BDX-613-2112
DISTRIBUTION CATEGORY UC-38

Index Terms

Burrs
Burr Properties
Burr Prevention
Deburring
Flash
Deflashing
Trimming
Metal Removal
Edge Standards

DEBURRING: AN ANNOTATED BIBLIOGRAPHY

VOL. V

LaRoux K. Gillespie
Staff Engineer
Bendix Corporation
Kansas City, Missouri

ABSTRACT

An annotated summary of 204 articles and publications on burrs, burr prevention and deburring.

Thirty-seven deburring processes are listed.

Entries cited include English, Russian, French, Japanese and German language articles. Entries are indexed by deburring processes, author, and language. Indexes also indicate which references discuss equipment and tooling, how to use a process, economics, burr properties, and how to design to minimize burr problems. Research studies are identified as are the materials deburred.

DISCLAIMER

When Eli Whitney originated the concept of mass production, he generated the problem of mass deburring. Today burr and flash removal costs U.S. industry an estimated two billion dollars a year. Despite this high price, industry in general treats deburring as a necessary evil and relies on "art" and tradition rather than science to eliminate it.

The following bibliography is an extension of Deburring: An Annotated Bibliography, Volumes I through IV, which were published the years 1974-1976 by the Society of Manufacturing Engineers. This report represents another of several attempts to make burr removal* as reliable and predictable a science as metal cutting is. The information contained in the references cited will provide the reader with an understanding of burr formation, properties, and mechanics of each deburring process and a general comparison between the capabilities of each process.

The references listed in this bibliography describe one or more of the 37 principal deburring or deflashing processes, the equipment or tooling used, how to use a process, the economics involved, the formation of burrs, or measures taken to prevent burrs. As such, this report covers both burrs and deburring. Many of the deburring processes are also frequently used to improve surface finish, clean, and descale. Only those articles which are directly related to deburring, which contain the words "burr" or "deburring" in the title, or which present significant related data are included in this paper, however. While many articles discuss more than just deburring, the annotated comments in this bibliography essentially describe only the deburring aspects of each article.

A special effort has been made to include articles which define edge standards or edge related effects, since they are directly related to the deburring processes.

The references shown were unearthed in a search of the following documents. The words in parentheses indicate the topics searched in each index.

Engineering Index, 1976; 1977; January-June, 1978 (metal finishing)

Applied Science and Technology Index, 1977; January-June, 1978 (metal finishing)

Metals Abstracts, 1977; January-May, 1978 (deburring, burrs, finishing)

Metal Finishing Abstracts, Vol. 18 (No. 5-6) 19; 20 (No. 1) (finishing, burrs, deburring, vibratory finishing, mechanical treatments)

Scientific Technical and Aerospace Reports, 1977; January-June 1978 (burrs, deburring, surface finishing, metal finishing)

*For brevity, burrs as implied in this introduction includes flash, dross, and allied protrusions. Deburring includes the removal of all these conditions.

International Aerospace Abstracts, 1977; January-June, 1978 (burrs, deburring, metal finishing)

Bibliography of Rubber Literature, 1971 (deflashing, finishing)

Internationale Biblographie der Zeifschriften Literatur, 1977, Part 1 (grat, entgraten)

Library of Congress Catalog - Books: Subjects 1920-1974; (metals-finishing)

Standard U.S. abbreviations are used throughout this bibliography. The following is believed to be a complete listing of these abbreviations.

ASME - American Society of Mechanical Engineers
NTIS - National Technical Information Service
R.Z.M. - Referativnyi Zhurnal-Tekhnologiia Mashinostroeniia
SAE - Society of Automotive Engineers
SME - Society of Manufacturing Engineers

Most of the foreign language articles have not been annotated because a translation was not available. Similarly, few of these entries are included in the indexes at the end of the bibliography.

Copies of 50% of the English language articles listed in this bibliography can be obtained from the library listed below. Probably 50% of the Russian, German, French and Japanese articles are also available from the same source. Repositories of the remaining citations can be identified by the librarians at Linda Hall Library. NTIS reports can be ordered from the address listed below.

Linda Hall Library
5100 Cherry
Kansas City, Missouri 64141

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

The author is indebted to the librarians and staff of Linda Hall Library for their assistance in retrieving the hundreds of magazines which were reviewed. Their courteous and friendly assistance in deciphering some of the requests is gratefully appreciated.

While a conscientious effort was made to include all entries related to burrs and deburring, some significant articles may have been inadvertently overlooked. The author would appreciate notification of any additional publications on the subject of burrs and deburring which do not appear in Volumes I through V of this bibliography.

FORMAT OF BIBLIOGRAPHY

The entries in this bibliography are divided into six major and 37 subheading deburring categories, two categories on burrs, one on designing to minimize burr problems, and one category entitled "Unclassified". Within each of these categories, entries are listed by year of publication, subsequent sub-divisions and alphabetically by author, then title. Articles by anonymous authors are listed before any of known authors. Patents are described if no other published information was available.

The deburring entries listed in the table of contents are for the most part fairly widely accepted and known deburring processes. Barrel tumbling was also once known as barrelling, rattling and tubbing. Harperizing and spindle finishing have also been called gyro finishing. The terms electropolish deburring and electrochemical deburring are used interchangeably by some authors although there is a distinct difference in equipment, tooling and side effects produced. The reader is urged to review articles listed in these last two categories carefully to prevent confusion. Liquid hone deburring involves forcing water and abrasive over burr laden edges. It is a gentle process which does not rely on blasting or impact pressures. The "burr properties" category includes all references which describe such burr properties as length, thickness, shape or hardness. "Burr Prevention" lists articles which describe how to prevent burrs. In general, most of these articles actually describe methods of minimizing burrs. The "Unclassified" category lists articles which were not reviewed or which do not fit in the other classifications.

Each article is indexed by several classifications in addition to those listed above. These indexes, located at the end of this publication, indicate which articles describe equipment and tooling, present formal research results, describe how to use a process, list the workpiece material, present data, or include some economic analysis. Indexes by author and publication language are also included.

The format used in this issue of the bibliography is similar to that used in Volumes III and IV of this bibliography. The processes have been grouped into basic categories of type of removal process. Because of this reformatting process, "H" in this volume and Volume IV is not the same as process "H" in Volumes I or II.

TABLE OF CONTENTS

DEBURRING PROCESSES

ABRASIVE JET DEBURRING

1958

A1. *Finnie, I., "The Mechanism of Erosion of Ductile Metals," ASME Proceedings 3rd U.S. National Congress of Applied Mechanics, 1958, pp. 527-532.

Discussion of the weight change which occurs in blasting operations.

1960

A2. Khruschov, M. M. and M. A. Babichev, "Resistance to Abrasive Wear and Elasticity Modulus of Metals and Alloys," Doklady Akad. Navk SSSR, 131, No. 6, 1960, pp. 1319-1322.

1967

A3. *Finnie, I., J. Wolak and Y. Kabil, "Erosion of Metals by Solid Particles," Journal of Materials, Vol. 2, No. 3, 1967, pp. 682-700.

Excellent summary of blasting effects on part weight change.

1969

A4. Kozyrev, S. P., "Wear of Metals by Hydro-Abrasive Flow," Mashinovedaniye, Vol. 6, 1969, pp. 106-112.

1971

A5. Ascarelli, P., "Relation Between the Erosion by Solid Particles and the Physical Properties of Metals," U.S. Army Materials Res. Center Tech. Report 71-47, 1971.

1972

A6. *Sheldon, G. L. and Ashak Kanhere, "An Investigation of Impingement Erosion Using Single Particles," Wear, Vol. 21, 1972, pp. 195-209.

Describes the basic equation relating stock loss (by weight) to blasting parameters.

1974

A7. *Handbook of Blast Cleaning Abrasive Performance, Bulletin 904-D, Wheelabrator-Frye, Inc., Mishawaka, Indiana, circa 1974.

Fine but brief technical guide to the use of steel blasting media.

1975

A8. *Hutchings, I. M., "Prediction of the Resistance of Metals to Erosion by Solid Particles," Wear, Vol. 35, 1975, pp. 371-374.

Author describes volume wear from blasting with quartz and SiC particles. Wear is proportional to the heat capacity per unit volume and the part temperature.

A9. Sorokin, G. M., "Influence of the Mechanical Properties of Steel on Its Resistance to Abrasive Wear," Russian Engineering Journal, Vol. 55, No. 5, 1975, pp. 31-34.

1976

A10. *Sheldon, G. L., "Effects of Surface Hardness and Other Material Properties on Erosive Wear of Metals by Solid Particles," ASME Paper 76-WA/MAT-8, 1976.

Describes stock loss of pure metals due to abrasive blasting with 60 mesh silicon carbide abrasive.

1977

A11. "Are Burrs Leaving You Out in the Cold?" Production Engineering, October, 1977, p. 12.

Brief description of national burr costs and the improvement of deburring costs by blasting large ring gears.

A12. "Blasted Burrs," Production, November, 1977, p. 53.

Describes one approach to blasting burrs off large gears.

A13. *"High Pressure Blasting Picks Off Burrs," Iron Age, Vol. 220, November 7, 1977, p. 63.

Miniature blasting jet removes burrs from precision miniature parts.

A14. Cavalier, Jerry, Jr., "Micro-Deburring Swiss Machine Parts," Tooling & Production, November, 1977, pp. 96-97.

The use of miniature abrasive blasting units removes burrs from small parts. Up to 500 parts can be deburred using only one pound of miniature glass beads.

A15. Papshev, D. D., et. al., "Increasing the Fatigue Strength of Titanium Alloy Components by Hydraulic Shot-Peening and Vibratory Barrel Finishing," Russian Engineering Journal, Vol. 57, No. 4, 1977, pp. 41-42.

A16. Weightman, Neil, "Cost Considerations in Micro Abrasive Blasting," SME Paper MR77-448, 1977.

Presents a number of deburring applications for micro abrasive blasting.

1978

A17. Zecher, Robert, "Advantages of Pressure Type Blasting Systems for Deflashing and Deburring Plastics," SME Paper MR78-327, 1978.

Describes machine design of blasting unit as well as technical and economic considerations for abrasive jet deburring.

ABRASIVE FLOW DEBURRING

1977

B1. *Borchers, Julius, "Production Research Observations on Abrasive Flow Deburring," SME Paper MR77-438, 1977.

A well done study of effects of abrasive flow deburring parameters on hole size, radius, and surface finish.

B2. Hersey, Avon H., "Abrasive Flow Bites the Burr," Tooling and Production, March, 1977, pp. 70-71.

General summary of abrasive flow deburring. Article indicates stock loss can be held to 0.0002 inch.

B3. *Miyatani, Takashi, Jungi Nakata, Tameyasu Tsukada, and Koya Takazawa, "Influence of Finishing Conditions on Work Accuracy by Extrude Hone Process," SME Paper MR77-437, 1977.

Experimental study of extrude hone deburring parameters on stock removal and surface roughness.

B4. Moulton, Thomas Otto, "Try Abrasive Flow Machining for Deburring, Polishing, Relieving, Blending," Machine and Tool Blue Book, April, 1977, pp. 88-90.

General summary of abrasive flow deburring in precision industry.

LOOSE ABRASIVE PROCESSES

1977

D1. *Barrel Finishing Manual, Shikishima Tipton Mfg. Co., Ltd., Nagoya, Japan (in English), circa 1977.

Presents an excellent and in-depth overview of the development of mass finishing and their capabilities. This brief publication (24 pages) is the best single source of information available on capabilities of at least one manufacturer's products.

BARREL TUMBLING

1959

D2. Matsunaga, M., Barrel Finishing, 1959, (in Japanese).

1970

D3. Jansen, A., "Flash Removal from Rubber or Plastics Articles by Tumbling," Great Britain Patent 1211089, November 4, 1970.

1976

D4. Bacquias, G., "Barrel Finishing Practice," Galvano-Organo (Paris), 1976, Vol. 45, No. 468, pp. 774-776.

1977

D5. "Flashing, When Frozen, Flees," Production Engineering, May, 1977, p. 81.

Brief shop hint repeats the widely used fact that freezing rubber parts assists deflashing.

D6. "Management and the Control of the Costs of Deburring," Finishing Highlights, November/December, 1977, pp. 53-56.

Presents a general commentary on deburring costs and some of the factors management needs to consider to control these costs.

D7. Luciani, C., "Practical Barrel Finishing," Trattamenti e Finitura, 1977, Vol. 17, No. 5, pp. 45-53.

Review of barrel finishing and burnishing and a vibratory finishing plant.

CENTRIFUGAL BARREL TUMBLING

1976

D8. Hinz, H. E., "The Centrifugal Machine as Honing Tool," Galvanotechnik (Saulgau), Vol. 67, No. 3, 1976, pp. 225-231.

Centrifugal barrel tumbling uses are described.

1977

D9. "Centrifugal Barrel Deburring," Tooling & Production, May, 1977, pp. 108-109.

Harperizing coil springs improves fatigue life.

D10. "Harper Develops Deburring System for Miniature Parts," Precision Metal, May, 1977, p. 36.

Brief note indicates centrifugal barrel machine performs deburring on precision miniature parts. Unfortunately, someone made several errors in the quantitative information presented.

D11. "PF Industry News," Products Finishing, October, 1977, pp 160.

Very brief mention of one company's use of centrifugal barrel finishing.

D12. *Gillespie, LaRoux K., and C. E. Roebuck, "Size Effects in Centrifugal Barrel Finishing," SME Paper MRR77-07, 1977.

Presents graphical and mathematical relationships for determining the stock loss and radius produced in centrifugal barrel finishing. The effect of burr size is also presented in mathematical form for 303 Se stainless steel burrs.

D13. *Kobayashi, H., F. Kobayashi, Jr., and M. Matsunaga, "Deburring and Finishing by Recipro-Finishing and Gyro-Finishing Machines," SME Paper MR77-464, 1977.

Describes gyro-finishing and recipro-finishing processes and their effect on burr size, edge radiusing, and surface finish.

1978

D14. "Deburring System Improves Product Quality," Modern Machine Shop, July, 1978, p. 82.

Harperizer is used to finish textile parts.

MAGNETIC LOOSE ABRASIVE DEBURRING

1975

D15. "Magnetic Abrasive Deburring," Manufacturing Engineering, August, 1977, p. 37.

Brief paragraph notes that magnetic abrasive deburring was effective in removing fine burrs.

D16. Ryzhov, E. V., and V. M. Panchenko, "Surface Quality after Magnetic-Abrasive Machining," Tr. Altaisk. Politekhn. In-Ta, 1975, No. 50, pp. 11-17. (See R. Zh. Mash., 1976, 8A83) (in Russian).

Describes process operation of magnetic abrasive process and the effect of the process on surface roughness.

SPINDLE FINISHING

1960

D17. Takeyama, E., Jitensha-Seisan-Gijutsu, No. 72, 1960, p. 3 (in Japanese).

Results of spindle finishing unit.

1977

D18. "Spindle Deburring Machine," Metalfax, November, 1977, p. 84.

Brief description of a spindle finishing machine.

1978

D19. Barash, M., "Production Technology Abroad," Manufacturing Engineering, April, 1978, p. 37.

Translation of Vestnik Mashnostroyeniya, Vol. 57, No. 8, 1977, pp. 68-70. Describes a spindle finishing application in which media is "fluidized" by means of a layer of compressed air. Emphasis is on surface finish improvement.

VIBRATORY DEBURRING

1969

D20. Radtke, Shrade Fred, Vibratory Finishing and Cost Analysis of Zinc Die Castings, Paris, 1969, 9 pages, Library of Congress Number 7S 239.R33 (available from U.S. Library of Congress).

1970

D21. "Deflashing Rubber or Plastics Molding with Carbon Dioxide," Caucho (Madrid), No. 244, September, 1970, pp. 33-35.

1971

D22. "Deflashing with Nitrogen," Plastics Rubber Weekly, No. 395, September 10, 1971, p. 53.

Liquid nitrogen machine is used in vibratory machine to deflash parts.

1975

D23. Bychkova, A. V., A. S. Grachev, M. B. Zhitonirskii, V. G. Kulakov, V. S. Kutyakov, and N. G. Usankin, "Experimental Study of Polishing and Glazing with Vibrational Equipment," Materialy 1-i Vses. Nauch.-tekhn. Konf. 'Soversh. Profsessov. Finish. Obrabotki V. Mashinostr.', Vysheish Shkola Press, Minsk, 1975, pp. 153-156 (see R. Zh. Mash., 1976, 3B623) (in Russian).

Presents effects of ball burnishing tests on surface finish.

1976

D24. American Machinist Basic Machining Series, Course V, published by American Machinist Magazine, 1976.

This self-teaching course has some rudimentary information about deburring processes.

D25. "Cryogenic Deflashing of Zinc Parts," Die Casting Engineer, September-October, 1976, Vol. 20, No. 5, pp. 34-35.

Zinc parts are vibrated at -129°C for 20 minutes. Article describes the parameters one must consider in the use of this process.

D26. How to Burnish, Polish, Grind and Pulverize with Steel Media, brochure by Superior Ball Company, Hartford, Connecticut, circa 1976.

Basic discussion of the use of metal forms for tumbling type processes.

D27. "Vibratory Finishing Machines," Metal Finishing Plant and Processes, Vol. 12, No. 6, November/December, 1976, pp. 178-185.

Contains a summary of the vibratory deburring machines offered by 21 American and European manufacturers.

D28. *Babichev, A. P., et. al., "Structure of the Working Cycle in Vibro-Abrasive Machining," Vestnik Mashinostroeniya, No. 4, 1976, pp. 39-40 (in Russian); English translation in Russian Engineering Journal, Vol. 58, No. 4, 1976, pp. 35-36.

Presents research results of vibratory finishing.

D29. Falkenberg, H., "Mechanical Pretreatment of Bulk and Individual Articles," Galvanotechnik (Saulgau), 1976, Vol. 67, No. 8, pp. 651-657.

Discusses barrel tumbling and vibratory operations before electroplating.

D30. Funke, D., "New Knowledge on Barrel Finishing," Galvanotechnik (Saulgau), 1976, Vol. 67, No. 7, pp. 579-581.

D31. Glazkov, V. A., "Selection of Filler for Vibratory-Finishing Halves of Bearing Cages," Russian Engineering Journal, Vol. 56, No. 11, 1976, p. 60.

D32. Hothersall, G. L., "Vibratory Finishing," Product Finishing (London), 1976, Vol. 29, No. 11, pp. 10-12, 14.

Provides a review of actions in precision barrelling, and media separation.

D33. *Lyalikova, N. T., and N. A. Erofeev, "Change in Microhardness of Metal Surface Layers after Vibroabrasive Machining," Isv. Toms K. Politekhn. in-ta, 1976, N.209, pp. 183-184 (see R. Zh. Mash., 1976, 12B589) (in Russian).

Research shows part hardness increases after vibratory finishing operations.

D34. Marechal, M., "Mechanical-Chemical Vibratory Finishes," Surfaces (Paris), 1976, No. 105, pp. 45-50.

Presents a review of vibratory equipment and methods.

D35. *Wolfhard, D., "Entgraten durch Strahlen und Tauchlappen," Metalloberflache, Vol. 30, No. 3, 1976, pp. 107-114.

Presents a summary of information presented at Fachtagung Entgraten '75 in Stuttgart, Germany, November, 1975. Blasting, tumbling, and spindle finishing are described and an extensive discussion of burr properties is given.

1977

D36. "Which Compound and Why," Products Finishing, September, 1977, pp. 60-66.

General article on selection and application of tumbling abrasive compounds.

D37. Arrman, R., "Barrels, Vibrators, Chips Compounds," Galvanoteknisk Tids. (Oslo), 1977, Vol. 20, No. 3, pp. 10, 12, 13, 19-22.

D38. *Gillespie, LaRoux K. and Arnold Monteiro, "Deburring Case Histories," SME Paper MRR77-06, 1977.

Five case histories of burrs are described to illustrate the rationale for attacking burr problems and to more fully define the limitations of some processes. These case histories emphasize tool design, side effects of deburring, deburring capabilities, machining sequences, hand tools and deburring of Teflon.

D39. Hinz, H. E., "Honing, Barrel Finishing, Vibrators, and Centrifugal Polishing," Galvanotechnik (Saulgau), 1977, Vol. 68, No. 6, pp. 511-516.

Describes the choices one has to make in selecting appropriate processes and parameters.

D40. *Johannesen, R. W., "The Total Deburring Cost," SME Paper MR77-132, 1977.

This paper emphasizes the in-depth analysis required to lower total deburring costs. Items which significantly influence cost in loose abrasive operations are described.

D41. *Kittredge, John B., "The Testing of Vibratory Finishing Media," SME Paper MR77-466, 1977.

Presents an excellent summary of the considerations which must be made when evaluating wear of tumbling medias. Formulas and empirical data are presented to illustrate the comments.

D42. Kobayashi, H., and F. Kobayashi, Jr., "Deburring and Finishing by Vibratory Barrel and Centrifugal Barrel," SME Paper MR77-428, 1977.

D43. Marechal, A., "Vibrators: Evolution of Material as a Function of Application and Utilization," Surfaces (Paris), 1977, No. 112, pp. 69, 72-74, 77.

Provides a review of vibratory finishing equipment, their operation and efficiency.

D44. *Nelson, J. R., "Cryogenic Deflashing of Plastic, Rubber, and Zinc Die Cast Parts," SME Paper MR77-445.

Describes the use of cryogenic tumbling processes on plastic, rubber and zinc parts.

D45. Papshev, D. D., et. al., "Finishing and Strengthening Parts Made of Hardened Steel by Diamond Burnishing and by Ball Burnishing," Russian Engineering Journal, Vol. 57, No. 3, 1977, pp. 38-41.

D46. *Sofronas, Anthony, "Vibratory Finishing Processes," Bendix Research Labs Report BRL/TR-77-8515, 1977.

An empirical analysis of part material and machine effects on burr size reduction, edge radiusing, and surface finish.

D47. Sondermann, Jorg, "Roto-Finish Mechanical Surface Finishing," Metallges. Rev. Act., 1977, Vol. 19, pp. 40-43.

Describes applications for vibratory finishing.

D48. *Southorn, Malcolm, "New Process--High Energy Finishing," SME Paper MR77-463, 1977.

Describes the osronaut version of vibratory finishing.

D49. *Young, Susan E., "Management Decisions in 1978," Precision Metal, November, 1977, pp. 33-49.

Presents survey results estimating numbers of machines and expendable supplies used in die casting, forging, and other related industries.

1978

D50. *"Correction," Machine and Tool Blue Book, July, 1978, p. 116.

Editor notes correct term in equation for vibratory economics for article which appeared in May magazine issue.

D51. *Gillespie, LaRoux K., "How to Analyze Vibratory Deburring Costs," Machine and Tool Blue Book, May, 1978, pp. 108-114.

Presents method for making an economic analysis of vibratory finishing. The principal equation shown, however, is not correct as printed.

SANDING

1977

E1. "Abrasive Belt Slag Grinder Attacks Production Bottleneck," Production, May, 1977, pp. 90-91.

Sanding machine removes torch cut slag from steel plates.

E2. *Claus, Joseph J. and Steven J. Kotula, "The Characterization and Removal of Burrs with Three-Dimensional Abrasives," SME Paper MR77-426.

Excellent summary of research performed on deburring by three-dimensional type abrasive wheels.

E3. Eckstein, Myron, "Abrasive Belt Machining Breaks Production Bottleneck," Machine and Tool Blue Book, December, 1977, pp. 84-87.

Slag from flame cutting is removed by belt sanding machine. Slag projects up to 1/8 inch above the part surface.

E4. Schuster, T. G., "Use of Widebelt Conveyorized Machining for Deburring and Surface Conditioning," SME Paper MR77-433, 1977.

Basic discussion of wide belt sanders and the factors which affect the surface finish on parts.

MECHANICAL DEBURRING

1971

F1. Sparrow, T. A., "Group Technology in the Soviet Foundry Industry," CREES Report, University of Birmingham, England, September, 1971.

Describes the use of Group Technology in a Soviet foundry performing fettling, trimming and piercing.

1977

F2. "Keeping Current: Components," Production Engineering, January, 1977, p. 84.

Router cutter is briefly described. This cutter has helix which cuts down from the top of a stack of parts and upward from the bottom of the stack.

F3. Boretskii, V. G., "Calculation of Internal Deburring Machine with High Speed Reciprocating Pneumatic Drive," Izv. Vyssh. Vchebn. Zaved Neft GAZ, n. 10, 1977, pp. 105-111 (in Russian).

Impact action device removes weld splatter from inside pipe. Article focuses on analytical analysis of device.

F4. Gazan, George A., "How to Make a Good Hole Better," SME Paper MR77-461, 1977.

Brief mention of the fact that ballizing can be used to remove large roll-over burrs.

F5. Reed, Walter J., "Presses Shave Flash Removal Cost from Steel and Malleable Castings," Machine and Tool Blue Book, April, 1977, pp. 82-87.

General summary of the machine requirements for trimming riser remnants from steel and malleable castings.

F6. Reinertson, Jerry, "Burrs--Chamfers--Cost," SME Paper MR77-456, 1977.

Describes the Reishaver contour chamfering machine.

F7. *Weichbrodt, Bjorn and Lennart Beckman, "Some Special Applications for ASEA Robots - Deburring of Metal Parts in Production," SME Paper MS77-736, 1977.

Describes use of robots for deburring.

1978

F8. "High Speed Cartridge Trimming," Manufacturing Engineering, Vol. 80, No. 2, February, 1978, p. 52.

Brief summary of use of high speed spindles to trim ammunition cartridges.

F9. "SME Sampler," Manufacturing Engineering, April, 1978, p. 105.

Presents a brief summary of a published paper on deburring by robots.

F10. Gillespie, LaRoux K., "Mechanized Deburring Machines--There's One for Every Need," Machine and Tool Blue Book, June, 1978, pp. 106-113.

Provides a general overview of the variety of mechanized equipment available for deburring. This is one of the few articles which cover the majority of machines in this category.

F11. Hoglund, Nils, "Selective Mechanical Contour Deburring," SME Paper MR78-328, 1978.

Describes design and use of mechanized mechanical deburring unit.

F12. Karlin, Beth, "Robots, N/C Said Answer to Deburring Quality Needs," American Metal Market/Metalworking News, June 19, 1978, p. 12.

Article highlights the fact that robots and N/C ECD offer promise for better deburring.

HAND DEBURRING

1950

G1. Mundel, Marvin E., Motion and Time Study, Prentice Hall, New York, 1950.

Presents an example of an improvement in hand deburring methods.

1954

G2. Hadden, Arthur A. and Victor K. Genger, Handbook of Standard Time Data, Ronald Press, New York, 1954, pp. 187-188, 242, 428, 459.

Presents standard data for estimating deburring time for simple conditions.

1958

G3. Barnes, Ralph M., Motion and Time Study, 4th Ed., John Wiley & Sons, 1958, p. 263.

Presents an example of a fixture used to speed hand deburring.

1978

G4. *Gillespie, LaRoux K., R. W. Johannesen and Jack L. McMillen, "Hand Deburring: A Necessity That Can Be Improved," SME Paper MRR78-03, 1978.

Presents an in-depth analysis of hand deburring problems and how they can be improved.

BRUSH DEBURRING

1976

H1. O'Keefe, John, "Power Brushes Present Efficient Method of Deburring Wide Variety of Material Surfaces," Canadian Machinery & Metalworking, Vol. 87, No. 11, November, 1976, pp. 36-37.

H2. Rands, Steve, The Use of Industrial Brushes, brochure by Brush Research Mfg. Co., Los Angeles, California, circa 1976.

Presents a running commentary on brushes and appropriate usage. While basically a sales brochure, the information contained is more complete than typically found.

1977

H3. "Automatic Abrasive Brush Deburring," Manufacturing Engineering, May, 1977, p. 56.

Abrasive impregnated nylon and polypropylene brushes remove tough burrs from heat treated gray iron.

H4. *Gang, Lutz-Achim and Thomas Wagner, "Systematik zur Optimalen Auswahl Geeigneter Entgratanlagen," Maschinenmarkt Wurzburg, Vol. 83, Number 41, 1977, pp. 785-789.

Excellent basic discussion on the systematic approach to solving burr problems.

THERMAL ENERGY METHOD

1976

J1. Muller, M. and T. Wagner, "Thermisch Chemisches Entgraten-Grenzen des ver fahrens und Entwicklungstenden Zen," Maschinenmarkt, Wurzburg, Vol. 82, No. 42, 1976, p. 747.

1977

J2. "Machining Update," Production, February, 1977, p. 41.

Brief summary of the actual burr removal mechanism in the Surf Tran process.

J3. "Principles of Thermal Energy Deburring," Industrial Heat, June, 1977, pp. 24-25.

J4. "Thermal Deburring," Design News, May 16, 1977, p. 20.

Very brief comment about performance of TEM deburring.

J5. "Thermal Deburring," Manufacturing Engineering, May, 1977, p. 11.

Very brief example of use of TEM deburring for removing zinc die casting flash.

J6. "Thermal Method for Deburring," Tooling & Production, June, 1977, p. 142.

Fluid drive components are deburred by TEM process.

J7. *Montag, A. C., "Thermally Deburring External and Internal Burrs on Delicate Parts," SME Paper MR77-447, 1977.

Describes use of TEM deburring method on more delicate parts than previously possible.

J8. "What Happens to Burrs in Thermal Energy Deburring?" Cutting Tool Engineering, March/April, 1977, p. 14.

Presents pictures and text illustrating how burrs are ignited in the thermal energy deburring method.

1978

J9. "Decontamination by Thermal Deburring," American Machinist, April, 1978, p. 59.

Thermal energy method is used to "clean" off metal particles from hard-to-reach areas of parts.

CHEMICAL DEBURRING

1976

M1. "New Chemical Polishing Process for Stainless Steel," Stainless Steel Industries, March, 1976, p. 20.

ELECTROCHEMICAL DEBURRING

1968

Q1. *Schnell, G., "Elysier-Formentgraten," Werkstattstechnik, Vol. 58, No. 4, 1968.

Describes equipment and applications of EC deburring.

1970

Q2. *Mauz, W., "Anlagen fur das Elektrochemische Formentgraten," VDI-Berichte, No. 159, 1970, pp. 113-117 (in German).

Describes EC deburring machines and some applications.

1976

Q3. Zientara, A., "Electrochemical Deburring of Gears," Mechanik, 1975, Vol. 48, No. 11, pp. 580-583 (see R. Zh. Mash., 1976, 6B168) (in Russian).

1977

Q4. *Mercer, Tom, "Chemical and Electrochemical Deburring," SME Paper MR77-452, 1977.

Presents several excellent case histories of ECD.

Q5. Merritt, Bob, "ECD Contours," SME Paper MR77-449, 1977.

Presents some examples of edge quality produced by ECD as well as some features of parts which can be produced by ECD.

Q6. Miller, Jerome, "Electrochemical Deburring," SME Paper MR77-470, 1977.

Describes tooling used in ECD, types of burrs which can be deburred as well as basic ECD requirements.

Q7. Schein, Henry, "Electrochemical Deburring," SME Paper MR77-451, 1977.

Basic discussion of ECD machine design and ECD.

1978

Q8. Kellock, Brian, "ECM Takes the Edge Off Deburring Problems," Machinery and Production Engineering, Vol. 132, No. 3398, February 15, 1978, pp. 39-40.

EC deburring reduces deburring from 40 hours to 8 hours on aluminum aircraft fuel component.

Q9. *Reed, Walter J., "Electrical Machining: Five Types You Can Use," Machine and Tool Blue Book, April, 1978, pp. 98-109.

Basic discussion of electrochemical processes includes deburring. A list of equipment manufacturers and their estimate of part capabilities for at least one of their existing machines is given.

Q10. Schaaf, Henry A., "Save Production Time, Money with New ECD Process," Machine and Tool Blue Book, April, 1978, pp. 113-117.

New ECD machine utilizes universal tooling. Basic elements of ECD are explained.

Q11. Swarup, Sanjay, "Electrochemical Deburring: A Perspective View," SME Paper MR78-251, 1978.

ECD operation, advantages and limitations are described.

Q12. Van Cleave, David A., "ECD Fights the Costly Burr," Iron Age, March 13, 1978, pp. 59-61.

Brief review of ECD and general trends relating to ECD.

ELECTROPOLISH DEBURRING

1977

R1. Bendt, K., "Electropolishing Instead of Mechanical Polishing," Galvanotechnik (Saulgau), 1977, Vol. 68, No. 10, pp. 887-892.

Includes some comments on electropolishing influences on deburring.

R2. Wood, Nat, "Tools Last Longer After Electrolytic Honing," Machine and Tool Blue Book, October, 1977, pp. 94-96.

Electropolishing removes tool grinding burrs and feather edges.

R3. *Zerweck, Klaus, "Optimizing Process Parameters in Electropolish Deburring," SME Paper MR77-450, 1977.

Describes the effect of electropolishing on burr removal and stock loss. Factors which influence throwing power are also discussed.

MULTIPLE PROCESSES

1976

U1. *Gang, L. A., T. Wagner, and G. Weiler, Studie Entgraten, Institut fur Produktionstechnik und Automatisierung Report, University of Stuttgart, Stuttgart, Germany, 1976, 125 pages.

Presents the initial results of a major study to develop computerized selection of deburring processes. A new method of defining edge quality is presented, an in-depth presentation of burr measurement techniques is given, a number of typical burr sizes in different materials and processes is given, and the effect of workpiece geometry on burr size and removal is briefly discussed. The operation of a number of deburring processes is given with supporting data on effectiveness. The computer grid for describing deburring capabilities is also presented as is a plan for additional work.

U2. *Gillespie, L. K., "Annihilating the Burr," SME Paper MRR76-14, 1976.

This 40-page report summarizes in table format the status of burr technology in 1976. It describes the capabilities of 37 deburring processes, describes the status of available equipment, techniques for minimizing and preventing burrs, designing to accommodate burrs, standards for edge conditions, techniques for predicting burr size, plant-wide approaches for cost reduction and evaluating economics. Thirty-nine references and 14 tables are included. This is one of the most complete summaries of the status of burr technology available in 1976.

U3. *Weiler, G. G. and J. Mann, "A Forgotten Operation: Deburring," Galvanotechnik (Saulgau), 1976, Vol. 67, No. 5, pp. 403-405.

Reports on a Stuttgart meeting in 1975 on the subject of deburring.

1977

U4. *"Burr" (Chapter 6) in Machining Technique-Data File, Mechanical Industry Promotion Association, Tokyo, Japan, (in Japanese), April, 1977.

Presents a relatively complete yet concise account of burr formation and deburring processes.

U5. "SME Deburring Conference and Expo," Products Finishing, May, 1977, pp. 92-95.

Highlights of upcoming deburring conference.

U6. *Bellows, Guy, "Deburring: A Finishing Checklist," SME Paper MR77-440, 1977.

Provides a convenient checklist of deburring processes by type of energy used to remove burrs.

U7. *Drozda, Tom, "Deburring: The Common Cold of Industry," Production, November, 1977, pp. 62-75.

Excellent summary of the status of deburring today. Article includes summary of process capabilities as well as survey results on economics and general status of deburring efforts.

U8. *Gillespie, L. K., "Deburring: An Annotated Bibliography, Vol. IV," SME Paper MRR77-04, 1977.

This annotated bibliography lists 148 articles and reports on burrs, burr prevention, and deburring. Entries are indexed by type of process and 14 other categories. Publication language and author indexes are also included.

U9. Gillespie, LaRoux K., Effects of Deburring Contaminants on Electroplating Adhesion, Bendix Kansas City Division Report, BDX-613-1757, April, 1977.

Describes the varied side effects caused by deburring processes. Concentrates on those related to plating processes.

U10. Gillespie, LaRoux K., "How to Estimate Your Deburring Costs," Machine Tool Blue Book, August, 1977, pp. 62-68.

Defines equations which can be used to predict deburring costs as well as cost elements associated with deburring.

U11. Gillespie, L. K, and Raymond Goldstein, "Needed Research on Burrs and Deburring," SME Paper MRR77-14, 1977.

Describes 41 needed research areas in deburring.

U12. *Gillespie, LaRoux K.,"Side Effects of Deburring Processes," SME Paper MRR77-17, 1977.

Describes how each deburring process affects such part characteristics as stresses, surface finish, contamination, cleaning, elastic limit, and size.

U13. *Gillespie, LaRoux K., "The Burr: A 1977 Report on the Technology of Reducing Its Cost," SME Paper MRR77-11, 1977.

This extensive summary presents 11 tables defining the capabilities of the 37 major deburring processes. In addition, a summary of recent improvements in each process is cited. Future needs are defined and a summary of process operations is given for recipro-finishing, flow finishing, hot wire deburring, orboresonant deburring, and EDM deburring. The major sources of burr-related literature are identified as are the sponsors of 20 recent conferences on this subject. One hundred and six references are given.

U14. Golden, Richard L., "Plant Wide Consideration in Deburring," SME Paper MR77-427, 1977.

Presents some basic methods engineering solutions to deburring problems

U15. *Kerr, Gordon, Phase I Report - AIAC Deburring Program, Canadair Limited, Report #RAM-000-121, Montreal, Canada, April, 1977. (Available from Technical Information Service, National Research Council of Canada, Ottawa, Canada, K1A 033).

This 114 page report summarizes the status of burr-related knowledge in the U.S. and in Canada. It defines a number of standards and costs found in the airframe industry as well as other aerospace industries. A 202-entry bibliography is included.

1978

U16. Finishing Highlights 1977-1978 Finishing Industry Yellow Pages, Spec Tech Publications, Inc., Oxnard, California.

This new directory lists 205 pages of finishing equipment vendor information and product information.

U17. "Trends in Deburring," Tooling & Production, May, 1978, pp. 84-89.

This extensive article summarizes an extensive report on deburring tradeoffs. Article also focuses attention on special processes or tools for deburring.

U18. *Gang, Lutz-Achim and Thomas Wagner, "Entgraten Lagen Zum Bearbeiten der Gesamten Oberflache," Maschinenmarkt, Wurzburg, Vol. 84, No. 26, 1978, pp. 467-471.

Presents a summary of the major deburring processes in use today.

BURR FORMATION AND PROPERTIES

1971

V1. *Pekelharing, A. J. and C. A. Gieszen, "Material Side Flow in Finish Turning," Annals of the CIRP, Vol. 20, No. 1, 1971, p. 21.

Excellent but brief summary of research on burrs formed by side flow.

1976

V2. King, R. I. and J. G. McDonald, "Product Design Implications of New High-Speed Milling Techniques," ASME Paper 76-DE-22, 1976.

Authors briefly note that drilling aluminum sheet stock at high speeds can reduce deburring costs by 80 percent. A small burr occurs on the hole entrance side while the exit side is "clean".

1977

V3. *Advanced Multilayer Drilling, Rockwell International Los Angeles Division Report AFML-TR-77-124, Part I, published July, 1977, for Air Force Materials Laboratory.

Extensive study of drilling stacks of various metals also lists burr dimensions produced.

V4. A Manual of Processes for the Abrasive Cut-Machining of Metals, Wallace Supplies Mfg. Co., Chicago, Illinois, circa 1977.

Comments on burrs formed in abrasive cut-off operations.

V5. *Gillespie, LaRoux K., "Estimating the Size of Cutoff Projections," SME Paper MRR77-01, 1977.

The cutoff projection left when cutting off lathe parts is analyzed and compared to empirical data. The equations developed are in close agreement with the thickness of cutoff projection actually measured.

V6. *Gillespie, LaRoux K., The Burrs Produced by Turning, Bendix Kansas City Division Report BDX-613-1748, March, 1977 (available from NTIS).

This 79-page report explains the formation of burrs in turning operations and presents the results of two major empirical studies of effects of machining conditions on burr properties. The implications of these results are also described.

V7. Powell, Harold, "Troubleshooting Abrasive Cutoff Wheels," Modern Machine Shop, March, 1977, pp. 94-98.

Author briefly notes that excessive burrs in abrasive cutoff operations may be the result of too coarse an abrasive grain. Parts should also be clamped securely to eliminate motion during break-thru.

1978

V8. *Gillespie, LaRoux K., "All About Burrs--Part 1: Minimizing Burr Costs," Machine and Tool Blue Book, March, 1978, pp. 116-127.

Presents a brief discussion of burr formation factors which influence burr size and a summary of standards relating to burrs.

V9. Kahng, C. H. and D. K. Tyler, "High Speed Drilling of Aluminum Alloy," SME Paper MR78-282, 1978.

This paper illustrates the effect of high speeds on drilling torque, thrust, burrs and edge quality.

V10. Smith, Leonard J., "Fundamentals of High-Speed External Broaching," Cutting Tool Engineering, March/April, 1978, pp. 4-8.

Article comments on broaching briefly indicates that provided the part exit edge angle is greater than 90 degrees burrs will be small.

V11. Wagner, Thomas, "Auswahl Geeigneter Verfahren und Anlagen zum Entgraten von Teilen aus Kleinund Grosssenien-fertigungen," VDI-Gesellschaft Produktionstechnik (ADB), Vortrag am 14.3.1978.

Presents some basic information on West German research on burrs and deburring.

BURR PREVENTION AND MINIMIZATION

1958

W1. *Maeda, T., "Reciprocating Blanking Method," Science of Machine, Vol. 10, No. 1, 1958, pp. 140-144 (in Japanese).

Describes results of opposed ram punch presses on edge quality. This approach prevents burrs from forming.

1974

W2. Kondo, K., et. al., "Application of Opposed Dies Shearing Process," Proceedings of the International Conference on Production Engineering, Part I, (Tokyo) 1974, p. 251.

1975

W3. *Makino, I., "Burr-Free Shearing Process," Press Technique, Vol. 13, No. 5, 1975, p. 93 (in Japanese).

1976

W4. Schaefer, F., "Low-Burr Design and Manufacturing," Werkstattstechnik, December, 1976, pp. 701-704.

W5. Schaefer, Friedrich, "No Burr Design and Production," WTZ Ind. Fertigung, Vol. 66, No. 12, December, 1976, pp. 701-704.

1977

W6. "Burrless Routing," Manufacturing Engineering, May, 1977, pp. 13-14.

Brief description of router cutter which minimizes burrs on profiled printed circuit boards.

W7. "Drilling Without Burrs," Tooling & Production, May, 1977, p. 169.

Brief comment on the fact that electrochemical machining can produce many burr free small diameters.

W8. "Multidiameter Tool Drills & Deburrs Simultaneously," Metalfax, November, 1977, p. 244.

Describes cutting tool which drills and deburrs top side of sheet metal holes.

W9. "New Router for Burrless Edge Finishing," Cutting Tool Engineering, September/October, 1977, p. 20.

General description of a tool having both left and right hand helix angles on a single cutter. This directs all cutting forces into the part.

W10. "Opportunity for Contract Shops in Precision Cutoff," Modern Machine Shop, April, 1977, pp. 128, 130.

Describes Rohbi bar stock cutoff clamping system for preventing cutoff burrs.

W11. *Drozda, Thomas J., "Plasma-Arc Cutoff Machines Chop Labor 60 Percent," Production, May, 1977, pp. 73-75.

Plasma arc machining produces a three-dimensional contour on pipe ends which eliminates deburring and two other operations. No deslagging or deburring is required on most of these ends which are later welded. Nitrogen or CO_2 is used during the cut to blow off molten slag before it solidifies on the workpiece.

W12. Edmondson, Richard, "High-Speed Flashless Forging," Manufacturing Engineering, May, 1977, pp. 36-39.

New hot forging process produces "flashless" forgings.

W13. McDermott, Jack, "Diecasting Precision Gears," Manufacturing Engineering, August, 1977, pp. 42-44.

Article indicates that a new zinc diecasting approach results in flash free castings.

W14. *Maeda, T. and M. Murakawa, "The Development of Burr-Free Slitting," Journal of the Japan Society for Technology of Plasticity, Vol. 18, No. 193, 1977, pp. 114-119 (in Japanese with English subheadings).

Describes approach to burr-free coil slitting.

W15. *Murakawa, Madao, Teizo Maeda, and Takeo Nakagawa, "Investigation on Burr-Free Shearing in Japan," SME Paper MR77-472, 1977.

Describes three approaches to truly burr-free punching and coil slitting.

W16. Wick, Charles, "How GM Uses Wedge Rolling," Manufacturing Engineering, February, 1977, pp. 33-34.

Wedge rolling eliminates the flash which occurs with drophammer hammer forgings.

W17. Yeo, Herbert G., "Burrless Edge Finishing," SME Paper MR77-465, 1977.

Describes router cutter which has both left hand and right hand helix to throw cutting forces into the part instead of out of the part. This minimizes or eliminates the heavy exit burr.

1978

W18. "Die Casting Machine Cuts Flashing," Design News, January 23, 1978, p. 44.

Special die casting machine eliminates most of flash on a part as a result of controlling final liquid pressure.

W19. "Flashless Forgings of Connecting Rods," Manufacturing Engineering, January, 1978, p. 37 (summary of Kuznechno-shtampouochnoye Proiz-vodstvo, Vol. 19, No. 2, 1977, pp. 3-6 (in Russian).

Very brief discussion of Russian approach to flash free forgings.

W20. "NC Turning Saves Time and Money for Deburring Operation," Machine and Tool Blue Book, April, 1978, p. 150.

Using N/C and cutting burrs off during the machining reduces deburring time.

DESIGNING FOR MINIMIZING BURR PROBLEMS

1963

X1. Machinery and Equipment for Rubber and Plastics, Bill Brothers Publishing Corp., New York, 2nd Edition, 1963.

This 600-page guide to equipment used in the plastics and rubber industry contains several pages of equipment related to deflashing and trimming.

1967

X2. *Hildebrand, Lynn R., "To Burr or Not To Burr--That Is the Question," Standards Engineering, August/September, 1967, pp. 11-13.

Humorous yet sincere article proposes some standards which are in use in one company.

1975

X3. "Ductile and Brittle Fractures," Metals Handbook, ASM, Metals Park, Ohio, Vol. 10, 1975, p. 68.

Burrs on 17-7 PH stainless steel spring washer resulted in part failure. Burrs on the tension side of part loading led to failure. When burrs were on the side in compression, no failures occurred.

X4. "Failures of Sliding Bearings," Metals Handbook, ASM, Metals Park, Ohio, Vol. 10, 1975, p. 412.

Burrs on drilled hole in a spherical bearing link caused rough bearing operation.

1976

X5. "Proposed Revisions of the Standard for Television Receivers and Video Products, UL 1410; Proposed Effective Dates," Underwriters Laboratories Bulletin on subject 1410, October 26, 1976.

Appendix C of this standard contains a description of a brief standard used to monitor edge sharpness of commercial components.

X6. Survey on the Italian Market for Metal Finishing and Surface Treatment Equipment, Theodore C. Trancu & Associates, Milan, Italy, June, 1976, (available from NTIS under Accession Number DIB-77-10-511).

This is a 95-page survey of potential markets for finishing equipment sales in Italy.

X7. The Japanese Market for Metal Finishing and Treatment Equipment, Kearney International, Inc., Tokyo, Japan, November, 1976 (available from NTIS under Accession Code DIB-77-06-505).

1977

X8. *Blount, Ezra, "A Review of Industry and Company Standards for Burrs and Related Edge Conditions," SME Paper MR77-471, 1977.

Presents an excellent summary of known industry and company standards as related to burrs and edge conditions.

X9. Bogenschutz, A. F., U. Buttner, J. L. Jostan, A. Marten, and H. Mietz, "Improvements in Precision in Deep and Contour Etching by Edge Properties," Bander, Bleche, Rohre (Dussledorf), 1977, Vol. 18, No. 9, pp. 398-401.

X10. *Gillespie, LaRoux K., "An Extension of Proposed Definitions for Burrs and Related Edge Conditions," SME Paper MRR77-09, 1977.

This document is an extension of an earlier report providing proposed industry definitions for burrs and related edge conditions. Twenty nine illustrations are presented to further explain the definitions. This report is composed of three sections: definitions, discussion of definitions, and an analysis of other published definitions. Twenty nine references are included.

X11. Gillespie, L. K., "Canada's $100-Million Thorn," Canadian Machinery and Metalworking, November, 1977, pp. 30-32, 70.

Contains a basic discussion of the cost of burrs in Canada. Reasons for this cost are presented as are potential solutions.

X12. *Gillespie, L. K., "Plant-Wide Control of Deburring Costs," SME Paper MRR77-05, 1977.

Contains a summary of the people and information requirements for reducing burr related costs on a plant wide basis. In addition, methods which have been employed to reduce plant wide costs are discussed.

X13. Ham, Inyong, and Walter J. Reed, "Preliminary Survey Results on Group Technology Applications in Metalworking," SME Paper MS77-328, 1977.

In a survey of 300 companies, 26% of those which used Group Technology performed deburring as one type of operation. Nineteen percent performed some other finishing operation.

X14. Hodska, Nicholas S., "Threaded Fasteners--Part I," Design News, April 18, 1977, pp. 215-221.

Author notes that "burrs" formed by piercing offers stronger holding than drilled holes. The author is referring to lancing.

X15. Muramaki, T. and C. J. Raub, "Investigation on the Effect of Edge Protection Media in Etching," Bander, Bleche, Rohre (Dusseldorf), 1977, Vol. 18, No. 9, pp. 396-398.

X16. Schafer, Friedrich, "Methods of Defining Edge Condition (Deburring Quality)," SME Paper MR77-468, 1977.

Describes the use of the Schafer system for defining edge conditions.

X17. Tresselt, A. R., "An In-Plant Standard on Burrs," SME Paper MR77-467, 1977.

Describes standards and the lack of them within industry.

X18. *"Capital Spending: Up 4.6% in 1978--On Top of a Good 1977," Production's Manufacturing Planbook: 1978, Production Magazine Special Issue, pp. 21-34.

Indicates how 27 industries allocate their equipment dollars. Finishing equipment is included in the breakdown.

X19. "Louvers Can Be Dangerous," Kansas City Star (newspaper), Special Homes Supplement, May 20, 1978, p. 14c.

Consumer product safety commission indicates children have recently been injured by burrs and sharp edges left on heat register louvers.

X20. Clement, George, "Chip Control Can Extend Tool Life," Tooling and Production, May, 1978, pp. 104-105.

Provides examples of how drill jigs should be designed with burr clearance.

X21. Rhea, Nolan W., "Ceramic Cutting Tools Make a Comeback," Tooling & Production, July, 1978, pp. 74-75.

Author indicates that when edges are ground on ceramic tools grinding marks should be parallel not intersecting at edges for longest tool life.

UNCLASSIFIED

1968

Y1. Patel, Dilip, Erosion Process as Influenced by Surface Hardeners, Master of Science Thesis, Washington State University, 1968.

1975

Y2. Potschke, Herbert, "Maschinelles Entgraten," Technische Rundschau, Vol. 67, No. 11, 1975, pp. 9, 11, 13.

Y3. Koshel, V. P. and M. A. Fetisov, "Finishing Equipment for Small Parts," Russian Engineering Journal, Vol. 55, No. 9, 1975, pp. 59-61.

1976

Y4. Hau, E., "Automatic Grinding and Polishing Machines," Galvanotechnik (Saulgau), 1976, Vol. 67, No. 7, pp. 574-575.

Describes machine used for edge polishing.

Y5. Hollingham, Jack, "Electrochemical Machining Saves Time and Money," Engineer, November 11, 1976, pp. 36-37.

Y6. Reinsch, Hans, "Surface Finishing and Deburring by Electrolysis," Metall, April, 1976, pp. 350-352.

Y7. Saujot, J. P. and R. Soulier, "Deburring Ferrous Metals in the Foundry," Fondeur, October, 1976, pp. 11-19.

Y8. Shevchenko, N. A., et. al., "Improving the Quality of Cemented-Carbide Inserts by Vibrational Machining," Russian Engineering Journal, Vol. 56, No. 10, 1976, p. 58.

Y9. Vogel, Hans and Lutz, Peter, "Deburring Steel Bars," Neue Hutte, December, 1976, pp. 760-761.

1977

Y10. Chizhov, V. N., "The Effect of Cutting Edge Rounding Radius on Machined Surface Quality," Russian Engineering Journal, Vol. 57, No. 3, 1977, pp. 20-22.

Y11. Dewar, J. P., "Metal Removal: Abrasive and Mechanical Methods," Industrial Finishing, April, 1977, pp. 18-21.

Y12. Goodrod, S. H., "Deburring--A Review of Methods and Equipment," Production Engineering, Vol. 56, No. 1-2, January-February, 1977, pp. 19-25.

Y13. Storey, Warren, "Cutting Deburring Cost Called Fertile Field for Savings," American Metal Market/Metalworking News, October 10, 1977, p. 19.

General article on deburring potential.

REFERENCES ON EQUIPMENT AND TOOLING:

A7, 12, 13, 14, 17; B4; D1, 7, 13, 18, 27, 28, 32, 34, 35, 39, 40, 42, 43, 44, 48, 49; E1, 3, 4; F2, 5, 6-11; J7; Q1, 2, 6, 7, 9, 10, 12; U7, 15, 16; W1, 8, 9, 10, 11, 12, 16, 18, 20; X1, 6, 7.

REFERENCES PRESENTING RESULTS OF RESEARCH:

A1, 3, 6, 7, 8, 10, 15; B1, 3, 4; D1, 6, 12, 13, 16, 19, 23, 28, 33, 35, 41, 42, 45, 46, 49; E2; F3, 5; H4; J2; R3; U1, 2, 3, 4, 7, 8, 12, 15, 17, 18; V1-3, 5, 6, 8, 11; W1, 3, 15, 19; X13, 21.

REFERENCES PRESENTING CASE HISTORIES OR DESCRIBING HOW TO USE PROCESS OR TOOLING:

A13, 16; D1, 12, 38, 41; G1, 3; H2; J7; Q4, 8; U7, 8; X2, 3, 4, 19.

REFERENCES LISTING MATERIALS DEBURRED OR STUDIED:

1. Low Carbon Steel
   A9; D12, 26, 33; E1, 2; F5; J8; V6; W11, 16.

2. Stainless Steel
   D9, 12, 26, 38; U9; V5, 6.

3. Alloy Steel
   A9; B3; D33; R2; V5, 6.

4. Aluminum
   A10; D12, 26, 38, 46; E2; Q8; V2, 3, 9; W9, 20.

5. Copper, Brass, Bronze
   A10; D26; F8; V5, 6; W6.

6. Zinc
   D25, 44; J5; W13.

7. Refractories

8. Cast Irons
   F5; H3.

9. Titanium
   V3; W7.

10. Beryllium Copper

11. Plastics
D3, 38; W9.

12. Powder Metals
D44.

13. Wide Range of Materials
D42; Q4; U1, 4, 13; W12.

14. Rubber
D3, 5, 44.

ARTICLES PRESENTING DATA:

A1, 3, 6, 7, 8, 10, 11, 14, 15; B1, 3; D1, 10, 12, 13, 16, 19, 28, 33, 35, 41, 42, 46, 49, 51; E2, 4; F3; G2; Q8; R3; U1, 4, 7, 8, 9, 12, 13, 15; V3, 5, 6; W1; X5, 8, 11, 13, 18.

REFERENCES DISCUSSING ECONOMICS:

A11, 17; D6, 23, 40, 49, 50, 51; Q9; U7, 8, 10, 13, 15; X11, 18.

REFERENCES DESCRIBING DESIGN APPROACHES:

D38, 40; H4; U1, 2, 4, 8, 13, 15; V8; X1-21.

REFERENCES DISCUSSING BURR FORMATION AND PROPERTIES:

D35; E2; H4; U1, 2, 4, 8, 13, 15; V1-11; W1, 3, 15; X5, 12.

REFERENCES DISCUSSING BURR PREVENTION AND MINIMIZATION:

D38, 40; U1, 2, 4, 8, 13, 15; V2, 5, 6, 8, 9; W1-20; X8, 12, 21.

REFERENCES DESCRIBING PLANT OR INDUSTRY WIDE APPROACH TO DEBURRING PROBLEMS:

U13, 14; X12.

REFERENCES DISCUSSING SPECIFIC PROCESSES:

Abrasive Jet
A1-17; D35, 49; U1, 13, 17, 18.

Abrasive Flow
B1-4; U1, 13, 17, 18.

Water Jet
U13.

Barrel
D1-7, 24, 26, 29, 37, 39, 44, 49; U1, 13, 17, 18.

Centrifugal Barrel
D1, 6, 8-14, 38, 39, 42; U1, 3, 13, 17, 18.

Magnetic Media
D15-16; U13.

Spindle Finishing
D1, 17-19, 35; U1, 13, 18.

Vibratory
A9, 15; D1, 6, 7, 20-51; U1, 13, 18.

Flow Finishing
D1; U13.

Recipro Finishing
D1, 13; U13.

Orboresonant
D48; U13.

Sanding
E1-4; U13, 17.

Mechanical
D24, 49; F1-12; U13, 17.

Hand
D6, 40; G1-4; U13.

Brush
H1-4; U1, 3, 13, 17.

Flame
U13.

Resistance
U13.

Hot Wire
U13.

Thermal Energy Method
J1-9; U1, 13, 17, 18.

Plasma Deburring
U13.

EDM Deburring
U13.

Chemical
M1; U3, 13.

Ultrasonic
U13.

Chemical Barrel
U13.

Chemical Centrifugal Barrel
U13.

Chemical Magnetic Loose Abrasive
U13.

Chemical Spindle
U13.

Chemical Vibratory
U13.

Electrochemical
D24; F12; H4; Q1-12; U1, 3, 13, 17, 18.

Electropolish
R1-3; U13, 18.

Electrochemical Brush
U13.

Electrochemical Barrel
U13.

Electrochemical Centrifugal Barrel
U13.

Electrochemical Spindle Finishing
U13.

Electrochemical Vibratory
U13.

Multiple Processes
U1-18.

Unclassified Listings
Y1-13.

FOREIGN LANGUAGE ARTICLES:

German
D8, 29, 30, 35, 39, 47; H4; J1; Q1, 2; R1; U1, 3, 18; V11; X9, 15; Y2, 4, 6, 9.

Japanese
D2, 17; U4; W1, 3, 14.

Russian
A2, 4; D16, 23, 28, 33; F3; Q3; W19.

French
D4, 34, 43.

Spanish
D21.

Italian
D7.

Norwegian
D37.

AUTHOR INDEX

Mercer, Tom, Q4.

Merritt, Bob, Q5.

Mietz, H., X9.

Miller, Jerome, Q6.

Miyatani, Takashi, B3.

Montag, A. C., J7.

Monteiro, Arnold, D38.

Moulton, Thomas Otto, B4.

Muller, M., J1.

Mundel, Marvin E., G1.

Murakawa, Madao, W14, W15.

Muramaki, T., X15.

Nakagawa, Takeo, W15.

Nakata, Jungi, B3.

Nelson, J. R., D44.

O'Keefe, John, H1.

Panchenko, V. M., D16.

Papshev, D. D., A15, D45.

Patel, Dilip, Y1.

Pekelharing, A. J., V1.

Potschke, Herbert, Y2.

Powell, Harold, V7.

Radtke, Shrade Fred, D20.

Rands, Steve, H2.

Raub, C. J., X15.

Reed, Walter J., F5, Q9, X13.