DETERMINING THE MACHINABILITY OF HIGH PERFORMANCE (HP) STEELS

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INTERIM REPORT NUMBER ONE

"GRINDING"

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INTERIM REPORT ON GRINDING

MACHINE TOOL

The grinding tests were performed on an Acer brand 5 horsepower, model 1224AHD surface grinder. This machine is equipped with a variable speed spindle drive and an automatic incremental downfeed. The workpiece table, which is the electro-magnetic chuck, is 12" wide and 24" long.

The surface roughness (finish) readings were taken on a Federal brand "Pocket Surf" portable surface roughness gage. The advantage of this instrument is its flexibility and versatility. Measurements can be made while the workpiece is still fixtured, chucked, or clamped in the machine tool and does not require workpiece removal to a bench setup. A calibration standard is included to insure the accuracy of roughness measurements.

WORK MATERIALS

The three steels evaluated in this phase of the contract were:

A36, 156 BHN, purchased from Earle M. Jorgensen Steel, Cleveland, Ohio.
A710, 229 BHN, donated by North Star Steel, Calvert City, Kentucky.
A709, 229 BHN, shipped from Missouri Fabricators.

The test samples of A36 and A709 were 1" thick by 12" by 5". The A710 sample was 1/2" thick by 12" by 5". All samples were ground on both sides prior to testing to insure a true, flat surface for measurements.

TEST CONDITIONS

The target surface conditions were 32, 16, and 8 micro-inch roughness readings (finishes) to correspond with appropriate material removal rates for these readings. The reciprocating table speed was 84 feet per minuter, maximum on this grinder. All grinding was performed dry, without coolant. The wheel speed was 1780 rpm, or 5,824 feet per minute on a wheel diameter of 12.5 inches.

TEST CONDITIONS continued

Most surface grinders are set to run at approximately 6,000 feet per minute, if they are not equipped with a variable speed spindle drive.

The grinding wheel used for these tests was designated as 9A100I8V52. This is a 100 grit aluminum oxide wheel, which is recommended for finish grinding to obtain the 8 and 16 micro-inch readings. This author has been involved with grinding tests for 39 years. A review of several years of surface grinding data revealed that only aluminum oxide wheels are used on steels. Silicon carbide wheels are recommended for all types of nonferrous alloys with few exceptions. Some of these exceptions are: austenitic stainless steels, gray cast iron, where both aluminum oxide and silicon carbide wheels can be used, compacted graphite cast iron (CGI), ductile irons, malleable irons, and white cast irons. The MACHINING DATA HANDBOOK, the only exhaustive publication of recommendations for machining and grinding, supports these applications of grinding media selection. For this reason, an aluminum oxide wheel was used for all these tests.

It is a common (but bad) practice to fine-dress the grinding wheel (use a slow traverse speed) with the diamond dresser to produce low surface roughness readings. This practice is **NOT RECOMMENDED.** A fine-dressed wheel is a ***dull wheel***, which will load up quickly and possibly induce high tensile stresses in the surface of the workpiece. This is a dangerous condition if the workpiece is ever subjected to alternating stresses, even at very low cycle speeds. The presence of high surface tensile stresses and any surface discontinuity (fastener hole, etc.) is a potential crack initiation site, which can grow and produce a fatigue failure under alternating stresses. If possible, grinding wheel speeds should be a maximum of 4000 ft./min. for finish grinding conditions to minimize stress. The publication, LOW STRESS GRINDING should be consulted to adjust all the grinding parameters to insure the absence of high tensile stress in the surface of the ground workpiece.

TEST RESULTS

The following table illustrates the surface roughness readings (micro-inch) produced with a variety of grinding conditions.

Downfeed in./pass	Crossfeed in./pass	Surface Roughness Readings, micro-inch parallel to lay	perpendicular to lay
		GRADE A36 STEEL	
0.0005	0.030	4, 5	16, 22
0.0010	0.030	16, 28	8, 15
0.0015	0.030	4, 5, 6	14, 18
0.0020	0.030	16, 20	12, 16 21
0.0005	0.130	8, 11, 12	17, 22, 24
0.0010	0.130	4, 7, 10	13, 16, 17
0.0020	0.130	12, 19, 9	9, 20, 37
		GRADE A709 STEEL	
0.0005	0.030	15, 17, 7	27, 27, 30
0.0010	0.030	13, 11, 10	19, 18, 20
0.0015	0.030	4, 6, 7	19, 21, 22
0.0020	0.030	6, 6, 5	18, 20, 22
0.0005	0.130	10, 11, 13	28, 25, 29
0.0010	0.130	6, 7, 9	26, 25, 35
0.0020	0.130	15, 10, 13	53, 49, 39
		GRADE A710 STEEL	
0.0005	0.030	5, 7, 6	11, 14, 14
0.0010	0.030	4, 4, 5	16, 12, 14
0.0015	0.030	8, 7, 7	17, 16, 14
0.0020	0.030	6, 7, 11	14, 13, 17
0.0005	0.130	17, 15, 9	21, 23, 25
0.0010	0.130	11, 16, 8	27, 19, 25
0.0020	0.130	12, 8, 9	21, 34, 22

CONCLUSIONS

These results indicate that obtaining surface roughness readings of 32, 16, and 8 micro-inch finishes is readily obtainable with a 100 grit aluminum oxide grinding wheel, using downfeed and crossfeed values in the ranges shown above. As is expected, the roughness readings taken perpendicular to the direction of the table travel are usually higher than the readings taken parallel to the table travel. A general "rule-of-thumb" is that the perpendicular readings are about 1-1/2 to 2 times higher than the parallel readings.

Grinding ratios, which are analogous to tool life values in machining, provide a relative indication of the efficiency of the grinding operation. The grinding ratio is defined as the volume of work material removed divided by the volume of grinding wheel consumed in the process. This is a very delicate test and requires very careful measurements of the workpiece and the grinding wheel diameter. Having performed dozens of grinding ratio tests over the 39 years of machinability testing, this author has accumulated a great deal of grinding ratio data on a variety of alloys. Most of the steels tested were relatively hard, 40 Rc to 52 Rc. Typically, grinding ratios for these hardened steels reach a maximum of 20 to 25. One alloy steel at 300 BHN had grinding ratios from 55 to 133. A grinding ratio of 133 means that for each 1 cubic inch of grinding wheel consumed, 133 cubic inches of steel are ground away. This is a highly efficient grinding process. **For grinding operations of high material removal rates where the surface roughness is not an important consideration, a 35 grit or 45 grit aluminum oxide grinding wheel would be more efficient than a 100 grit wheel. To obtain fine finishes (low surface roughness readings) a fine wheel of 100 grit or finer, 220 or 320 grit, should be used.**