \text{CE} = \%C + \frac{\%\text{Mn}_{\text{eff}}}{20} + \frac{\%\text{Si}}{30} + \frac{\%\text{Ni}}{60} + \frac{\%\text{Cu} + \%\text{Cr}}{20} + \frac{\%\text{Mo}}{15} + \frac{\%\text{V}}{10} + \%5^* B \]

Where \( \text{Mn}_{\text{eff}} = \text{Mn} - (1.71^* S) \)
Using the Machinability Data Base

• The Estimator will calculate and return the $V_{30}$ Machinability Value from the best fit curve (3rd order polynomial when using uncoated cutting tools)

$$y = 1493.7x^3 - 1945.6x^2 + 38.748x + 694.87$$

Where $y = V_{30}$ Machinability Value,

and $x = CE$ developed by Ito-Bessyo
Using the Machinability Data Base

• The Estimator for the machinability value while turning steel bars with coated cutting tools is calculated from the best fit curve of the $V_{30}$ value plotted with a modified carbon equivalent equation as follows:

$$CE = \%C + \%Mn/4.5 + \%Si/6 + \%Cr/4+ (%Cu + \%Ni)/15 + \%Mo/2.5 + (%V)^{1.8}$$
Using the Machinability Data Base

Tentative (pending update to CE equation)

![Graph showing the relationship between V30 Machinability (fpm) and Carbon Equivalent Modified (wt %). The equation is given as $y = -1632.5x^2 + 1577.1x + 1002.2$ with $R^2 = 0.571$.](image)
A review was conducted on the availability of information on machinability of other ferrous and non-ferrous metals at several metal and manufacturing societies.

- ASM International
  - Sells print and online digital handbooks to members and non-members. The Machining Handbook has multiple references to machinability tables from Metcut’s Machinability Data Center

- Society of Manufacturing Engineers
  - Sells print and online digital articles and handbooks with a focus on machining parts from many metal alloys to members. Members may also ask for machinability information from discussion groups, such as the Machining and Material Removal Community
Availability of Machinability Data

- American Foundry Society
  • Sells print and online digital articles and handbooks with limited information on machinability to members. Members may order a new handbook on a procedure for machinability testing of gray and ductile cast iron.

- Ductile Iron Society
  • Sells print and online digital articles and handbooks with limited information on machinability to members. Members may order reprints or read an article online about a comparison of machining ductile castings to machining steel forgings for an automotive gear application.
Availability of Machinability Data

- Precision Machined Products Association
  • Has a help line for members with machining questions. PMPA staff use tables from the Metcut Machinability Center with recommendations to machine deeper and faster with coated cutting tools. They also refer members to cutting tool suppliers for recommendations. PMPA does not provide information on machinability of metal alloys.

- Copper Development Association
  • Has machinability ratings listed online in their copper alloy database in the fabrication properties section of each alloy. The ratings do not include machining parameters. The online information is available to members and non-members.
• Conclusion:
  - The machinability data compiled by the BAG Machinability Subcommittee and available on the Steel Market Development Web Site at www.autosteel.org is unique.
Summary

• The BAG Machinability Subcommittee has developed a machinability test for “autosteel” bars and measured the machinability value while turning 36 steel grades with uncoated and coated cutting tools.

• The machinability data is available for design engineers on the Steel Market Development Web Site at www.autosteel.org.

• Other metal alloy and manufacturing societies do not have machinability data bases that may be correlated to metals like the one on the Steel Market Development Web Site.
A BIG thank you to

- The American Iron and Steel Institute for its generous support of this study
- Member steel bar makers for supplying the steel bars for the project
- Member organizations for testing the steel bars and determining the machinability values
Thanks for Listening!

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