North American Stainless

Machinability comparison between NAS Ultra 303, NAS Standard 303, and Competitor Premium 303 for high machinability market.

Background

NAS has been working to develop stainless steel bars for free machining market comparable to premium products with high machinability that can be currently found on the market. NAS has started to conduct a new melting practice for better chemistry and inclusion control including Calcium treatment on free machining grade Type 303 (NAS Ultra 303) in order to improve machinability.

NAS Ca treated 303 heats were tested for inclusion distribution and compared with 303 premium machinability grade supplied by competitors. Similar type of Ca inclusions have been found in NAS Ca treated 303 heats. NAS has adopted this new melt practice with Ca treatment on free machining stainless Type 303.

By improving the entire process including chemistry, microstructure, and mechanical property control, NAS has developed a premium 303 grade and performed a machining study between NAS Ultra 303, NAS Standard 303, and Competitor Premium 303 bars sold for high machinability market.

Study Description and Methodology

In this study the bar samples are marked as "A" for NAS Ultra 303, "B" for NAS Standard 303, and "C" for Competitor Premium 303. The primary objective was to observe tool wearing and cutting force in a turning operation of each sample. The tool wear and forces were measured and recorded at different cutting speeds and charted for comparison. The machinability testing was conducted under the contracted services of TechSolve, Cincinnati, Ohio. The tooling used was a DNMG 431 KCM-15MP, designed for light to medium machining of austenitic stainless steel, with Shape: 55^{o} diamond, Nose radius: 0.015", Coating: Ti-CN-Al2O3, Flood Coolant of Trimsol: 8% concentration. The machine tool used was a Hardinge Lathe: Model LC65, with Max Spindle Speed: 4400 rpm, Horsepower: 25 hp, Work holding: Collet-chuck, Axis: 2. Parameters set at Depth of Cut: 0.025", Feed: 0.004"/rev, Feed length: 1.75".

Chemistry comparison of bars used in machining study:

Sample	C	Mn	S	Si	Ni	Cr	Mo	Cu	N	Ca	Ti	Nb
(A) NAS Ultra 303	0.0376	1.8785	0.3500	0.5380	8.3895	17.0865	0.2825	0.3320	0.0570	0.0026	0.0020	0.0220
(B) NAS Standard 303	0.0331	1.8210	0.3300	0.4475	8.4190	17.1180	0.3070	0.3665	0.0427	0.0001	0.0020	0.0170
(C) Competitor 303	0.0492	1.8140	0.3630	0.5850	8.1980	17.4200	0.1830	0.4810	0.0427	0.0073	0.0020	0.0190

Mechanical property comparison of bars used in machining study:

Sample	Hardness Brinnel	UTS (Ksi)	YS (Ksi)	El. %	Reduction of Area (%)
(A) NAS Ultra 303	178.00	86.43	47.38	35.04	47.44
(B) NAS Standard 303	196.00	93.48	50.61	50.63	57.00
(C) Competitor 303	178.00	93.27	48.03	47.60	55.48

Results

Cutting Force and Tool Wear:

Cutting force and tool wear was measured at low, medium, and high cutting speeds by removing the same amount of material for each sample bar. Figure #1 and #2 represent cutting forces and tool wear at the high cutting speed of 700 SFM (surface feet per minute) when removing 28.33 inch³ of material from each sample. It can be seen that lower force is required for the same material removal for sample bars (A) NAS Ultra 303 and (C) Competitor Premium 303, as compared to the sample bar (B) NAS Standard 303. Likewise, the tool wear for NAS Ultra 303 and Competitor Premium 303 are similar and lower at high cutting speed than NAS Standard 303.

Fig. #1

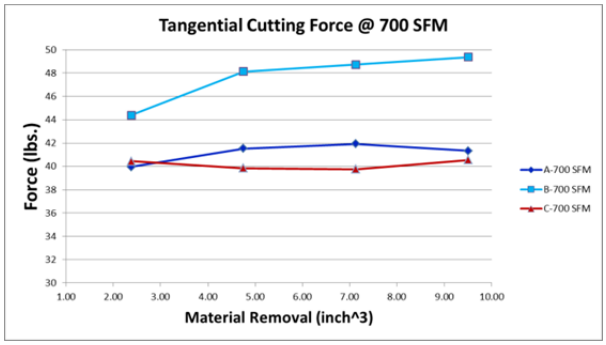
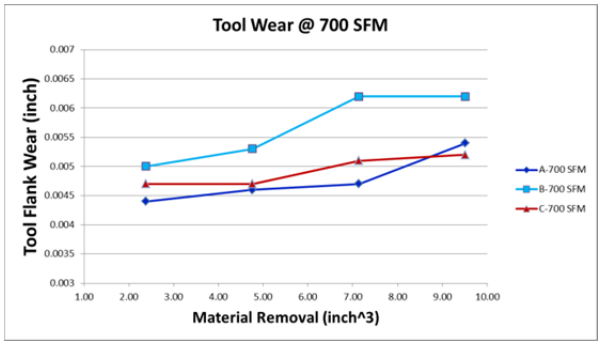


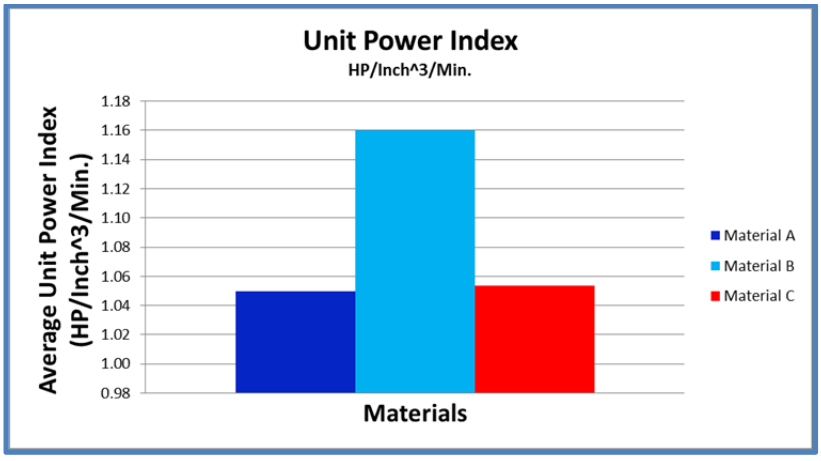
Fig. #2



Unit Power Index:

The Unit Power Index is a widely used measurement of machinability. It describes the power required to remove one cubic inch of material in one minute. Based on the test's cutting speed (SFM), feed rate (IPR) and depth of cut and cutting force the chart in Figure #3 was calculated.

Fig. #3- Record of Unit Power for Each Material



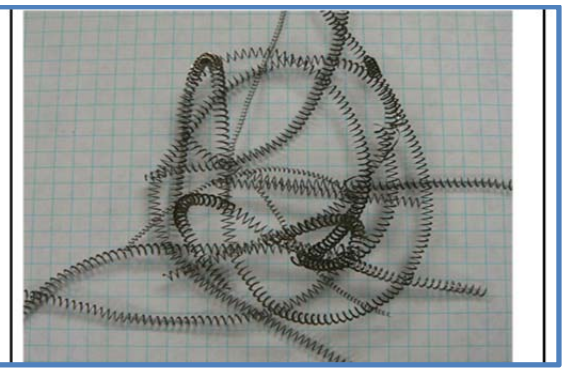
Chip Comparison:

The chip quality was compared for all three samples in Figure #4. Both NAS Ultra 303 and Competitor Premium 303 chips were classified as very good elemental chips in comparison to the inferior washer type helical chips from NAS Standard 303.

Fig #4- Typical Chip Classification for Each Material

NAS Ultra 303

NAS Standard 303



Competitor Premium 303

Conclusion

The machinability comparison study shows that NAS Ultra 303 stainless bar produced with the new melting practice is comparable with Competitor Premium 303 stainless bar, and superior to NAS Standard 303.

- The tool wear when turning NAS Ultra 303 and Competitor Premium 303 was comparable and 15-16% better than NAS Standard 303.
- The Unit Power Index for turning NAS Ultra 303 and Competitor Premium 303 was comparable and 11-13% better than NAS Standard 303.
- The chip quality of NAS Ultra 303 and Competitor Premium 303 was comparable and classified as elemental chips compared to the inferior washer type helical chips from NAS Standard 303.

Although this study and conclusion is based on limited set of machining conditions there is no reason to believe that this performance will not hold for other conditions. Machine shops using NAS Ultra 303 should explore the advantages of this new material in order to determine the optimum machining conditions for their specific requirements.