Fiber Abrasive Finishing Systems for End-Deburring Extruded Aluminum Profiles

Prepared by: D. Mark Fultz, VP Marketing
for
Abtex Corporation, Dresden, NY

ABSTRACT

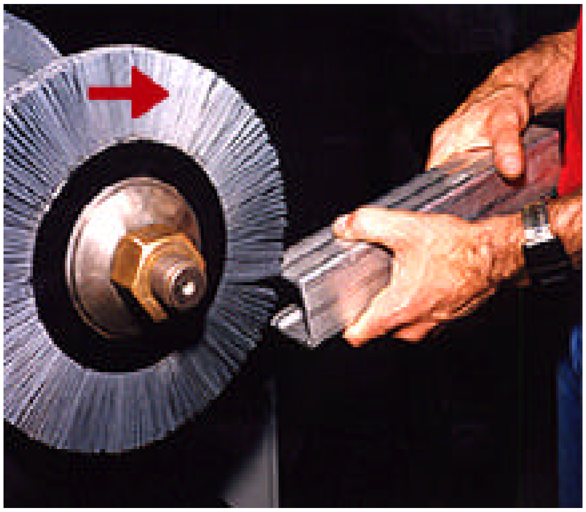
The expanding use of aluminum extruded shapes is placing higher quality demands on extruders and fabricators. Electronics related applications such as heat dissipation components (heat sinks) require that there be no loose flakes or burrs. Other applications with functional considerations as well as safety and esthetic are forcing the industry to supply sawn ends which are burr free and slightly radiused.

This paper discusses an abrasive medium which is ideal for end deburring aluminum extrusions. When formatted into a disc brushing tool, it can be applied on a machine based system for manual, semi-automated, or fully automated end deburring of aluminum extrusion ends. It is a practical and efficient process which offers increased productivity, safety, and consistently high quality levels. This process has been proven with over 100 installations throughout the United States, Canada, and Europe.

INTRODUCTION

End deburring aluminum extrusions has typically been an off-hand process. An abrasive media such as a wire, abrasive filament, buffing, or non-woven wheel is rotated and the extrusion is presented by hand for deburring as shown in Figure 1.

In order to completely deburr the profile, the operator must present it in such a way as to allow the abrasive to strike and wipe against each inside and outside dimensional edge. This necessitates repositioning the part and varying the angle of presentation.



As this entire process is dependent on operator skill, inconsistent finishing is often the result. Variables such as depth of penetration, dwell time, and angle of attack are all uncontrolled. Furthermore, because this is generally a high volume process, operators are subjected to prolonged repetitive motion.

Figure 1 Off-Hand Deburring of an Aluminum Extrusion

In 1980, a process was developed to improve the operation of end deburring aluminum extrusions. Using abrasive nylon filaments formatted into a disc brushing tool, a deburring system was developed.

FIBER ABRASIVES

The term "fiber abrasive" is used to describe an abrasive nylon filament. Developed approximately 25 years ago, they have been used in brush form for a variety of industrial applications. These generally involve deburring, edge radiusing and surface finishing.

The filament is composed of heat stabilized nylon which has been coextruded with a mineral abrasive grit. The grit is impregnated throughout the filament as well as exposed on the external surfaces as shown in Figure 2.

As the filament is applied to the work piece and begins to wear, new abrasive grit is exposed. The filament is, in effect, self sharpening.

Abrasive action occurs on both the tip and the sides of the filament. Slower R.P.M.'s are employed to allow the fiber to strike and wipe against the surface. This, combined with the flexibility of the fibers, makes it ideal for finishing irregularly shaped objects.

Figure 2 Nylon Filament Impregnated with

Abrasive Grit

Abrasive options are, for the most part, limited to silicon carbide and aluminum oxide. Other, more exotic abrasives are available. Their expense, however, limits their use to very specific applications. Grit sizes range from 600 through 46 (mesh number used in abrasive separation). Filament diameters range from .018" - .060". As seen in Table 1, filament diameter increases as grit size increases. This relationship is necessary in order to effectively bind the abrasive. By weight, abrasive loading of the filament ranges from 20% to 40%.

Table 1 Abrasive Nylon Filament Diameters and Grit Sizes

Filament Dia. Inches (mm)	.012 (.30)	.018 (.46)	.022 (.56)	.030 (.76)	.035 (.089)	.040 (1.02)	.060 (1.52)
Grit Size	600	500 600	120 320	240	180	80 120	46

In both ferrous and non-ferrous applications, silicon carbide is the most widely used fiber abrasive. For aluminum applications specifically, there is no threat of corrosion from iron contamination. The silicon carbide grit is produced under controlled conditions and contains no free iron [1].

The fiber abrasive is not considered a material removal tool. Despite the fact that a large grit size can be applied (up to 46 mesh), the flexibility of the filament limits its cutting action. The fiber abrasive will remove some material, but at a minimal rate. For this reason, burrs and sharp edges are preferentially abraded away. This enables the tool to deburr without affecting the dimensional tolerances of the part.

Brushing Tool Formats

Fiber abrasives are typically formatted into brushing tools using conventional brush making machinery. Abrasive brushing tool formats therefore include these familiar types seen in Figure 3.

Brushes of these types are commonly applied with hand tools, manual stationary equipment (drill press, pedestal grinder), semi-automated (CNC, NC, robotics), and dedicated finishing systems.

Figure 3 Typical Brushing Tools Employing Fiber Abrasives

Aluminum Extrusion End Deburring

For end deburring aluminum extrusions, two brush formats are generally used; the radial wheel or the disc.

2. Radial Wheel

The radial wheel, as the name implies, employs fibers extending radially from a hub. The brush is commonly mounted on a horizontal shaft and rotated in a direction which causes the fibers to strike the part in a downward motion. The brushing action with a radial wheel is thus unidirectional.

End deburring with a radial wheel is predominately an off-hand procedure. For the purposes of illustration, we will assume that a rectangular profile is being deburred. The operator presents the profile to the wheel in roughly a perpendicular angle. The brush tips contact the upper horizontal edges of the profile, deburring the upper outside edge and the lower inside edge. The part would then need to be rotated 90 degrees a total of three additional times and presented to the wheel in a similar manner in order to completely deburr the part. Although use of the fiber abrasive radial wheel is an ideal choice for off-hand deburring of aluminum extrusions, the process limits productivity and quality is subject to operator skill.

2.Disc

A more efficient format for end deburring aluminum extrusions is the disc brushing tool. The disc is constructed of a backing into which the filaments are embedded. The fibers extend perpendicularly from the backing. Unlike the unidirectional rotation of the radial wheel, the disc offers multidirectional wiping action.

To take advantage of the disc format, the disc is rotated on the vertical plane. The extrusion end is presented, in a controlled manner, perpendicular to the face of the brushing tool as shown in Figure 4. The end of the extrusion is then passed from left to right through the top half of the brush. With a counter clockwise rotation of the disc, as the extrusion enters into the face, the fibers are in a downward motion. This deburrs each horizontal upper edge of the profile. When the part moves to the center point, the fibers are now traveling from right to left. The filaments impact and deburr the right facing, vertical surfaces. As the shape moves to exit the disc, the fibers are traveling from bottom to top. The bottom horizontal surfaces are now deburred. The extrusion is then brought back through the lower half of the brush. In the center position, the fibers are wiping from left to right and thus deburr the remaining left facing vertical edges. This process offers 360 degree deburring regardless of profile geometry.

Figure 4 Extrusion Presented to Disc for End Deburring

Disc Construction

Variables in disc construction affect its performance in this application. The quality of the process is dependent upon optimizing each of these variables in relationship to each other. These are:

- Density
- Face/Band Width
- Trim Length
- Filament Diameter
- Grit Size

1. Density

Density refers to the number of individual filaments across the face of the brush. Maximum density could be achieved by packing the filaments against one another, offering an almost solid face. This would not be practical in this application.

The individual filaments need to flex in order to provide a wiping action which will follow the contours of the profile. Heat dissipation is also critical in order to avoid a condition referred to as “nylon smear”. The melting point of the nylon used in these filaments is in the range of 210 degrees Celsius - 250 degrees Celsius (410^0 F - 482^0 F). Extreme density, depth of penetration, or dwell time can generate heat sufficient to melt the nylon. The melted nylon would then be transferred onto the part where it cools and bonds. Subsequent anodizing will reveal this phenomenon.

Employing a disc brushing tool with too little density will require prolonged dwell time. Individual filaments are required to work harder with less support. This leads to premature filament breakage and reduced brushing tool life.

The optimal brush density is shown in Figure 5. The filaments are distributed evenly across the face of the brush. Filaments are close enough to support one another yet spaced to allow flex and heat dissipation.

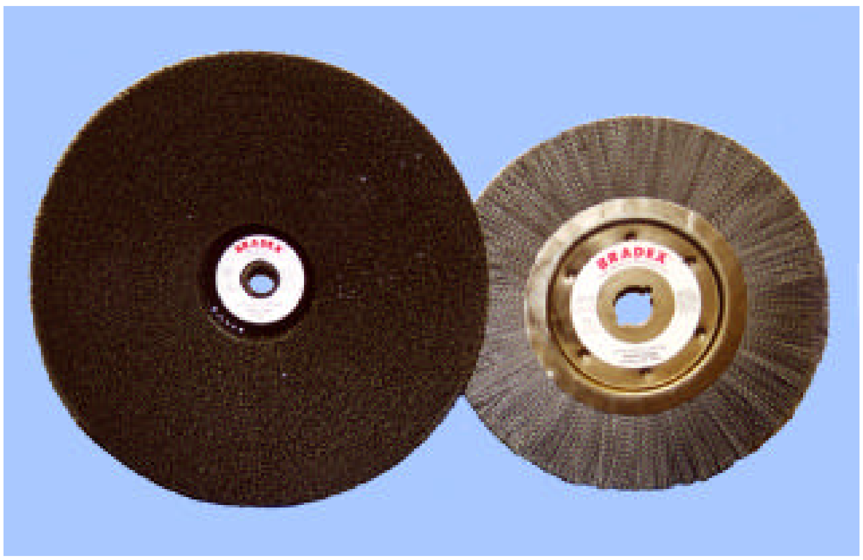


Figure 5 Optimal Density of Disc and Radial Style Brushing Tool

2. Face/Band Width

The face of the disc brushing tool refers to diameter of the brush which is occupied by filaments. The band width is a term which describes the distance between the inner ring of filaments and the outer diameter of filaments as shown in Figure 6. The band width determines the overall profile height which the brushing tool is capable of deburring. A 12 inch disc brush with a 4.5 inch band width is able to effectively deburr a profile no taller than 4.5 inches. Taller extrusions would require a larger diameter brushing tool.

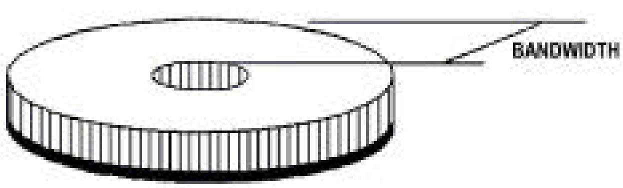


Figure 6 Band Width of Disc Brushing Tool

3. Trim Length

The trim length is the length of the visible filament, or the distance from the tip of the filament to its base. This affects how aggressive the brushing action is. Generally, with all other variables fixed, the brush becomes more aggressive as the trim length is shortened. With proper density, a brush is rarely too aggressive for this application. Longer trim lengths however will reduce aggressiveness. To compensate, longer dwell times are needed. There also is the tendency to increase part penetration into the brushing tools' face. This is largely counter productive.

4. Filament Diameter and Grit Size

In many applications, it is often most effective to use a smaller diameter filament. This is true for end deburring aluminum extrusions. The filament is more flexible and, in a given density, more abrasive surface area can be exposed to the part. Larger diameter filaments may have a tendency to hit and bounce off the part [1]. As was seen in Table 1, grit size and filament diameter are related. The most effective combination for end deburring aluminum extrusions is .022"/120 grit.

Rotational speed of the brushing tool also is a critical factor in the process. The rule of thumb for the application of fiber abrasives is for speed not to exceed approximately 3600 surface feet per minute. Optimal speed however is determined by considering the brush construction variables and the parts to be deburred. Experience has shown that, for a 12 inch or 14 inch disc brushing tool, speeds between 1000 RPM and 2000 RPM are optimal. Speeds in excess of this can result in nylon smearing. Slower speeds will extend cycle times.

Process

In order to fully exploit the advantages of the fiber abrasive disc brushing tool, a machine based system was developed to improve:

- Productivity
- Quality
- Safety

These benefits are achieved largely through elimination of the variables associated with the off-hand operation.

Productivity - The machine based system offers reduced cycle times. It can often accommodate multiple parts to deburr per cycle.

Quality - Depth of brush penetration is accurately set and maintained (+/- .005”) throughout the deburring cycle. Adjustment is necessary only as the brush wears.

Safety - The multidirectional wiping action of the disc brushing tool eliminates the need for rotating the part. The part is now securely clamped during the deburring cycle.

End Deburring Systems

1. Single Head System

A. Manual - This system employs a 2 horsepower motor driving a 12 inch or 14 inch diameter disc. The extrusion(s) is loaded and the operator engages the clamp arm. The table is then pushed to process the extrusion end through the brush face. As the extrusion passes through the upper half of the brush and the table reaches its travel limit, the motor/brush assembly index upward. As the operator reverses the loading table direction, the extrusion passes through the lower half of the brush. The deburring cycle is completed.

B. Semi-Automatic - The semi-automatic single head system is identical in concept to the manual single head. The added benefit to the semi-automated system lies in reduced operator involvement. This system features a pneumatic clamping mechanism and a driven loading/transport table. The operator loads the extrusion(s) and depresses two palm buttons. Parts are then automatically clamped, deburred and unclamped. A programmable controller handles all functions. The table is driven with a variable speed DC motor.

2. Double End Systems

Double end systems are custom designed to best meet the needs of a customer. They are designed as either a “return to operator” or “flow through” system.

A. Return to Operator (RTO) - A RTO system is generally a semi-automatic design. The operator loads the extrusion(s), activates the system, and unloads as the deburred parts are returned to him. Two opposing 12 inch or 14 inch disc brushing tools are driven by two, 3 horsepower brake motors. The motor assemblies are mounted on a single tool slide to ensure alignment. The brush/motor assemblies are adjustable to accommodate a range of extrusion lengths. A reversing brake motor is utilized to provide the necessary brush direction change in order to provide 360 degree deburring. After passing through the top half of the brush, the motor is braked and rotation is reversed. The extrusions are then brought back through the top half of the brush again to complete the deburring cycle.

B. Flow Through - A flow through system is designed to be either semi-automatic or fully automatic.

1. Semi-Automatic flow through systems require operator involvement for loading and activating the system. Finished parts are automatically unloaded off of the opposite end of the system. A total of four brushing heads are used in this system. Two 2 horsepower motors per side, rotating counter to each other provide the deburring action. The motors are saddled on a tool slide for precise alignment and adjustability.

2. Fully Automatic systems are designed to be incorporated into a production line. The deburring concept follows that of the semi-automatic flow through system. The part transfer and clamping mechanism is designed to accept the extrusion as it is conveyed.

Conclusion

Fiber abrasives are an effective media for end deburring aluminum extrusions. When formatted into disc brushing tools, the multidirectional rotation of the disc can be utilized by applying it on a machine based system. An end deburring system presents the extrusion to the brush in a controlled and precise manner. Systems are available in manual, semiautomatic, and fully automatic designs to meet virtually any production need. They offer increased productivity, enhanced safety, and consistent, high quality deburring.

References:

[1.] Watts, J.H., “Abrasive Monofilaments - Factors that Affect Brush Tool Performance”, SME Deburring and Surface Conditioning Conference, MR89-112, San Diego, CA, February 13 - 16, 1989