



NEW PRODUCT ARTICLE



NEXT GENERATION CENTERLESS GRINDING

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Introduction

Industries as diverse as aerospace, automotive, maritime, medical devices, and oil and gas depend on high precision round components. Manufacturers in turn depend on precision centerless grinding to achieve the desired roundness, dimensional tolerance, and finishes of their products. Typical applications and industries include:

- High production, large volume continuous grinding
- Parts ranging from miniature roller bearings to locomotive axles
- Fastener manufacturing
- Tool manufacturing
- Steel mills
- Automotive related components
- Bearing components
- Machine tools
- Turbine shafts and components (land- and air-based)

With increasingly demanding applications, tolerances are becoming tighter and the finishes required are getting finer. Grinding machine and wheel manufacturers are being asked to provide new technology and expertise in order to meet these demands.



Figure 1 Norton Century centerless wheels.

Abrasive Grain Overview

Substantial research has been completed over the last 20 years on the cutting tool portion of the wheel, the abrasive grain. Prior to this, standard aluminum oxide (refer to Figure 2) was the product of choice due to its highly friable (sharp and easily broken down) nature. Certain chemistry changes provided slight improvements such as the off-white, pink, red, and purple variations. However, a more significant technological change in abrasives development was needed.

In 1990, Norton Abrasives introduced the first ceramic alumina abrasive, Norton SG (refer to Figure 3). This new grain offered significant performance improvements in all areas of precision grinding. This was a result of a combination of the hardness of each ceramic alumina grain and the new science of “controlled micro-fracturing”. The ceramic alumina grain fractures at a controlled rate which provides two distinct advantages over aluminum oxide:

- A constant and consistent supply of sharp cutting edges
- An increase in the utilization of each grain from 25% to 80%

The resulting benefits were a continuously sharp abrasive that cut up to 100% faster without burn for very hard and difficult-to-grind materials. In addition, the Norton SG abrasive provided up to 300% life improvement due to the superior utilization of each grain.

Improved iterations of ceramic alumina grain were produced from 1990-2006. In 2007, Norton Quantum (NQ) ceramic alumina abrasive grain was introduced, a revolutionary leap forward in grain technology. As a result, NQ has become the reference standard in the precision grinding industry for the last eight years.

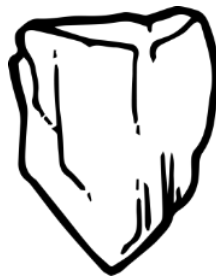


Figure 2 Blocky aluminum oxide grain.

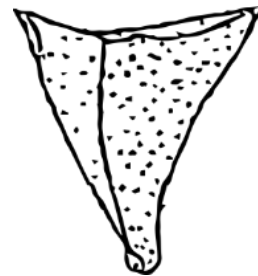


Figure 3 Norton SG: Sharp, hard ceramic grain.

New B45 Centerless Grinding Bond

Organic abrasive products have two major components: abrasives and bond (refer to Figure 4). The abrasive is the cutting tool portion of the wheel while the bond holds the abrasive in the matrix to form the wheel. The space between the abrasive and the bond is referred to as the structure or porosity of the product.

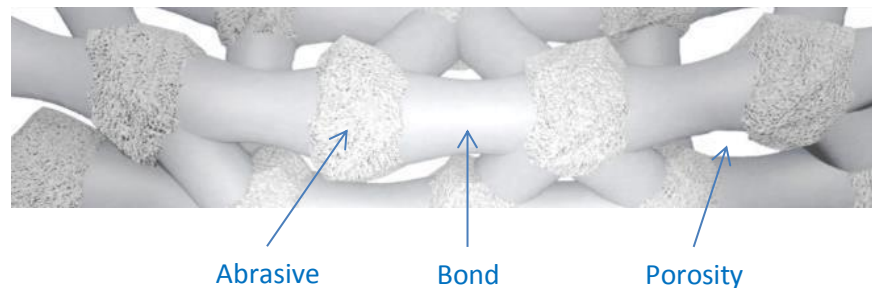


Figure 4 Abrasive and bond matrix.

The revolutionary Norton B45 centerless bond platform features an exclusive chemistry that greatly improves grain retention in the wheel. This enables wheels to be constructed with more porosity for a given hardness. This directly translates into a wheel with the grain retention of a hard grade and the performance of a soft grade.

Benefit - Versatility

The versatility of the Norton B45 bond can be seen on the wide range of materials that it can grind. Some of the materials successfully tested in semi-rough and semi-finish applications include:

- Steels: mild to high carbon, Cr and Mo alloys
- Stainless steels
- Copper
- Titanium, Ti64
- Nickel super alloys: Inconel, Waspaloy™, Hastelloy™

The Norton B45 bond can be utilized with the full range of Norton abrasives and blends, including:

- Aluminum Oxides
- Silicon Carbide
- Ceramic Alumina: Norton SG, Norton Targa (TG), Norton Quantum (NQ)
- Norton Vortex

Benefit – Longer Wheel Life

The best quantification of wheel life is the grinding ratio, or G-Ratio. This is a measure of the amount of material removed as compared to the amount of wear of the wheel (refer to Equation 1 below). The amount of material can be measured in mass (grams or pounds) or volume (in³ or mm³) so long as equal units are used. This method removes any variation in production levels during the observed time.

$$G \text{ Ratio} = \frac{Mass_{part}}{Mass_{wheel}} = \frac{Volume_{part}}{Volume_{wheel}} \quad (1)$$

In two separate head-to-head trials, the Norton Century45 grinding wheels had significantly longer wheel life than the competitive wheels by demonstrating improved G-Ratios. In one of the applications, the Norton wheel simultaneously improved the surface finish of the parts. In the other case study, the Norton wheel significantly improved the overall machine cost performance.

Case Study 1

Machine: #3 Cincinnati
 Wheel size: 20 x 8 x 12
 Material: 1045, 304, Copper
 Part OD: Variable 0.5"
 Part length: 1" - 2"

Results: 243% improvement in G-Ratio over incumbent wheel.
 Improved surface finish across bar length.

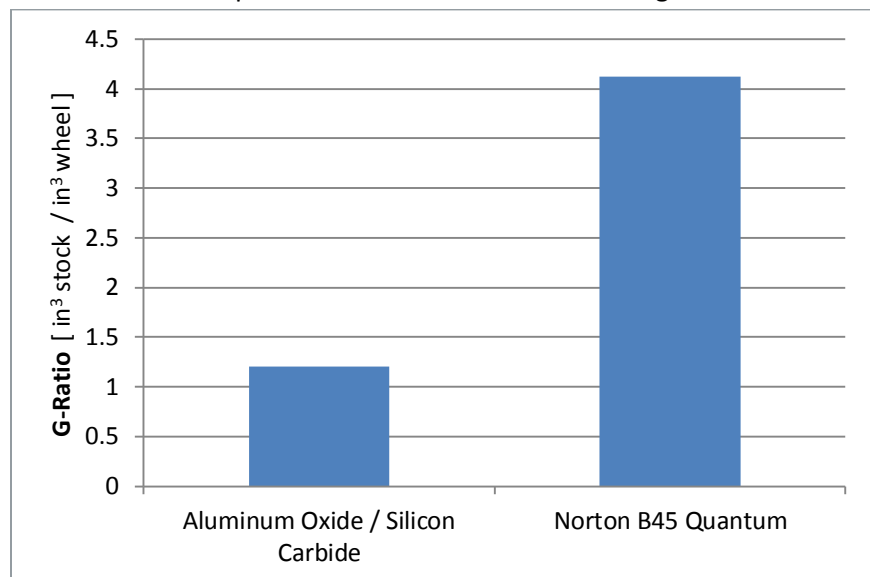


Figure 5 G-Ratio of wheels from Case Study 1.

Case Study 2

Machine: #3 Cincinnati, 50 HP
Wheel size: 24 x 8 x 305
Material: 1045, 10V45, 4140, 17-4 PH
Part OD: 3.5" - 7.5"
Part Length: 4" - 6.5"

Results: 32% improvement in G-Ratio over incumbent wheel.
100% improvement in machine cost performance.

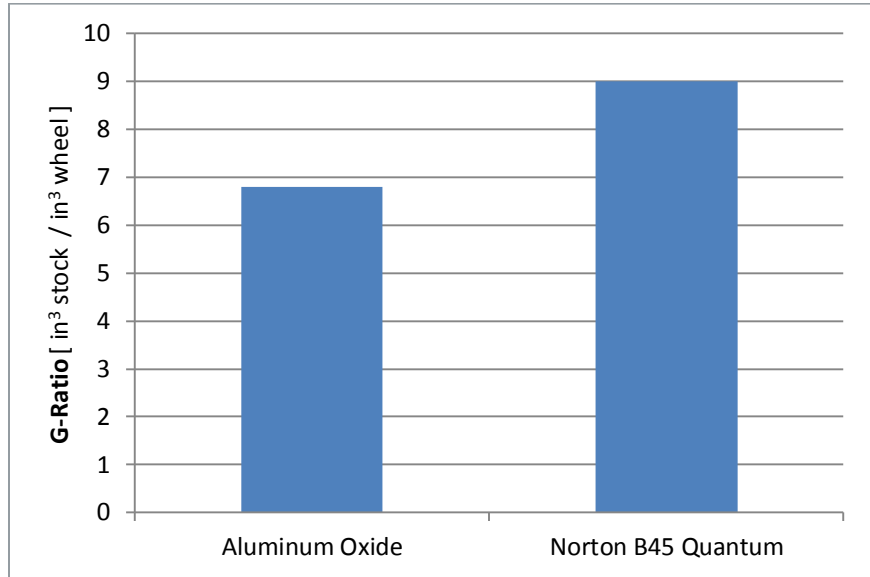


Figure 6 G-Ratio of wheels from Case Study 2.

Benefit – Increased Stock Removal Rate

In most centerless grinding facilities, labor and machine costs can account for as much as one third of the cost of a part. Improvements to the throughput of a machine can therefore have a large impact on overall plant productivity and profitability. This stock removal rate can be quantified in several ways, including:

- Volume per time: [mm³/min] or [in³/min]
- Mass per time: [gram/min] or [pounds/min]
- Diameter per pass: [mm/pass] or [in/pass]
 - Feed rates must be equal for comparison
 - Starting diameter must be similar for comparison

Case Study 3

Machine: Cincinnati Twin Grip, 40 HP
 Wheel size: 24 x 20 x 12
 Material: Inconel
 Part OD: 0.5" - 1.75"
 Part Length: 378" - 384"

Results: The Norton Century45 wheel stock removal = 0.008" - 0.012" per pass.
 Incumbent wheel stock removal = only 0.005" per pass.
 Norton Century45 wheel reduced manufacturing process from 4 to 2 passes.

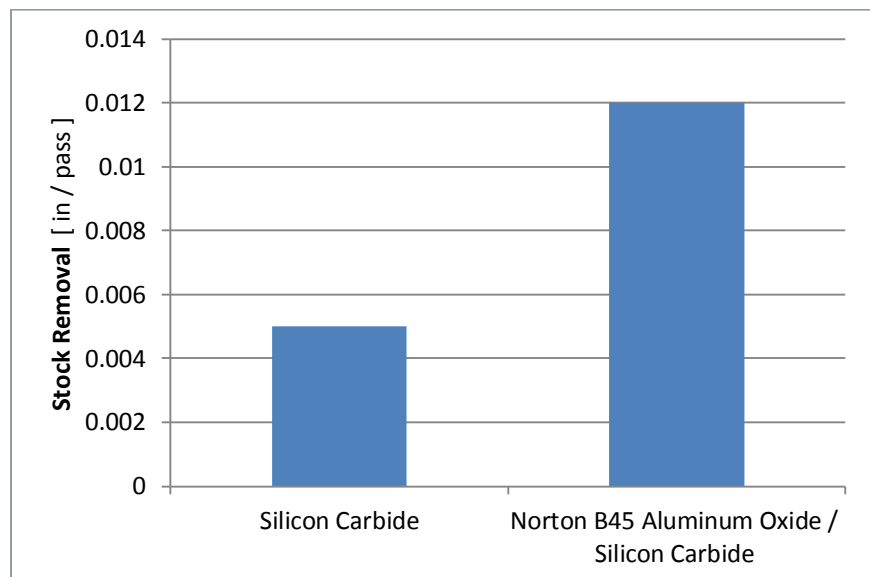


Figure 7 Stock removal of wheels from Case Study 3.

Benefit – Quieter Grind

According to the Bureau of Labor Statistics, approximately 30 million people in the United States are exposed to hazardous noise in their place of work. Noise-related hearing loss is consistently listed as one of the most prevalent occupational non-fatal illnesses in private industry. Every year, thousands of workers suffer from preventable hearing loss due to high workplace noise levels.

Short term exposure to loud noise can cause a temporary reduction in hearing or a persistent ringing (tinnitus). The duration of these short-term problems may range from a few minutes to hours after leaving the noisy area. Repeated exposure to loud noise can lead to permanent tinnitus and/or hearing loss. Once damaged, there is no way to repair the degradation to the ear; neither surgery nor a hearing aid can help correct this type of hearing loss.

The increased porosity of the new Norton B45 grinding wheel offers a significant reduction in noise level while grinding hard metals such as Inconel. In Case Study 4, the Norton B45 wheel was shown to reduce the grinding noise by a staggering 23.2 dB. To put this reduction in context, many commercially available foam ear plugs offer Noise Reduction Ratings in the range of 25 to 28 dB. This type of a reduction dramatically increases the safe time in a given noise environment as specified by NIOSH publication 98-126.

Case Study 4

Machine: Cincinnati Twin Grip, 40 HP
Wheel size: 24 x 20 x 12
Material: Inconel 718
Part OD: 0.5" - 1.75"
Part Length: 378" - 384"

Results: Norton B45 wheel was 23.2 dB quieter than incumbent wheel

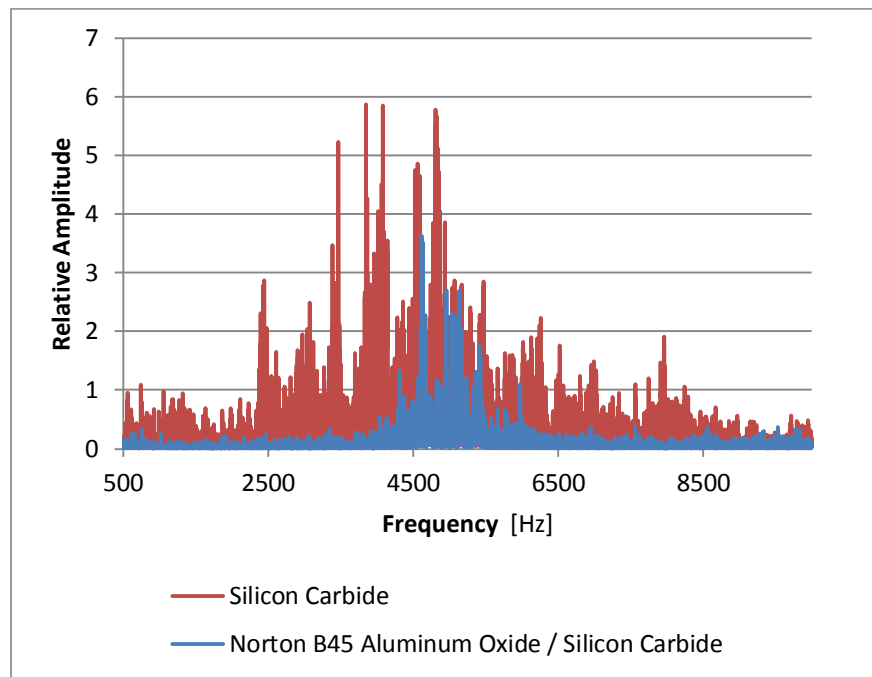


Figure 8 Frequency spectrum of wheels from Case Study 4.

Summary

Total cost reduction is the goal of all manufacturing organizations. On average, abrasives consumables only account for about 3% of the total cost. Machinery, labor, and overhead account for up to 80% of total manufacturing budgets (refer to Note: The Norton Process Solution Program (PSP) analyzes the cost, quality, safety, and service components of a grinding operation, with the goal of minimizing cost and maximizing overall productivity and safety.

Figure 9). Optimizing the abrasive process to decrease the cycle time offers the greatest chance for return. With a 20% decrease in cycle time, on average, there will be a reduced total cost per part of more than 15%.

Typical cost reductions

On average abrasives and cutting tools only account for about 3% of total manufacturing budgets. Therefore the impact of price reduction or increased product life is an insignificant cost saving.

PSP will help improve productivity, therefore having a much greater impact on the overall cost saving. See examples below.

Decreasing the price of abrasives
A 30% price reduction will only reduce costs per part by 1%.

Increasing the life of abrasives
Even a 50% increase in product life will only reduce costs per part by 1%.

Increase overall productivity through PSP
With a 20% decrease in cycle time per part there will be a **reduced total cost per part of more than 15%.**



Note: The Norton Process Solution Program (PSP) analyzes the cost, quality, safety, and service components of a grinding operation, with the goal of minimizing cost and maximizing overall productivity and safety.

Figure 9 Typical abrasive manufacturing total cost breakdown.