Index Terms

Burrs

Deburring

Hand Deburring

HAND DEBURRING: A NECESSITY THAT CAN
BE IMPROVED

By

R. W. Johannesen
President
Rodeco Company
Sanford, North Carolina

LaRoux K. Gillespie
Senior Engineer
The Bendix Corporation 078 7000
Kansas City Division
Kansas City, Missouri

Jack L. McMillen
Retired, Formerly
Special Project Engineer
Woodward Governor Company
Rockford, Illinois

ABSTRACT

Hand deburring is a necessity that many companies perform either on a part-time or a full-time basis. Although hand deburring cannot be totally eliminated, an in-depth look at company approaches to this problem can result in significant savings. This paper highlights some of the problem areas and solutions for this facet of deburring.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ABSTRACT

Hand deburring is a necessity that many companies perform either on a part-time or a full-time basis. Although hand deburring cannot be totally eliminated, an in-depth look at company approaches to this problem can result in significant savings. This paper highlights some of the problem areas and solutions for this facet of deburring.

INTRODUCTION

It has been estimated that deburring costs American industry two billion dollars every year. This same estimate considers that the labor equivalent of 150,000 workers is involved in what can be considered to be basically hand deburring work. From these estimates, it is easy to show that close to one and one half billion dollars are spent on hand methods of deburring and edge finishing. Despite this staggering sum, little specialized research effort has been applied to this area. A review of 2000 publications for information on the subject of burrs reveals no more than 25 which concentrate at all on this subject. Only one of these 2000 publications presents any research data on this subject.¹ While some companies have developed in-house time standards of deburring, no published data exists on any of these standards.

Many of the reasons for the lack of facts on the subject are known. A major difficulty is defining the quality of the edge produced. Also, many companies do not have a definable definition of their requirements. These same companies do not want to admit they have not solved hand deburring problems. Until recently, there was little apparent reader interest in the subject. The people who know how to solve the problems often cannot describe their approaches well in writing. The nature of hand deburring implies that salesmen are not promoting their products as widely as is the case for mechanized processes. Few people have an appreciation of industry-wide needs and approaches. While these are not all of the reasons for the lack on information, they are the more predominant ones. Each of these reasons can be why many companies have large internal deburring costs.

DISCUSSION OF HAND DEBURRING

In-House Costs of Hand Deburring

One of the most effective methods of convincing companies they need to look at hand deburring costs is to require a key manager to make three calculations:

- o Count the machinists and related machine operators within the company;
- o Multiply this sum by 0.03; and
- o Multiply the sum by the yearly salary average of machinists.

This provides a very crude estimate of in-house hand deburring costs. It is based on the estimate that the equivalent of 3 percent of the production workers perform hand deburring and finishing. While this is a very easy estimate to make, it may be grossly in error. As one recent survey has pointed out, a large percentage of companies devote 10 percent of their piece part cost to burr removal.² Similar results have been reported in a recent report from Canada.³

To get a more accurate definition of burr costs, it is possible to perform an in-depth method engineering study or complete Table 1. In either case questions occur: Why are deburring costs so high? and What can be done to reduce these costs? The following pages provide some background on these subjects.

What is Hand Deburring

Hand deburring, hand work, bench work, or manual deburring can be any operation in which a hand held deburring tool is used or in which a hand held part is placed against a fixtured tool. It includes the cutters and motorized tools listed in Table 2. While this list is not complete, it is representative. The actual number of tools used is essentially endless when considering variations in geometry, size, and techniques.

Why is Hand Deburring Used

A number of reasons for using hand deburring are given in Table 2. In a particular situation, every one of these reasons can represent the least expensive approach to deburring. Part of the problem today exists in determining when these reasons are not really valid. As an example, hard-to-reach burrs are not in themselves a valid reason for hand deburring because, of the 37 deburring processes known,⁴ seven will reach very remote areas. The key is really some combination of accessibility, burr size, edge requirement, available equipment, and cost. With the notable advances that occur every year in the deburring processes, the fact that a burr could not be removed seven years ago by process ABC is often irrelevant today. That is particularly true when some of the burr minimization techniques used today are incorporated.

A few years ago it was impossible to vibratory deburr large parts without getting part-on-part impingement. When this was objectionable, these parts were often hand deburred. Today, vibratory machines are available which can virtually assure that such impingement does not occur. Similar major improvements have been made to abrasive flow deburring, the thermal energy method of deburring, and other processes.

One key to reducing hand deburring costs is to ensure that the percentage of improper applications of this process is kept low. While this is not easy to do, it can be done by close and continuous scrutinization of deburring operations.

The following is a listing of some of the "less than admirable" reasons industry performs some hand deburring. It is in these areas where major improvements can be made.

Table 1. Elements of Deburring Costs

Source of Cost	Estimated Hours Per Year on Deburring	Salary Dollars	Overhead (Dollars/Hr)	Yearly Cost Dollars
Hand Deburr People				
Deburring Machine Operators				
Deburr Foreman				
Engineering or Management				
Inspection				
Deburr Equipment Depreciation				
Maintenance of Equipment				
Sharpening of Deburr Tools				
Deburr Supplies				
Energy Costs				
Deburr on Machine Cycle				
Scrap Due to Inadequate Deburr				
Warranty Work Caused By Burrs				
Floor Space Costs				
Total				

Table 2. Devices and Reasons for Using Hand Deburring

Cutters	Motorized Tools	Reasons for Using Hand Deburring
Burr tools	Minisanding belts	Burrs hard to reach
Knives		Very small number of parts
Scrapers	Recipro sanders	Touch up burrs left by mechanized processes
Files	Jitterbug sanders	Highly variable burr size prohibits other techniques
Abrasive filled rubber	Recipro files	Short turn-around-time required on few parts
Sandpaper		Least expensive approach on small lot sizes
Picks	Motorized spindles	Deburr machine won't accept this size part
Abrasive stones		Very close tolerance parts
Abrasive coated nonwoven nylon		Delicate parts
Drills		Precision finish on parts 8 μ in. (203 μ m)
Reamers		Small allowable maximum edge radii (0.002 in. on 50.4 μ m) maximum
Mounted points		Large minimum allowable edge radii (0.060 in. on 1.5 mm) minimum
Rotary files		Extruded material not removed by mechanical process
Mini-brushes		Lead in/lead out threads not removable by other processes
Countersinks		Deburr on machine time (for safety or efficiency)
		Mechanized machine is out of commission for x days
		Prevent media impregnation or oxide creation
		Same radius required on different edge angles
		Can't change the process once it has been accepted by military
		Hand operations more flexible

- o I don't know anything about other deburring processes.
- o It is easier to call out hand deburr than to evaluate the best approach.
- o No one cares.
- o I don't have time to think about deburring.
- o We never know where the burrs will be.

While some of these may seem ridiculous, casual conversation with individuals responsible for specifying manufacturing sequences indicate these are some very prevalent reasons. They are not limited to small companies or easy to produce parts. Engineers throughout industry often feel those are valid reasons for the conditions.

Problems Created by Hand Deburring

The expense of hand deburring is not the only reason it should be evaluated closely. Ten areas are listed in which hand deburring leads to some form of undesirable situation.

- o Time required
 - Can't depend on constant efficiency
 - Parts in work for two years
 - Parts at burr bench for months
 - Can't predict part completion
- o Quality level
 - No guarantee all edges were worked
 - Can't maintain small radii
 - Confusion between parts finished and those not begun
- o Defining acceptable handwork edge standards
- o Rejected parts
 - Cost of rejections
 - Cost of bad parts in next assembly
- o Deburr worker turnover
 - Layoffs
 - Upgrades
 - Quit
- o Lack of hand work education

- o Tooling
 - High costs for wide variety of tools
- o Handling
 - Difficult to hold miniature parts
 - Secondary problems such as fingerprints and rust from chemicals in hand
- o Consistency of results
 - Lot to lot
 - Part to part
 - Edge to edge
 - Person to person

Discussions with a major transmission manufacturer revealed that some of their parts were on the burr benches for 9 months. At that time, a 6 month backlog of work awaited hand deburring. The many human variables involved, in combination with varying burr sizes, make it impossible in many situations to accurately predict when parts will leave the burr bench.

One of the more disastrous problems is that, while taking a break or while being distracted by something, a deburr operator can accidentally place parts to be deburred in the "finished" basket. There really isn't any guarantee that a particular part was ever touched by a deburring knife. Someone other than the operator can absent-mindedly pick up a burr-laden part to look at it through a microscope and never give a thought to which pile it came from or went to.

A recent study of the ability of precision hand deburring operators to produce edge radii less than 0.004 in. (101.6 μ m) indicates that while possible it is not often achieved.¹ Such small radii require special approaches which are significantly different than normal deburring.

Hand work leads to a variety of actual edge conditions. Some areas of a part will have large gouges on the edges. Some edges will have a relatively uniform break, while others will have a radius. On aerospace type parts, the inspection department must determine which of these conditions are acceptable for which areas of which parts. An inspector essentially establishes a pseudo-edge standard in his mind. If several inspectors review the same parts, some will feel that these are not all allowable.

Few people realize the cost incurred when parts are rejected. The parts must be rescrutinized, deburred, and reinspected. Reject forms must be filled out as well as resubmittal forms. The inspection department, the foreman, and the deburr people must be shown the problem. A rework technique has to be selected and some evaluation made of how to prevent the problem in the future. In some cases, the quality engineer has to make a weekly written report of reject reasons and corrective actions taken. This report is then reviewed by other engineers and managers. When someone has to write something extra or provide rework instructions, money is wasted.

Few people are willing to acknowledge the problems caused by deburr operator turnover. New people can mean less experience and more problems. Since little if any formal training is ever provided for these operators, quality or deburring time or both suffer. Individuals throughout the country have privately indicated that when a layoff occurs, machine operators with more seniority often "bump" down into deburring. Suddenly an operator used to machining large parts is overnight a "burr man" deburring miniature parts under a microscope.

The key here is really not what precipitated the change but the observation that formal training for hand deburring doesn't seem to exist. Unlike machine operator training courses, hand deburring is still largely an art which few people can communicate in any training session. Sudden personnel changes really affect hand deburring operations.

Special hand tools are often necessary to reach out-of-the-way burrs. Unfortunately, if many different tools are required by many operators, tool costs, resharpening, and inventory costs can be significant.

Miniature parts are often difficult to hold and position for any operation. This also becomes a major problem when hand deburring precision parts under a microscope. The part, the tool, and the burr combine to frustrate the most patient workers.

Other than time, the major complaint with hand deburring is the lack of consistency. This consistency can be a problem lot-to-lot, part-to-part, edge-to-edge, and person-to-person. The previously mentioned study of hand deburring indicated that, using conventional deburr knives and miniature brushes and sandpaper, edge repeatability was approximately ± 0.002 in. (± 50.8 μm) on precision miniature parts. While that is adequate for most parts, it is not adequate when requirements are for radii of 0.003 in. (76.2 μm) maximum, and the best nominal radius obtainable is 0.004 in. (101.6 μm). Some reasons for lack of consistency in part deburring are given in the following listing:

- o Operator attitude,
- o Comments of people around him,
- o Operator education,
- o Status within working family,
- o Time available to do parts,
- o Rated time,
- o Peer pressure,
- o Supervisory pressure,
- o Difficulty of edge access, and
- o Availability of hand tools.

A stated or implied need such as "we require seven parts right away" may increase the rate of deburring, but in some cases it will also decrease the quality of results.

There are other factors affecting deburring quality and costs:

- o High turnover of engineers responsible for solving burr problems;
- o The use of N/C;
- o High turnover in metal finishing department;
- o Inspector good or bad days; and
- o Inspector turnover.

A positive aspect is that N/C machines have given us an increased level in burr consistency. Because of a guaranteed tool path motion, burr location on a part will be the same 5 years from now as it is today. The elimination of hand feeding has also helped to reduce burr size in some, but not all, cases.

Why is Deburring Treated Badly?

Deburring apparently has always suffered from a social stigma. At one time removing burrs required no training, skill, or care. The only concern was to assure that a file, stone, or abrasive paper left a chamfer on a large, loosely toleranced part. It was the type of task anyone could do. Even today a large percentage of deburring falls into this category.

Even when deburring is a concern it is still not given the attention it deserves. The following observations about deburring have been made in the past.

- o It's a common problem.
- o We never used to have problems.
- o It is often classed as a "cover-up" or "cosmetic" operation.
- o It is performed by the lowest paid help.
- o We can always do it by hand; therefore, it can't be too difficult.
- o In the past it was treated as black art, no data on burrs was available.
- o In the past no rationale for minimizing the problem was widely known.
- o Engineers and managers assume it is a trivial problem so they assign wrong people.
- o No one wants to be associated with "losers" or mundane problems.

Because some deburring fitted this category of unskilled labor, there was little need to seriously consider deburring needs. As a result, deburring remained largely an art and little engineering or research effort was devoted to this area of metalworking. Even when edge requirements and productivity became more critical, the status of deburring in the so-called "pecking order" never changed. The introduction of vibratory deburring in the late fifties heralded a decade of new deburring processes. Today, individuals serious about maximum cost reduction have to evaluate 37 deburring processes. Part of the current interest in burrs now is the result of the following factors:

- o A basic data base on deburring capabilities exists;
- o An urgent need to evaluate every contribution to productivity exists;
- o The need to establish some quantitative form of capabilities and needs exists;
- o A large amount of precision or high volume deburring exists;
- o Worldwide publicity has recently shown that deburring can be improved; and
- o There has been a lack of skilled dependable help.

One of the most significant yet least appreciated reasons deburring is shunned by worker and engineer alike is that successful solutions often require more technical background on burrs and deburring than most engineers or workers have. As an example, the formation of burrs is a plastic deformation process. An in-depth understanding of burr formation practically requires a doctorate in stress analysis. While literature is now available describing burr formation in easily understood language, the ability to predict burr formation accurately and the ability to define deburring capabilities requires a technical background and considerable experience, astuteness, and cleverness.

Lastly, deburring is often ignored because it is often economically less significant than the machining operations.

Approaches for Minimizing Hand Deburring

Hand deburring does not lend itself to ready analysis. If it did, it would not be an area of mystery and high cost. However, in any engineering study, some basic approaches and considerations can be identified which will lead to better solutions:

- o Analyze actual hand deburring costs;
- o Determine actual in-house burr needs;
- o Determine the key problem areas of in-house hand deburring;

- o Tentatively evaluate whether or not potential benefits outweigh the cost of improvements; and
- o Seek out solutions.

The analysis of actual manual deburring costs is relatively straightforward.^{5,6} Costs alone, however, should not be the only criteria used to determine whether special effort should be concentrated on manual efforts. After costs are obtained they need to be compared to some kind of base value:

- o By total annual dollar cost,
- o By cumulative dollar total,
- o As a percentage of shop manhours,
- o As a percentage of machining costs,
- o As a percentage of sales dollars,
- o By comparing to industry cost as a whole, and
- o By comparing to percentage costs in a specific industry.

While a cost reduction of any kind is desirable, these evaluations provide some relative measure of the long range potential benefits, since such factors as total shop or machining man hours are required in all long range planning.

The determination of actual in-house deburring needs, as opposed to what is being performed, is not an easy item to establish. It requires the evaluation of functional requirements, the evaluation of in-house standards, and the evaluation of in-house practice.

At the present time, with the exception of the hydraulics, pneumatics, and aircraft industries, there is little consensus on functional edge requirements. The fact that many parts have 20 to 30 edges for which functional requirements need to be ascertained further complicates this aspect. It is no easy matter to determine if the actual requirement is "burr free with 0.005 in. (127.0 um) maximum chamfer," or "burr free to the extent that edges will not cut hands or cables."

Frequently companies find that the only in-house burr standards are in the mind of the designer, or the inspector, or the hand deburring workers. While this does not present a problem for many companies, it is absolutely essential for minimum cost in many facilities that everyone clearly understand the required limits of hand work.

As many speakers have noted, there are many facets of manufacturing in which process instructions and actual practice do not agree. Deburring is no exception. The printed instructions (if any) frequently are not followed in practice. Part of this is the result of one or more of four reasons:

- o Overlooking instruction details,
- o Misinterpreting instructions,
- o Better shop solutions to the situation, and
- o Resistance to changes.

While some of these practices may be detrimental to cost or quality, the majority are not. It is essential, however, in any evaluation of hand deburring to be aware of these differences. At this point (completion of item two in the list of five basic approaches), many of the key problem areas of in-house hand deburring will be evident. The shop foremen, the manufacturing engineers, the inspectors, the methods engineers, and the production workers all can readily recall some of the general and specific problem areas. A shop record of actual deburring time on each part design provides evidence of some areas of improvements. Some of the most revealing aspects of the problem come from those actually doing the deburring. The Appendix to this report contains comments made by several deburring workers in a recent informal survey of one company. The following are some of the more prevalent concerns:

- o Nonavailability of hand tools,
- o Interpersonal relationships,
- o Rumors about status within the company,
- o Inappropriate manufacturing instructions,
- o Lack of expressed interest on the part of engineers,
- o Adequateness of environment, and
- o Availability of accessories.

While dissatisfaction with factors such as these does not necessarily indicate wasted effort, the undertone is symptomatic. Close evaluation of performance over several months will substantiate that some of these do adversely affect performance.

When documentation of problem areas is complete, it is possible to ascertain whether the potential cost of solutions is in line with the potential savings. Despite many advances in deburring, in many situations it is still more economical to live with some or all of the hand deburring in existence. Fortunately, even when this is the case, techniques are available to reduce some of the costs.

Locating solutions to burr problems is easier now than in the past. The recently published book *Deburring Capabilities and Limitations*¹² offers many ideas for specific and general needs. Other publications offer specific suggestions and provide reference information for finding solutions.^{4,6} The following listing provides some solutions to hand deburring problems:

- o Define in-house standards on burrs and deburring;
- o Provide the time and money to truly solve burr related problems;
- o Involve people who are willing to solve the problems;
- o Buy and read the literature;
- o Combine two types of deburring whenever possible;
- o Consider the use of robots;
- o Determine exactly what tools, machines, and processes are available;
- o Copy methods used by others;
- o Provide worker training;
- o Establish multiple grades of deburring classification;
- o Utilize consultants;
- o Farm out portions to job shop deburring facilities;
- o Work with deburring machine vendors;
- o Document results; and
- o Maintain a continuing awareness.

One of the only well-publicized cases of minimizing hand deburring costs was related by The Hamilton Standard Division of United Aircraft Corporation in the 1960's.⁷ They performed an in-depth study similar to that proposed in this paper. After evaluating their approaches and problems, they found they could save 30 percent of their deburring costs by developing a simple in-house approach to defining deburring needs, and by implementing a then new process. Since then others have considered standards that can be utilized.^{3,8-10}

Several large companies have been able to dramatically improve deburring by implementing intensive one year or six month reviews. In almost every case, a portion of this improvement resulted in some form of standardization. Unfortunately, in many cases, the individuals responsible for making the changes were reassigned after this intensive effort resulting in the loss of some of this knowledge.

One of the equipment vendor's continuing complaints is that companies with burr problems send them sample parts for review with unrealistic burrs and no facts about the parts, schedules, or costs. When the vendor notifies them that the parts have been processed and they turn out to be unsatisfactory the inquirer quickly drops the subject.

It is unrealistic to expect wonderful results with a "one-shot" evaluation, no dialogue, unrealistic parts, and no cost involved. Successful solutions to many burr problems require a continuing dialogue with facts. While some vendors have not developed an appreciation for company burr needs, as a result of the extensive recent publications in this field, many vendors have a good understanding of several processes as well as burr formation and minimization.

One author on the subject of minimizing deburring costs recently made the following observation:¹¹

"You will note opposition. Engineers who like to over specify dislike to add burr notes. Machining operators are searching for ways to practice method short cuts, called methods creep. Therefore, they are not interested in adding deburring work. Deburring is beneath their standard. Quality people are reluctant to accept new tasks such as burr control--especially since scientific measurement of burrs is difficult, if not impossible. Purchasing people are undesirous of criticizing vendors whose parts do not meet burr standards. Industrial relations will have strong objection since the reallocation, elimination or new control of the work effort can create grievances."

A personal observation of this author is that "The operator philosophy that large burrs make work for the deburring department must be resisted."

The implication that machine operators don't worry about burr minimization because their friends might be laid off if the burr bench ever caught up is all too real, although seldom mentioned.

Another observer noted that in his company N/C machine operators refused to partially hand deburr parts because once before they had performed the deburring and had generated too large of an edge break. The high expense of these parts convinced them that, despite available time and management wishes, they were not going to repeat that mistake. In this instance a failure to educate workers, and to provide appropriate tools, and the stubbornness of a few individuals, contributed to higher than necessary hand deburring costs.

Miscellaneous Observations

Improving hand deburring is both a technical and an interpersonal problem as indicated by previous comments. It also requires a close analysis of a hodgepodge of types of problems. Consider the following observations:

- o Toothpicks and writing paper have worked on gold parts susceptible to damage.
- o Pareto Principle - 35 percent of rejected part numbers account for 70 to 90 percent of all rejects.
- o A scraper is used for small burrs on long straight edges of 6 in. (152 mm) or more, particularly on aluminum. For bigger burrs use files or sanders.

- o Jitterbug sanders concentrate the action on the outside edges and may not do anything to interior holes.
- o Burr knives and cutters generate more burrs albeit smaller ones.
- o When deburring during machine cycle, in addition to a final hand deburr, there is no way to control how much deburring occurs on machine cycle (breaking edges too much/too little, as well as percent of edges touched).
- o It is frequently cheaper to machine heavy burrs than to hand deburr.
- o Hand deburr operators develop a rhythm for doing deburring. This rhythm may not be the most economical.
- o When deleting illustrations showing where and how to deburr, hand deburr time increases.
- o Layoffs and the associated worker "bumping up and down" has a major effect on deburr quality.
- o It's the little things (tools, instructions, money) that can save so much time and money.
- o Actual hand deburring times are frequently twice the rated standard hour time. Mechanized deburring is closer to 80-90 percent efficient.
- o Defining requirements and approaches on paper can increase quality and the accuracy of time study or rated times.
- o By using a tool to push the burr into a more favorable location you can reduce deburr time.
- o Many vendors don't deburr parts even though the contract specifies it.
- o Picking media from parts can require more time than hand deburring.

This apparently random entry of hand deburring solutions is the actual sequence of observations recorded by one burr watcher over a few months. These are production observations made on a variety of parts, each of which required hand deburring.

The solutions to these types of problems never get published. Someone at a recent deburring conference spent three days listening to authorities on various deburring processes. While traveling home he casually mentioned to another attendee that he increased the life of this deburring files up to five times by the simple addition of chrome flashing. Since he was working on the very tough inconels and related high nickel alloys, this was a significant observation for him, but this simple solution was never mentioned during the conference because he thought it would not be of interest. Unfortunately, too many individuals have assumed their solutions are too basic to warrant any

public notice. At the present time there is not a single basic publication available describing how to hand deburr any feature. This may sound unbelievable and to some it is of little consequence, but consider the following questions, each of which affects deburring costs.

- o When should you use a bur ball or abrasive filled rubber?
- o Should you deburr before or after boring a hole? (On small precision holes do it before to prevent boring bar deflection by heavy work hardened burr; then deburr boring burr.)
- o Is it faster to take a knife and rotate it around a hole, or sand the surface then take a knife around the hole, or rotate a shavit tool around the edge, or sand, ream, and use a bullet?
- o Is it easier to rotate the tool or the part?

There are several problem and expense areas not already discussed:

- o Designing hand tools,
- o Sharpening hand tools,
- o Storing hand tools,
- o Retrieving hand tools, and
- o Maintaining adequate hand tool inventory.

In a large facility of 25 to 100 deburring workers, several hundred dollars can be spent each week keeping up with these items. Some large companies have a \$250,000 inventory of hand deburring tooling and related aids.

The problem of providing appropriate hand tools has been discussed in some of the literature but many of the specific needs have not. For example, there is a need for an adjustable hand tool similar to a potato peeler for working on commercial parts. There is also a need for a piloted bushing that would fit in holes flush to the shoulder with a controlled cutting edge on the outside radius of the shoulder (Figure 1).

In each company, workers have basic concepts of hand tools which would help. In one case it is a tool which grips the part by its internal diameter. In another, it is a pin vise with brass jaws which will not indent marks on small parts. Tools which can deburr 0.30 in. (0.75 mm) holes without generating chamfers larger than 0.002 in. (50.8 μ m) are needed.

In utilizing loose abrasive tumbling processes such as vibratory deburring and barrel tumbling, an operator will eventually face the problem of removing undersized media (rocks) from holes and slots. While this is not deburring, it is similar and time consuming. In removing these rocks (rock picking) or to minimize this problem, it may be necessary to follow some of the following approaches.

Figure 1. Piloted Tool With Adjustable Blade

- o Use different size media,
- o Use soft media which breaks easily,
- o Use limestone which is consumed by acetic acid,
- o Use ultrasonic cleaners to loosen rocks,
- o Use water flushing dental device to loosen rocks,
- o Use ultrasonic plating probes to loosen rocks,
- o Use sewing needles as media,
- o Plug holes prior to tumbling, and
- o Don't use tumbling processes.

SUMMARY

In summarizing the basic thrusts of needs for improving hand deburring it is essential that most of the following factors be implemented:

- o Read the literature,
- o Analyze the costs,

- o Educate the burr people and machinists,
- o Understand burr formation,
- o Practice burr minimization,
- o Develop a cost reduction program, and
- o Pay workers enough to eliminate turnover.

The literature on deburring is well documented now and readily available.^{4,12-16} Costs have been defined in general terms.⁵ Educational needs and approaches have been defined, and the development of burr related cost reduction programs has been defined.⁶ Burr formation and minimization have been described in detail.^{12,17} A number of simple cost reducing approaches have been publicized.¹⁷ Some standard methods engineering considerations have been summarized.¹¹

Despite some major advances in deburring, many needs still exist for industry-wide improvements:

- o Papers defining which hand tools and cutters work best in a given situation;
- o Explanations of why certain tools work best;
- o Defining typical situations for which hand work is least expensive when performed before and after vibratory finishing;
- o Define industry-wide time standards on hand deburring which are based on burr size, location, workpiece material;
- o Develop improved mechanized processes such as microminiature sanders and microminiature laps;
- o Provide operator education;
- o Publish major articles on cost savings incurred by careful investigation of hand operations;
- o Define how burr size affects hand deburring time; and
- o Perform human factors research on how to improve hand operations, particularly those involving microscopes.

Pratt & Whitney's slide-tape presentation "Clean Engines" is an example of one form of training aid that is essential for efficient and effective education of deburring workers and engineers throughout the world. While other deburring topics are under consideration for packaged audio/visual presentations, it is important to not wait for industry to solve a specific company's burr problems, because industry moves relatively slow. In addition, even if it did suddenly provide the total solution to a company's problems, the company would have spent unnecessary deburring dollars for several years waiting for someone else to solve the problem.

REFERENCES

¹L. K. Gillespie, Hand Deburring of Precision Miniature Parts (Topical Report). UNCLASSIFIED. Bendix Kansas City: BDX-613-1443, October, 1975, (Available from NTIS or as SME Paper MRR77-08, 1977).

²T. Droza, "Deburring the Common Cold of Cold of Industry," Production, November, 1977, pp 62-75.

³G. Kerr, Phase I Report - AIAC Deburring Programs. Montreal, Canada, Canadiar Limited, Report RAM-000-121, April, 1977.

⁴L. K. Gillespie, The Burr: A 1977 Report on the Technology of Reducing Its Cost, SME Paper MRR77-11, 1977.

⁵L. K. Gillespie, "What is the Actual Cost of Burrs, Parts I and II," Abrasive Technology, May/June, 1976, pp 4-7. Also published (less reference) as "How to Estimate Your Deburring Costs," Machine and Tool Blue Book, August, 1977, pp 62-68.

⁶L. K. Gillespie, Plantwide Control of Deburring Costs, SME Paper MR77-05, March, 1977.

⁷B. S. Miller, "Control Deburring Quality," Metalworking, November, 1965, pp 40-48.

⁸A. R. Tresselt, An In Plant Standard on Burrs, SME Paper MR77-467, 1977.

⁹Ezra Blount, A Review of Industry and Company Standards for Burrs and Related Edge Conditions, SME Paper MRR77-471, 1977.

¹⁰L. K. Gillespie, An Extension of Proposed Definitions for Burrs and Related Edge Conditions, SME Paper MR77-09, 1977.

¹¹R. L. Golden, Plantwide Consideration in Deburring, SME Paper MR77-427, 1977.

¹²L. K. Gillespie (edited), Deburring Capabilities and Limitations, SME, 1976.

¹³L. K. Gillespie, "Deburring: An Annotated Bibliography," SME Paper (no number), 1974.

¹⁴L. K. Gillespie, "Deburring: An Annotated Bibliography, Volume II," SME Paper MRR75-04, 1975.

¹⁵L. K. Gillespie, "Deburring: An Annotated Bibliography, Volume III," SME Paper MRR76-07, 1976.

¹⁶L. K. Gillespie, "Deburring: An Annotated Bibliography, Volume IV," SME Paper MRR77-04, 1977.

¹⁷L. K. Gillespie, "Economic Tradeoffs in Deburring," SME Paper MRR76-17, 1976.

¹⁸A Guide to Deburring, Deflashing, and Trimming Equipment, Supplies, and Services, SME Bibliography Series Report, 1976.

APPENDIX

COMMENTS OF HAND DEBURRING WORKERS

Subject 1 is a female with 18 years experience using a scope. She is extremely capable and efficient on precision miniature parts.

"We can't get any tools made to hold part by I.D. of hole."

"I have to use a dog nose pin vise to hold the parts and that takes longer on every part."

"The crib continually runs out of the small nylon brushes. Someone should increase the quantities for these brushes."

Subject 2 is a male with 15 years of experience. He began on large parts and spent 10 years on scope work.

"The machinists leave too much burr. They don't change tools often enough. They don't keep sharp tools in the machine."

"Methods engineering pushes machinists to increase feedrates."
(Inference is that this increases burr size.)

"We don't have enough brass jaw pin vises." (Normal pin vises distort and mark precision miniature parts.)

"Methods engineering's time studies and estimates grossly underrate the time required to deburr parts."

"You just can't work 8 hours looking through a microscope."

"You can't take shortcuts on some of these extremely miniature parts with threads."

"We have to ultrasonic clean some parts to see the burrs but "Methods" doesn't include that time in their allowance."

"We get some parts that will be scrapped later because they have scratches or tool marks on them, but we have to deburr them because we don't know what inspection will buy."

"If they would inspect parts for scratches before we deburr we wouldn't waste our time on these parts."

"We deburr the parts as best we can and just ignore our efficiency rating because the foremen don't put any pressure on us for efficiency. They understand the problem."

"No one makes their rated time."

"Yesterday I deburred 18 miniature parts (pieces) that was 40 percent efficiency."

"We finally have some good microscopes."

"The magnification we use on the scope influences our results."
(Some operators can work at higher magnifications.)

"Even our best girls have parts rejected."

Subject 3 is a male who has spent 20 years as an electroplater and has spent 3 months as a deburr operator in sheet metal department. He does some file work and some scope work.

"It would help if they would change the height of the fluorescent light above our table to prevent glare."

"I can't get some of the rotary cutters from the crib that used to be available." (Rotary files, and fine white emery wheels.)

"I would refuse to deburr in the heavy machining area because the noise in there is too high. It's not bad here. That sound enclosure for the vibratory machine helps." (Hand deburr people all work near vibratory finishing equipment.)

"The detail they put on our production travelers (shop work sheets) is good. We don't have to guess what they (Engineering) want."

"Part drawings aren't available in the department any more so I have to walk up front to get a copy any time I have a question."
(Implication - I lose 20 minutes productive work every time I have to get a drawing.)

Subject 4 is a male who has spent 10 years operating vibratory and centrifugal barrel tumbling machinery with hand work to fill in.

"I need a three-fourths-inch water line to get enough flushing action when I wash off parts and media." (One-half-inch water line is available now.)

"We need to put a wall up around the rock area because when I rinse media water splashes onto the slick floor around my area. I almost fell yesterday."

"I need a new oven to dry media and parts. This one doesn't hold the heat even though Maintenance just fixed it."

"The special collars you made for the centrifugal barrels are too high to use." (Barrels were not used for 2 years because of this.)

"The hold down clamps for the special centrifugal barrel lids don't lock in and with the screen in the lid I can't reach under to lock them." (Screen used to keep thin parts from floating out during the cycle.)

"We keep all production traveler sheets for centrifugal barrel tumblers and vibratory machines in our area instead of in the file cabinet with all the other operation sheets. It's not official, but I don't have to go looking in four foremen's file cabinets every time I have a part to run."

"Most operation sheets have the correct information. Occasionally I find an operation which calls out a media but specifies a different media code number."

"I need some pans made so I can lay my arms over the edges without cutting my arm. These plastic pan lids hurt my arms after 5 minutes and they warp easily, too." (The problem is that many parts must be separated by hand from media because of part size/media size ratio.)

"The plastic lid on the sound enclosure is a pain to use. Somebody should redesign it so that it won't crack and will slide freely."

"I need a light above my work table. Now I have to adjust three ring lights to get enough light."

"The girl deburring through the scope says she wants the ceiling light above me turned off because it glares in her scope."

Subject 5 is a female who has 13 years experience using the scope. She is one of the fastest and best workers on scope parts, and is perennially caught in layoffs because of low plant seniority.

"Several of our special design knives are not set up correctly to keep them in the system. When a certain part goes out of production, stores cancels the requirement for that tool." (Engineering needs to make some of these a general use tool, or show them as a requirement against parts having a long production schedule.)

"My foreman says they can't find the blueprint on two of these tools and now he's lost the only tools I have of this design."

"I have our men make me some special tools when I need them. Only one of these men can make what I need when I tell him what I want. I keep the tools in my tool box and they don't have any tool number."

"I can't get any more of these 48100069 tools."

"The new people (hand deburr operators) don't know about the discontinued tools. When I come back from layoff I remember what I used to use and I scrounge around until I find one."

"We need a special classification for deburr people who have to use scope."

"Every time there's a layoff the skilled deburr scope people get bumped out by machinists with more plant seniority."

"Most of these machinists never had to use a scope, they come from a department where they used files and red devils to deburr."

"These people hack up these miniature parts and what isn't scrapped by inspection has to be reworked by someone with experience."

"It takes at least 6 months for a person who is capable to learn how to do scope work right."

"The new people don't get any training; they are given parts and a set of knives and told to deburr."

"The new people don't get any help from anyone in the department."

"The people who can do the deburring get all the rework of those who can't. That's frustrating to get the same pay as someone who can't do the work and have to clean up his mess, too."

"Most of these people who can't do the job don't even know they are not doing it good enough. The foreman gives us the rework and doesn't say anything to the people who hacked them up."

"I hear the company wants to put all burr people in the same classification as the broom men (floor sweepers), oilers, and packaging men. Then they'll have a pool of people they can draw on for any need. Can you image a broom man trying to work under a scope on these parts."

"The bumped-down machinists will leave the bench as soon as they can because of the work and the money."

"We have burr people just waiting for retirement. No one presses them. We get the hard parts, and they get the easy parts for the same pay."

"Some burr people have bad nerves and bad eyes. That limits the parts they can do."

"The minority and the handicapped get away with murder while I have to work my head off."

"I get \$5.51/hour which is \$.50 less than a machinist, but most machinists can't do the burr work that I have to."

Subject 6 is an inspection foreman.

"We get too many parts with burrs." (Quality report shows at least one group of parts rejected every week from this department because of burrs.)

"We get some parts month after month that we reject for burrs because the centrifugal barrel tumbling machine doesn't remove all the burrs and no hand operation is called out." (Apparently responsible engineer is not advised, foreman does rework without notifying engineer.)

"We used to have a lot of parts get into stores with minute burrs on them on two particular assemblies."

"We had to go 100 percent inspection for burrs on all parts which go into these assemblies."

"If we don't see the burrs they are picked up on the precision gages and gouge the next five or six parts."