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Session P - Mechanical Finishing

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MECHANICAL FINISHING

SESSION P

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Mechanical Finishing Session P

Vibratory and Barrel Finishing Techniques for Optimum Productivity

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VIBRATORY AND BARREL FINISHING TECHNIQUES FOR OPTIMUM PRODUCTIVITY

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INTRODUCTION

Mass Finishing techniques have been described in detail in several publications, and are largely used in the industry with different degrees of success. The purpose of this paper is to highlight the important elements that comprise vibratory and barrel finishing processes, and explain their influence on optimizing productivity. Media selection, media to parts ratio, function of compounds and optimum cycles for burnishing are reviewed, and their effects on finishing quality are discussed.

In order to appreciate mass finishing operations, basic understanding of the type and effect of forces applied within a load of parts and media during processing is quite helpful. When analyzed, these forces can be summarized as compression, and shear. (Fig. 1)

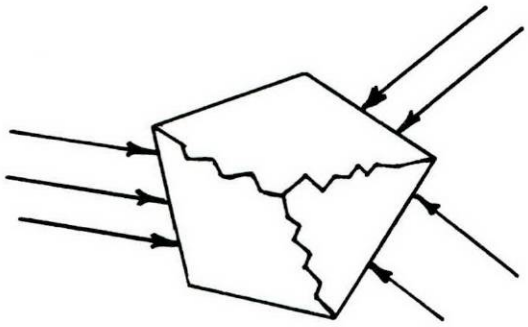
During deburring (and radiusing) with abrasive compounds and media, shear and attrition on part surfaces, result in cutting and stock removal. Simultaneously, compression forces act on abrasive particles. Due to their rigidity, these particles breakdown into finer sizes.

In burnishing processes, with non abrasive media such as steel shot, the predominant force in action is that of compression. The load applied from the layers of media above the parts, reaches the surface at points of contact with the media. Under compression stress, the relatively malleable metal layers exposed to this action deform and spread out to even out the "hills and valleys" of the surface. Hence the burnishing action.

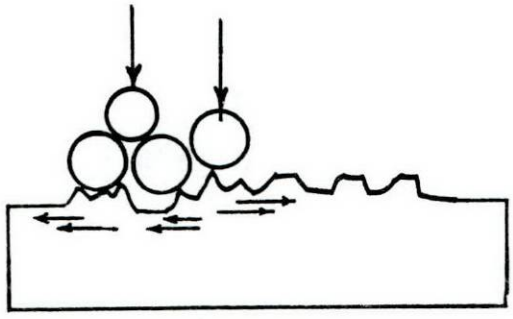
Controlling these forces to provide optimum results, can be achieved by careful choice and use of mass finishing components. These are: Media, Compounds, and Process Cycle.

Another important consideration must be given to metallurgical properties such as ductility of the metal being processed. For instance, initial surface hardness may be further increased as a result of work hardening during the process. This behavior would be a determining factor on the degree of finish obtainable within a given cycle.

Selecting the proper combination of media, compound and finishing cycles based on known metal properties would lead to process optimization and higher productivity.

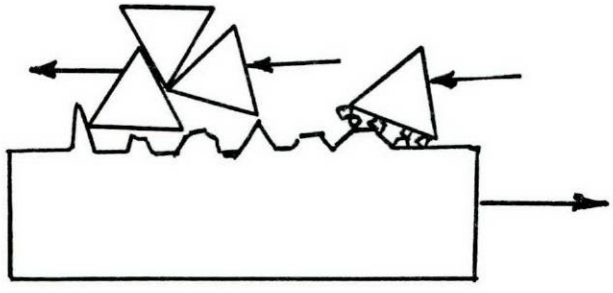


Compression
Effect on Abrasive
Particles



Compression
Effect on Surface
During Burnishing

Shear Attrition



Shear and Attrition
Effect on Surface
During Deburring

Fig. 1

A. MEDIA SELECTION

Media used in mass finishing are selected to achieve:

1. Separation between parts during processing and thereby prevent parts damaging.

2. Provide the required surface finish e.g. deburring, smoothing, burnishing.

The selection of the proper media must take into account type, shape, and size to be specified for a given application.

Abrasive type media are available to satisfy various degrees of metal stock removal as required. They are commonly referred to as fast, medium or low cutting types.

This is accomplished by controlling the abrasive content of the media. The harder and coarser abrasives, such as aluminum oxide and silicon carbide, are generally used in media designed for heavy stock removal and deburring. The surface microinch obtained with this type is usually high (above 10), resulting in mat finishes.

Finer abrasives such as silica flours and pumice are found in media designed for surface smoothing and light deburring with little stock removal. Very smooth surfaces, although non reflective, can be obtained with microinch values down to 1 1/2".

Non abrasive media, such as case hardened, soft steel, and porcelain are strictly used for burnishing with no stock removal. The surface refinement obtained is only reduced minimally although with a high degree of specularity. Using case hardened steel shot with abrasive additives destroys the media outer case, leading to its eventual pitting. Such media is totally ineffective in producing high lustre on burnished work, if not maintained perfectly smooth and clean.

Similarly, porcelain media used with abrasive additives(compounds) will become sufficiently rough to act as a cutting type. No effective burnishing can then be resumed, until the media are glazed again with adequate burnishing compounds.

For processes requiring stock removal and highly reflective surfaces, separate media for cutdown and for burnishing should be considered as the most effective alternative.

An exception to this rule is the use of soft metallic media such as zinc or soft steel slugs. These can be "loaded" with abrasive during the cutdown step, then cleaned free of abrasive, and used with burnishing compounds for generation of high lustre.

Media shape and size selection must be made after proper consideration of the shape of parts to be processed.

Access to corners, and recesses must be considered. Media should flow freely through holes or large enough not to pass through, in order

to prevent media lodging in parts. In the latter case frequent screening is necessary to discard the worn down media from the load.

Maximum deburring efficiency is usually obtained with flat sided media such as triangles, pyramids, and star shapes, due to the larger or surface contact that these shapes offer.

Precision or less agressive stock removal is usually obtained with cylinders and cones which offer a line contact to the part surface.

Spherical media, offer point contacts, and are mainly recommended for burnishing operations. Similarly, pins, balcones and angle cut cylinders are designed to reach corners and recesses, and may be mixed with spherical media for more effective burnishing.

It must be noted that the selection of media size in vibratory and barrel finishing can have a pronounced effect on the quality of finishing obtained, and the cycle time needed to achieve it.

Generally, larger size media will deburr or burnish more rapidly, due to the higher pressure exerted at points of contacts with the parts. However, fluidity of large sizes is far less than that of smaller sizes, leading to a more agressive hammering effect in vibratory machines, and rougher cascading action in horizontal barrels. Consequently, impingement, and part damage may occur.

Of special consideration in ball burnishing and vibratory machines, is the ability of the machine to turn the load at maximum efficiency. An optimum size and shape of steel media are usually specified by mass finishing suppliers to suit individual purposes.

The need to separate media from parts at the end of a given cycle must also be taken into consideration. Sufficient difference between media and parts size (and shape) must exist for the process to be completed. A variety of screen separators with an automatic media return system are available for continuous and automoted processes.

B. MEDIA TO PARTS RATIO

Specifying the correct media to parts ratio for optimum productivity is largely obtained through trial and error.

There are however general guidelines that may be used:

For barrel applications, a ratio of 3-4:1 by volume is often used, while vibratory machines require a higher ratio of 5-6:1 for the same type of parts, media and finish desired.

The ratio also varies according to the process in use. Deburring and rough finishing can be obtained with a relatively low ratio while quality finishing and burnishing to a high lustre requires a higher ratio (10-12:1). Another factor of importance is the size and weight of parts to be processed. Large and heavy parts e.g. lead alloy castings, may require separate compartments for processing parts individually, one part per compartment, or fixturing, usually in a high ratio of media to part loading

One technique to estimate an adequate ratio, is to visualize a box that will hold a single part, surrounded on all sides by one or two layers of the media to be used.

The volume of that box represents that of media volume per part.

It is always recommended that a high ratio be used on new applications, then the ratio reduced gradually with subsequent loads until an optimum level is reached for a corresponding acceptable finish.

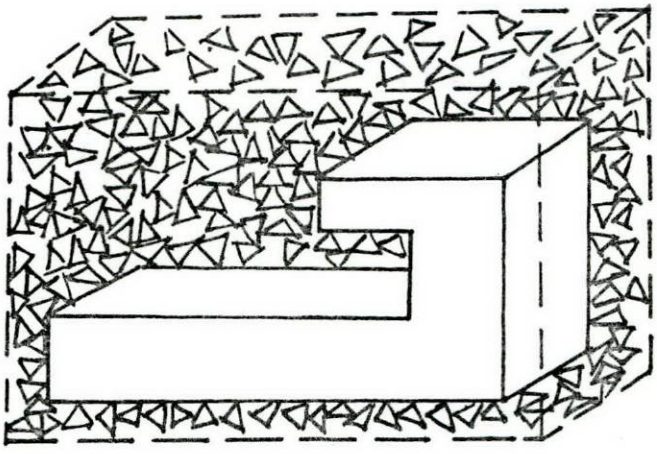


FIGURE 2
MEDIA TO PART RATIO

C. EFFECT OF COMPOUNDS

Compounds for specific applications and finishing requirements are specified as part of mass finishing operations. These are designed for cleaning, deburring, burnishing, rustproofing, etc.

Deburring compounds generally contain abrasives slected to achieve various degrees of cut and polish. Water is added in small quantities along with these compounds to the load to form a slurry. As expected, the abrasive grains breakdown as a function of time, load and type of machine used during the process. The very fine residue eventually becomes ineffective in stock removal, and merely acts as a polishing medium.

In vibratory machines, the impact energy is transmitted to the entire load during the process while in horizontal barrels, the action is mostly concentrated in the slide area near the top of the load. Consequently, abrasive grains breakdown much faster in vibratory machines than in horizontal barrels (of equivalent load size).

When heavy deburring or stock removal is needed, in which cycles in excess of 8 hours are used, recharging the abrasive compound at given intervals is recommended. Otherwise, stock removal rate tapers off and deburring or radiusing falls short of desired values. (Fig. 3)

Optimum resluts can be obtained if abrasive compounds are recharged every4-5 hours in vibratory machines and 10-12 hours in horizontal barrels, (assuming 8 and 20 hour cycles, or more, respectively). Usually, 1-2 lbs of abrasive compound per cubic foot of load is used for every charge, with sufficient water to develop a thin slurry of suspended abrasive. (Fig. 4)

In non abrasive compound deburring and surface refinement, the stock removal depends on the abrasive action of the media, aided by specific compounds. These compounds, liquid or powder, dissolved with water are added to the load to maintain a chemical balance on the surface of the work, provide lubricity and keep the media surface clean. The most effective process in this type of operation, is the liquid flow through vibratory technique. A liquid compound is diluted and metered continually into the load and allowed to drain out of the machine. Such a system utilizes very little compound and results in clean and bright finishes, since the metallic fines and abrasive residues are constantly flushed out of the load. The media remains clean, exposing fresh abrasive surfaces throughout the cycle. As a result, stock removal and surface refinement are faster.

Using plain water without compounds in flow through systems is counter productive. In the absence of detergency (supplied) by the compound), wetting of the media and parts is ineffective, and flushing of fines is incomplete. As a result, loading of media with metallic fines inhibits the media function drastically.

Abrasives residue and resin (where resin bonded media are used) build up in recesses of parts, and present great difficulty for subsequent finishing operations such as cleaning and plating.

Usually a flow rate of 2-4 gallons per cubic foot of load per hour of a 0.5-1% concentration of these compounds is adequate for optimum results.

It must be noted that excessive compound concentration could also reduce the efficiency of mass finishing processes. Increased lubricity and foaming tend to attenuate the reciprocating motion within the load in vibratory machines, and minimizes the slide action in horizontal barrels. (Fig. 5 - 6)

Long deburring cycle with single abrasive charge.

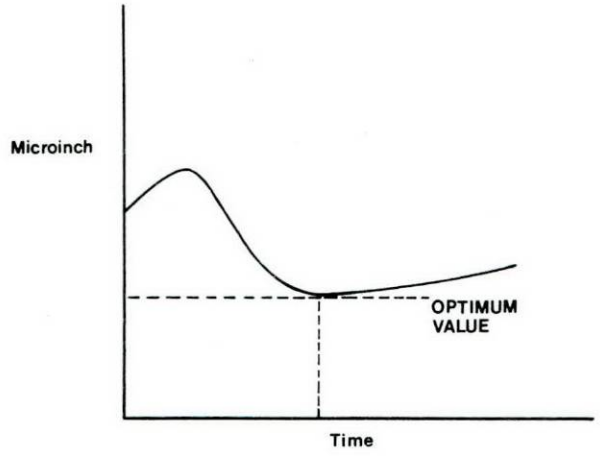


FIGURE 3

Long deburring cycle with abrasive recharging.

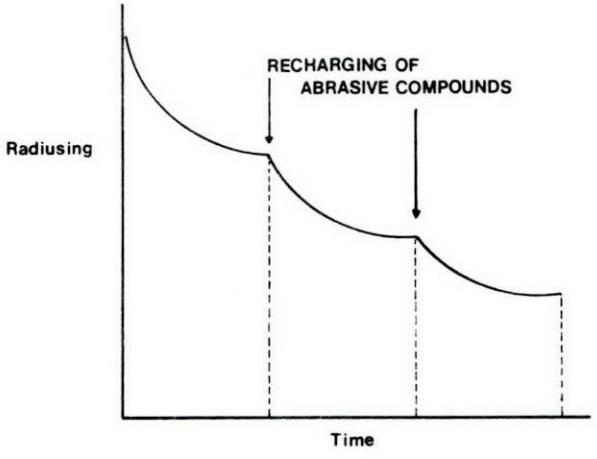
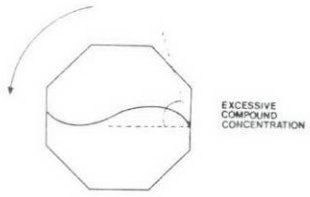
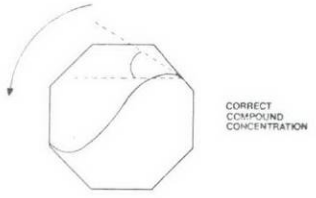


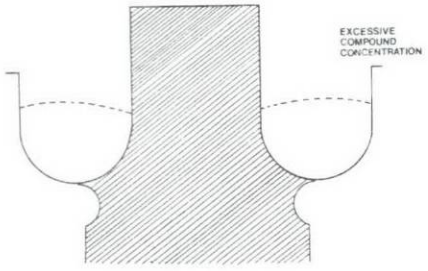
FIGURE 4

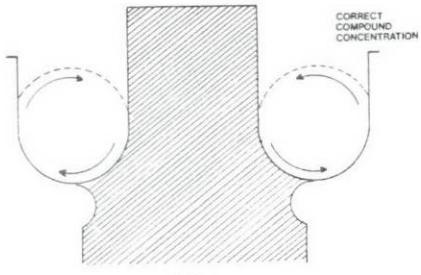
EFFECT of COMPOUND CONCENTRATION in BARRELS





EFFECT of COMPOUND CONCENTRATION
in
VIBRATORY MACHINES





D. OPTIMUM CYCLES FOR FINISHING TO A HIGH LUSTRE

Before starting a burnishing process, the parts must be carefully examined. The metal surface should be in a reasonable state of smoothness and free of oil and scale.

A starting surface roughness of 30-50 microinches could not be appreciably reduced by a single ball burnishing step. Work hardening at the surface induced by the heavy load applied during ball burnishing increases the elastic limit of the surface crystals and permanent deformation takes place. (No further flattening of the surface irregularities.) (Fig. 7-8)

Consequently, a large proportion of surface irregularities remain unchanged, and a low microinch level cannot be obtained.

An intermediate surface smoothing and leveling is therefore required to bring the surface to a condition that allows burnishing to proceed more effectively. (Fig. 9-10)

Properly selected abrasive media can be used to bring the surface roughness to 10-15 microinch, or less, by actually abrading the surface irregularities away at a controlled rate.

Some abrasive media such as the preplate resin bonded types can bring the surface roughness of diecast to below 3 microinch. Ball burnishing applied to such surfaces can produce mirror like finishes in a very short time, usually 30-60 minutes. (Fig. 11)

The effect of heavy loads applied to the surface on work hardening of these surfaces is so common that optimum ball burnishing cycles are invariably found to be 40-90 minutes, depending on the metal processed. Beyond these limits, further crystal flowing is impossible (unless media load is increased), and longer cycles are futile. (Fig. 12)

Naturally, increasing the load applied to the surface proportionally decreases the optimum time required for finishing, as the elastic limit of the metal is quickly reached. Large vibratory machines in excess of 30 cubic foot capacity and centrifugal machines can reduce finishing times typically to less than 10 minutes.

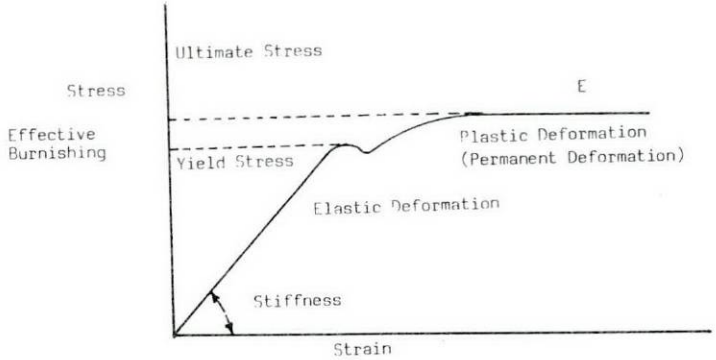


FIGURE 7

GENERAL STRESS - STRAIN CURVE FOR METALS

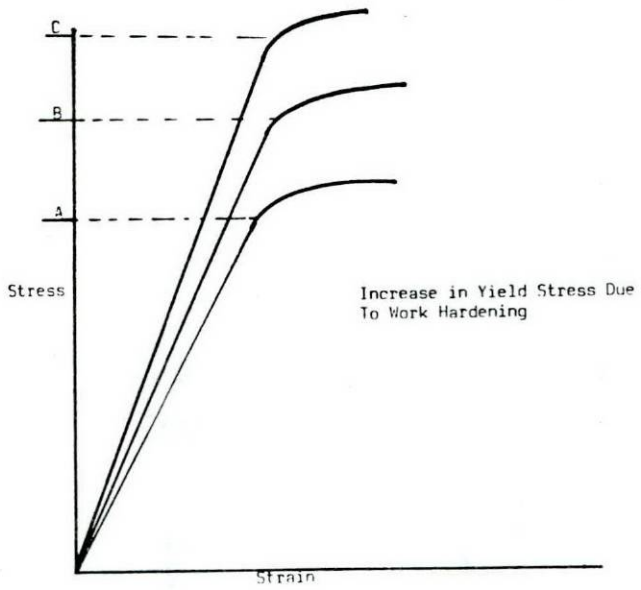


FIGURE 8

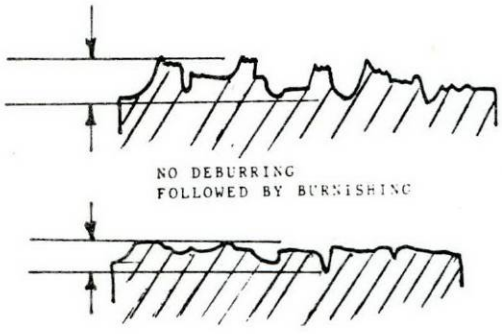


FIGURE 9

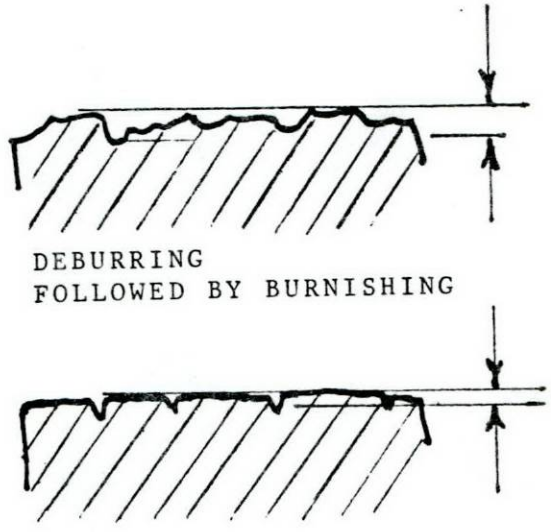


FIGURE 10

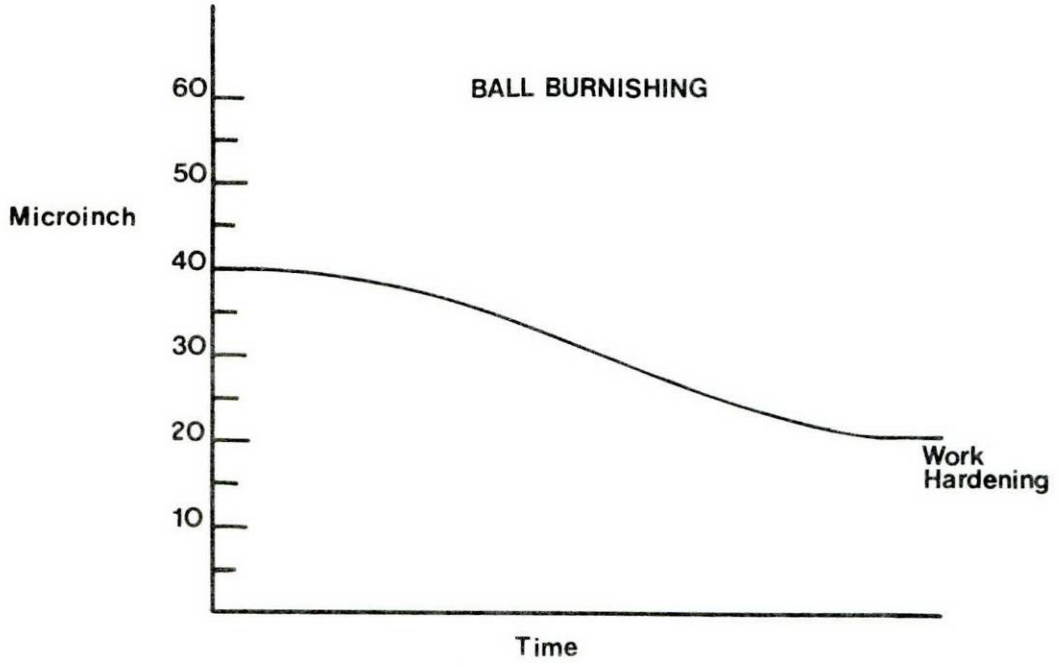


FIGURE 11

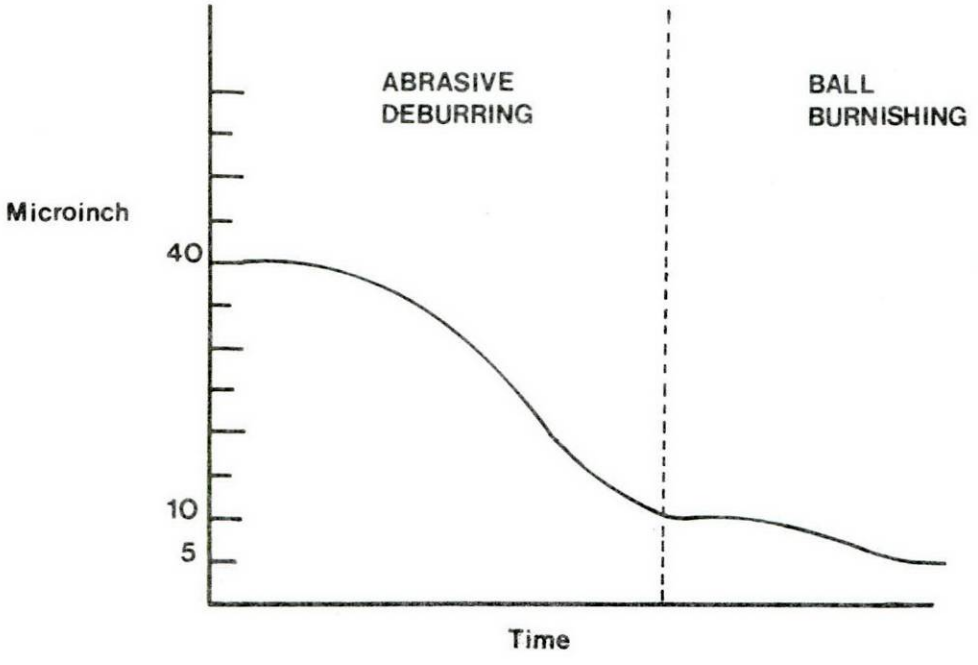


FIGURE 12

E. EFFECT OF LOADING AND UNLOADING OF MACHINES

As unimportant as it may seem, loading-unloading plays an important role in obtaining a quality surface finishing, and may in effect cause a rejection of an entire load, if not carefully carried out.

This is particularly true with soft metals such as zinc diecast, aluminum and brass stampings that must be processed with media.

Bulk loading of a large number of parts into an idle machine, will leave the parts in a concentrated bunch over the media. When the machine is started, there will be no effective separation of the parts by the media. During a very short period (less than a minute) at the start of the process, scratching, gouging and damage by entanglement may occur as a result of part on part contact. In the case of burnishing with steel shot for example, the damage may be irreparable.

Gradual loading of parts interspersed with media is therefore always recommended. (Fig. 13-14)

This can be easily achieved in loading vibratory machines, by setting them in motion while gradually loading the parts. "Dumping" of parts into the machine in one location even as it is running must be avoided.

In horizontal barrel loading, layers of media and parts must be loaded in sequence, to achieve proper separation and cushioning between the parts from the start.

Unloading of highly finished parts should equally be carried out with care to prevent part on part impingement. Screen made of plastigol coated wire or polypro grids are best suited for cushioning the parts during separation and unloading. In vibratory screening unloading, care must be excercised in preventing parts from catching onto the screen. When this happens, a bottleneck is created and parts "bunch up" gradually on the vibratory screen, causing entanglement or part on part damage.

CONCLUSION

The important mass finishing elements are media, compound and cycles. Selecting the proper combination, gives the operator the surface finishing requirements in optimum cycle times.

Understanding of some basic metallurgical properties and of forces generated within load in process, allows the finishing engineer to specify the proper mass finishing parameters for optimum productivity.

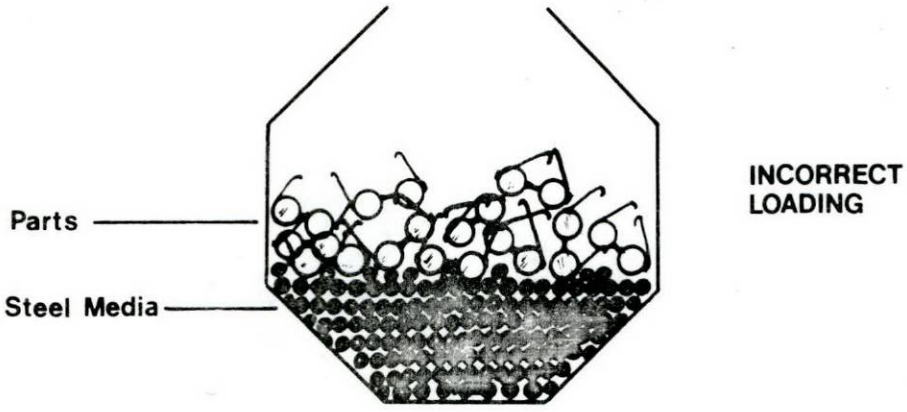


FIGURE 13

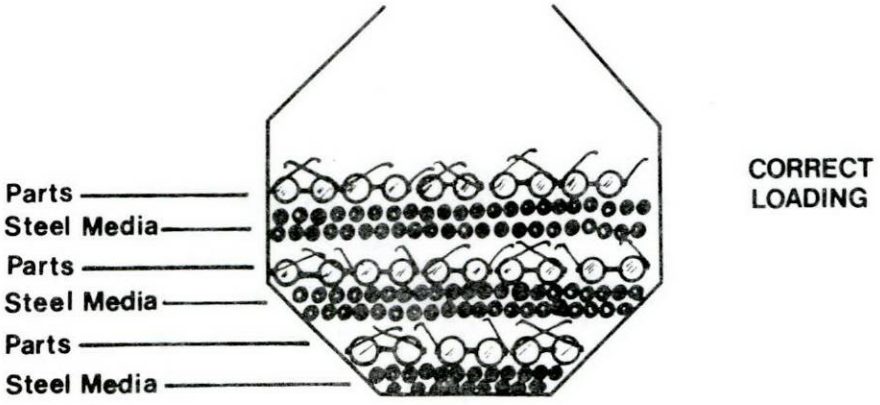


FIGURE 14

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P-2

Mechanical Finishing Session P

Surface Finishing and Deburring with Non-Woven Nylon Abrasives

Thomas V. Keating
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SURFACE FINISHING AND DEBURRING WITH NON-WOVEN NYLON ABRASIVES

by Thomas V. Keating
Lea Mfg. Co., Waterbury, CT

Non-woven synthetic material consists of nylon fibers that have been cross-layed, carded and needled into a matrix that has been sprayed on both sides with a slurry of phenolic resins and abrasive particles that coats the fibers. After drying and curing the resin bonds the fibers at their intersections and also bonds the abrasive grain to the fibers.

The resulting low density base material can then be converted into a number of configurations. These include pads, discs, rolls, buffs, brushes, wheels and belts. These are used for cleaning, surface preparation, deburring and satin finishing.

The abrasive grains utilized in this material include aluminum oxide, silicon carbide and other softer abrasives. This material has features that make it flexible, non-loading, waterproof, controllable in cut, non-metallic and uniformly impregnated with abrasive.

The selection of grades range from ultra fines to coarse.

The various industries include printed circuit boards, aerospace, jewelry, automotive hardware, diecastings, lock hardware, lighting fixtures, silverware, wood furniture and decorative finishing.

In relation to the printed circuit board industry, these non-woven nylon abrasives are ideally suited in producing brushes. This results in surfaces being cleaned without excessive stock removal. The finish imparted to the printed circuit board can be controlled by selecting abrasive particle size in the nylon fleece along with the degree of impregnation needed. A high scratch density finish can be achieved due to the high number of controlled cutting points at the surface of the material.

Surface preparation is an essential part of the printed circuit board production process. The key to success in this surface preparation is to select the most appropriate method of removing surface contamination and to produce an optimum surface geometry for adhesion of resist or plating chemicals.

Methods of surface preparation are either mechanical or chemical. Often mechanical methods are preferred because of their ease of control, lower cost and efficiency.

The use of abrasive brushes predominates the mechanical methods available. Abrasive nylon filament bristle brushes are used because of their long life characteristics but lack the ability to produce an ideal keyed surface (see Profilometer Reading and Graph No. 1). Non-woven nylon abrasive brushes are increasingly used especially when brush performance is the most important consideration (see Profilometer Reading and Graph No. 2). The reason for surface preparation is not only to remove surface oxidation, but also to provide a roughened surface which will give good adhesion of plating or resist applications. The performance of the brushing operation must therefore be judged against this background.

Oxide films which form on copper board surfaces show light interference patterns in the form of rainbow colored areas. Normally, the color of a particular area indicates the thickness of the oxide film.

e.g. Red 0.38 Microns (15 Micro Inch)
Violet 0.20 Microns (8 Micro Inch)

It is necessary to totally remove this oxide film to present a clean board surface. Consequently, the agression characteristics of the brush under process conditions should be considered. In this context, aggression is defined as the ability of the brush to remove copper from the board surface.

Aggression is directly proportional to brush pressure that is set to the minimum level which insures total removal of oxide film at the board through-put speed (see Graphs No. 3 through No. 6).

The board surface should be roughened to achieve good adhesion of subsequent resist coatings. Therefore, the degree of roughness generated by brushing should be considered. This surface roughness can be measured using a surface Profilometer. This reading will give various parameters describing the maximum depth of surface scratches, number of scratches and other values as illustrated in Graphs No. 1 and No. 2 mentioned earlier.

Problems may arise when deep surface scratches are present on the board surface. Deep scratches can cause cavities on the resist. These cavities will allow chemicals to penetrate beneath the resist and may allow subsequent processes to bridge or cut circuit tracks. This is particularly critical on fine line boards. For these reasons, non-woven nylon brushes are superior to bristle brushes which tend to be too harsh and unforgiving in the process.

In the deburring process, the recommended brush would be a hard impregnated disc brush made with special fine silicon carbide discs of high concentration of abrasive grain compressed with a hard synthetic resin. This brush should be utilized for the removal of large burrs while still maintaining a good surface. It replaces 180 grit and 240 grit bristle type brushes.

The scrubbing and cleaning process requires the removal of oxides and contaminates. This also produces a preperly defined surface roughness of adhesion of resist and electroless copper.

This operation normally has no or limited deburring requirements. Where no deburring is needed in the scrub/clean operation, a standard flap brush with either super fine silicon carbide abrasive or very fine aluminum oxide abrasive is suggested. For light deburring up to 20 microns is combined in the scrub operation, a normal impregnated brush with moderate hardness is recommended. This replaces 320 bristle brushes.

The finest light scrubbing of Tin/Lead solder, or gold, solder mask preparation, etc. should utilize a standard flap brush made of ultra fine silicon carbide abrasive.

As we have indicated earlier, these non-woven abrasives have many other industrial applications.

Illus. No. 7 shows a typical printed circuit board cleaning operation.
Illus. No. 8 demonstrates a finishing flap brush on panels.
Illus. No. 9 indicates satin finishing on silverware.
Illus. No.10 shows the use of spindle mounted flap wheel on a casting.
Illus. No.11 is a belt polishing application.
Illus. No.12 shows light deburring on a casting.
Illus. No.13 is a non-woven abrasive disc operation.

TEST IDENTIFICATION
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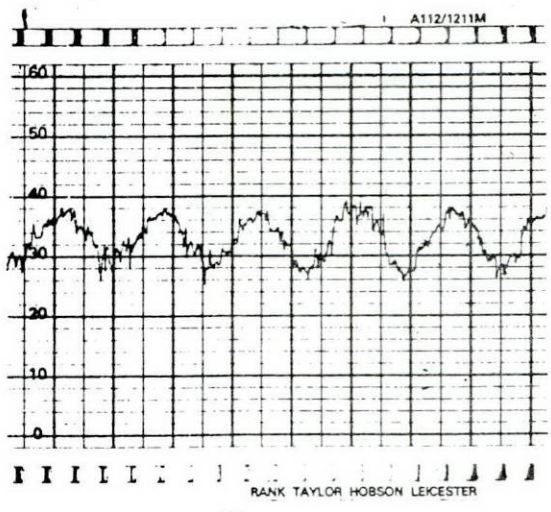
TEST CONDITIONS
STD TEST

BRUSH TYPE
320 GRIT BRISTLE BRUSH

SURFACE MEASUREMENTS

AVERAGE ROUGHNESS	RA	=	.49 MICRONS
PEAK-VALLEY HGT.	RT	=	2.36 MICRONS
TEN POINT HGT.	RZ	=	1.68 MICRONS
PEAK HGT.	RP	=	1.22 MICRONS
RMS ROUGHNESS	RQ	=	.58 MICRONS
SKEWNESS	SK	=	.12
KURTOSIS		=	2.23
AVE.R'NESS DEPTH	R3Z	=	1.52 MICRONS
AVE.WAVELENGTH	LA	=	129.21 MICRONS
HIGH SPOT COUNT		=	7.05 PER MM.
MEAN SLOPE		=	1.38 DEGREES
HIGH SPOT SPACING		=	154.17 MICRONS
MEAN PEAK RADIUS		=	172.57 MICRONS
MEAN VALLEY RADIUS		=	-223.78 MICRONS

GRAPH SCALES
VERTICAL MAGNIFICATION = 5000*
HORIZONTAL MAGNIFICATION =20*



Graph 1
Surface finish achieved using Bristle Brush. Surface profile shows low scratch density.

1.

TEST IDENTIFICATION
FTS273A 7/12/83

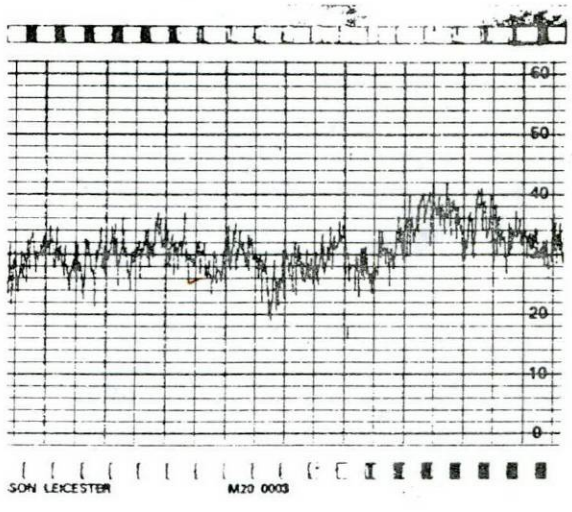
TEST CONDITIONS
STD TEST

BRUSH TYPE
S SUPER FINE

SURFACE MEASUREMENTS

AVERAGE ROUGHNESS	RA	=	.4 MICRONS
PEAK-VALLEY HGT.	RT	=	2.51 MICRONS
TEN POINT HGT.	RZ	=	1.65 MICRONS
PEAK HGT.	RP	=	1.26 MICRONS
RMS ROUGHNESS	RQ	=	.51 MICRONS
SKEWNESS	SK	=	.01
KURTOSIS		=	3.28
AVE.R'NESS DEPTH	R3Z	=	1.37 MICRONS
AVE.WAVELENGTH	LA	=	57.37 MICRONS
HIGH SPOT COUNT		=	17.82 PER MM.
MEAN SLOPE		=	2.57 DEGREES
HIGH SPOT SPACING		=	56.91 MICRONS
MEAN PEAK RADIUS		=	92.86 MICRONS
MEAN VALLEY RADIUS		=	-100.44 MICRONS

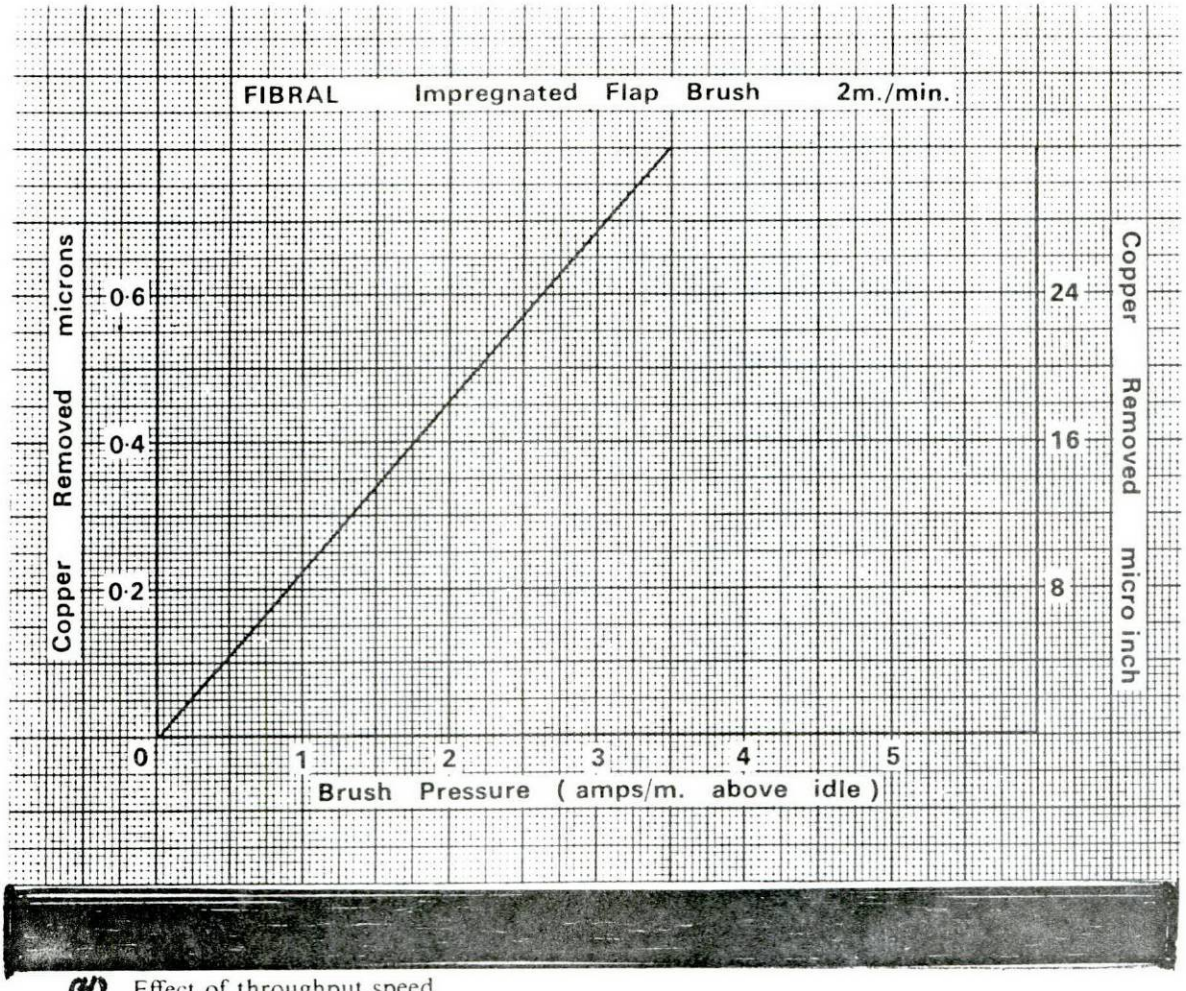
GRAPH SCALES
VERTICAL MAGNIFICATION = 5000*
HORIZONTAL MAGNIFICATION =20*



Graph 2
Surface finish achieved using Fibral Super Fine Silicon Carbide Flap Brush. Surface profile shows high scratch density.

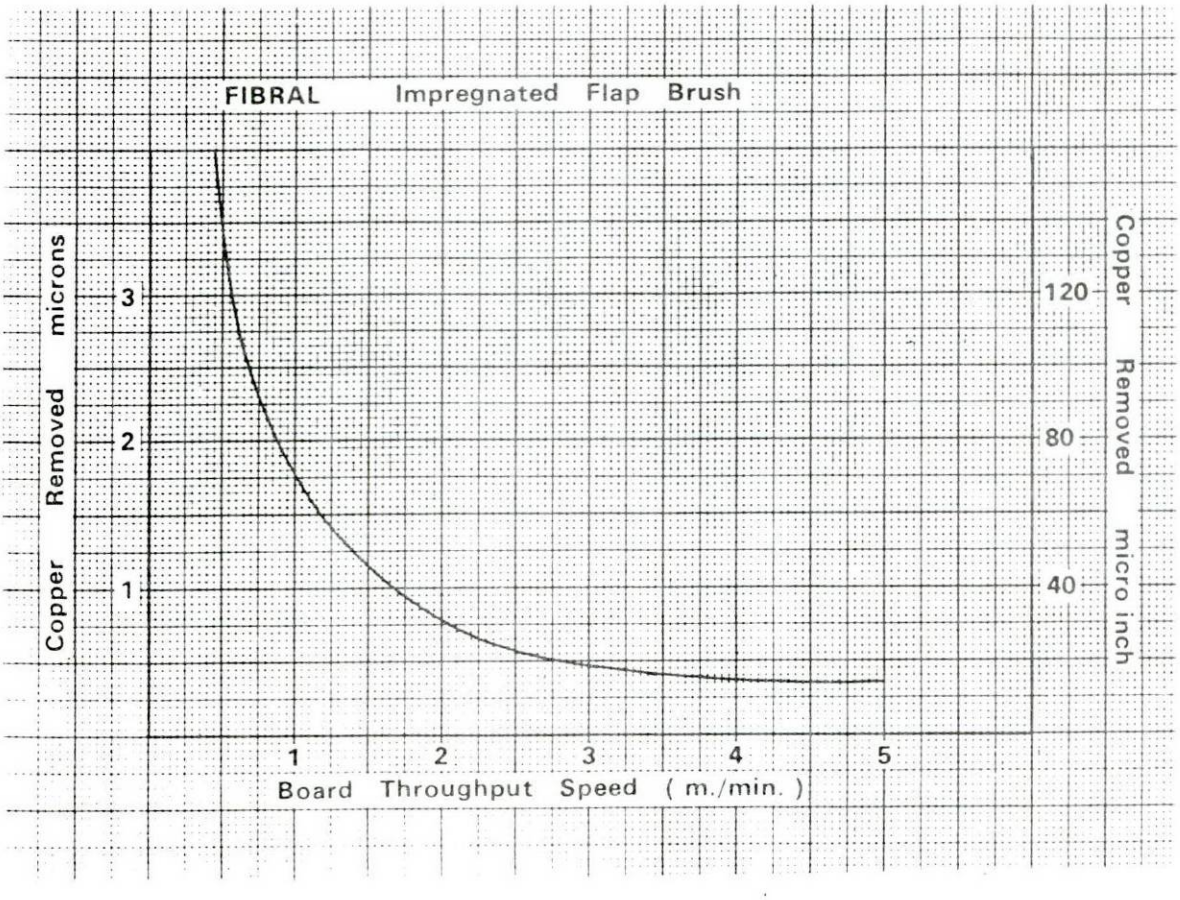
2.

(3) Effect of brushing pressure

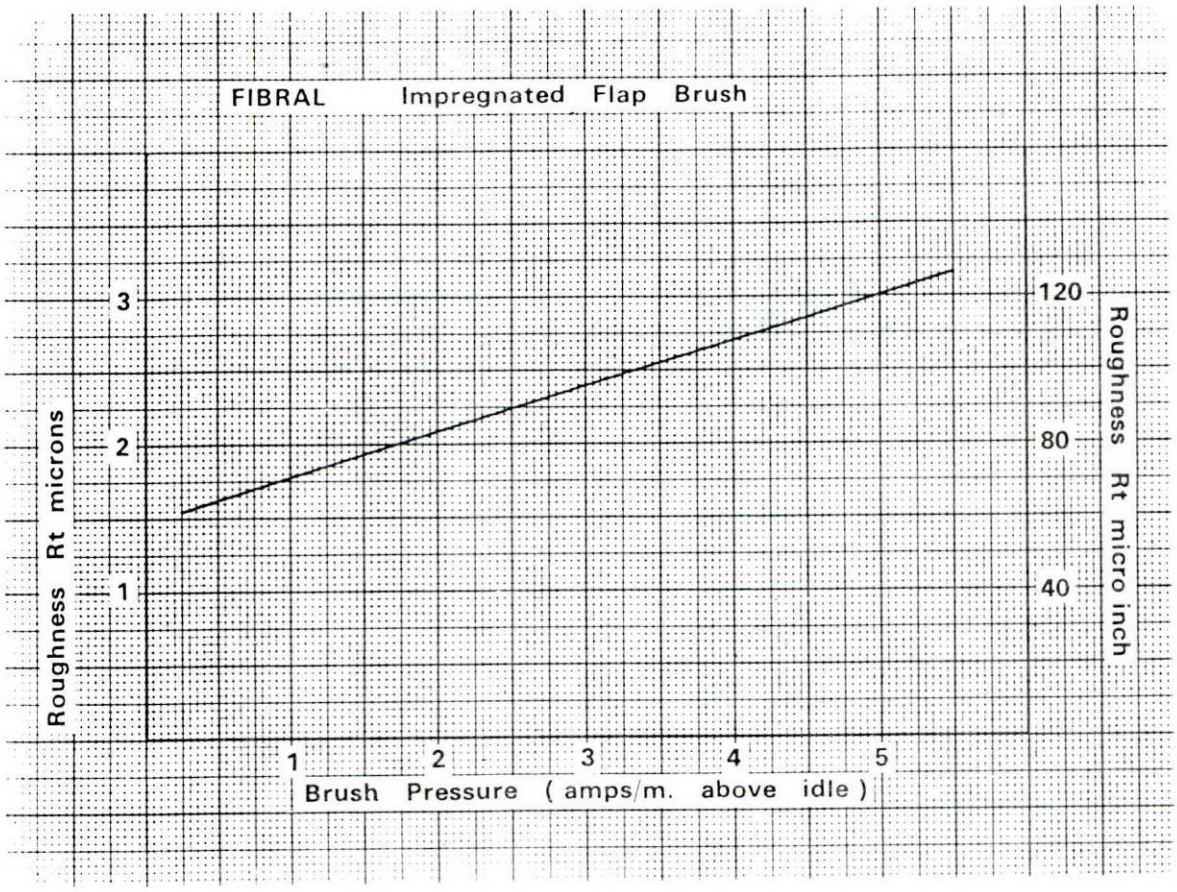


(4) Effect of throughput speed

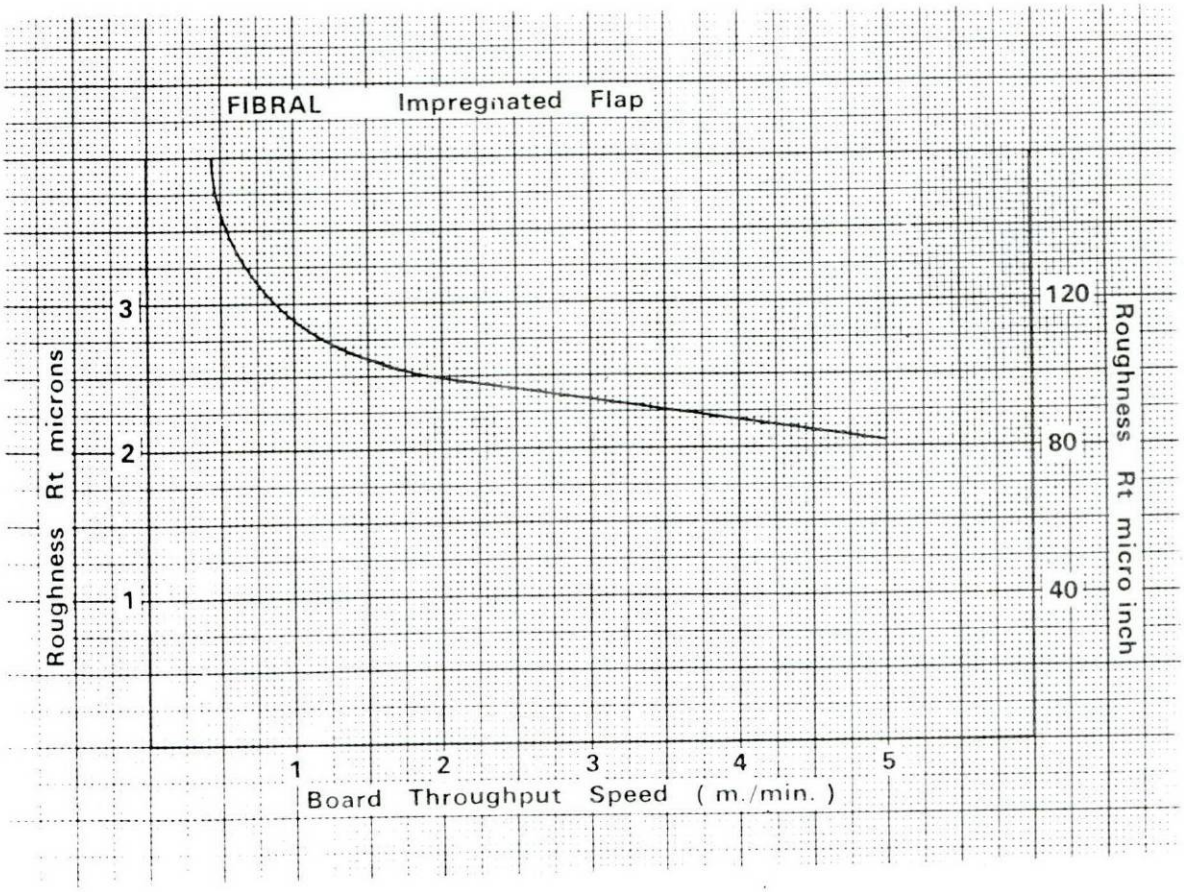
Aggression is inversely proportional to throughput speed.



(5) Effect of brushing pressure on surface finish



(6) Effect of throughput speed on surface finish



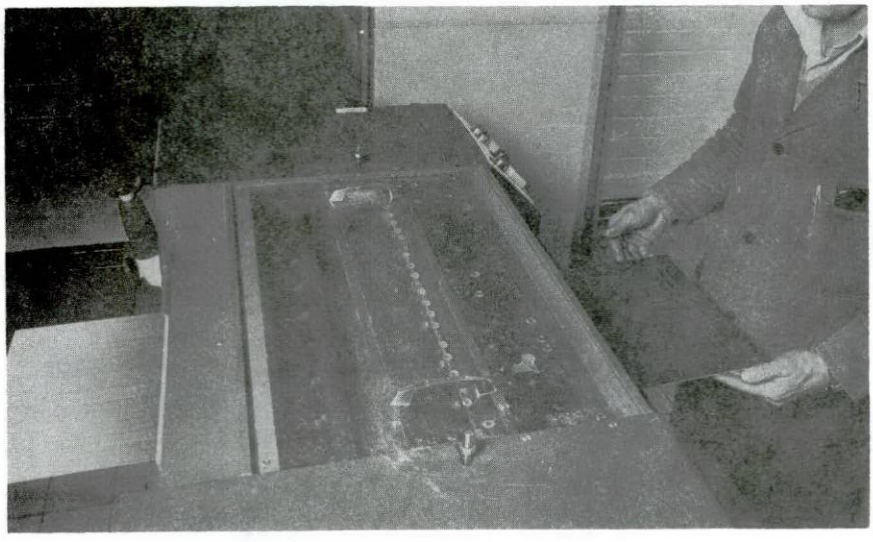


Illustration 7



Illustration 8

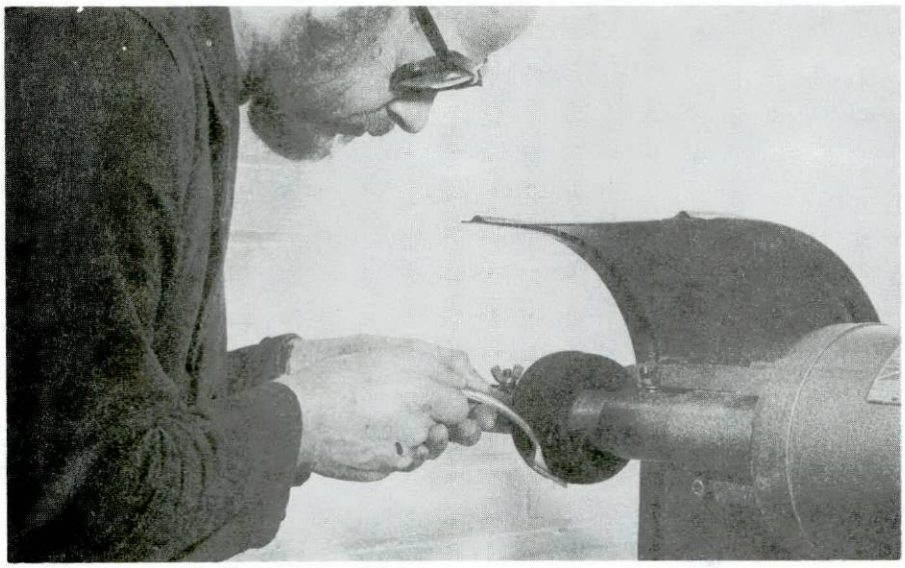


Illustration 9

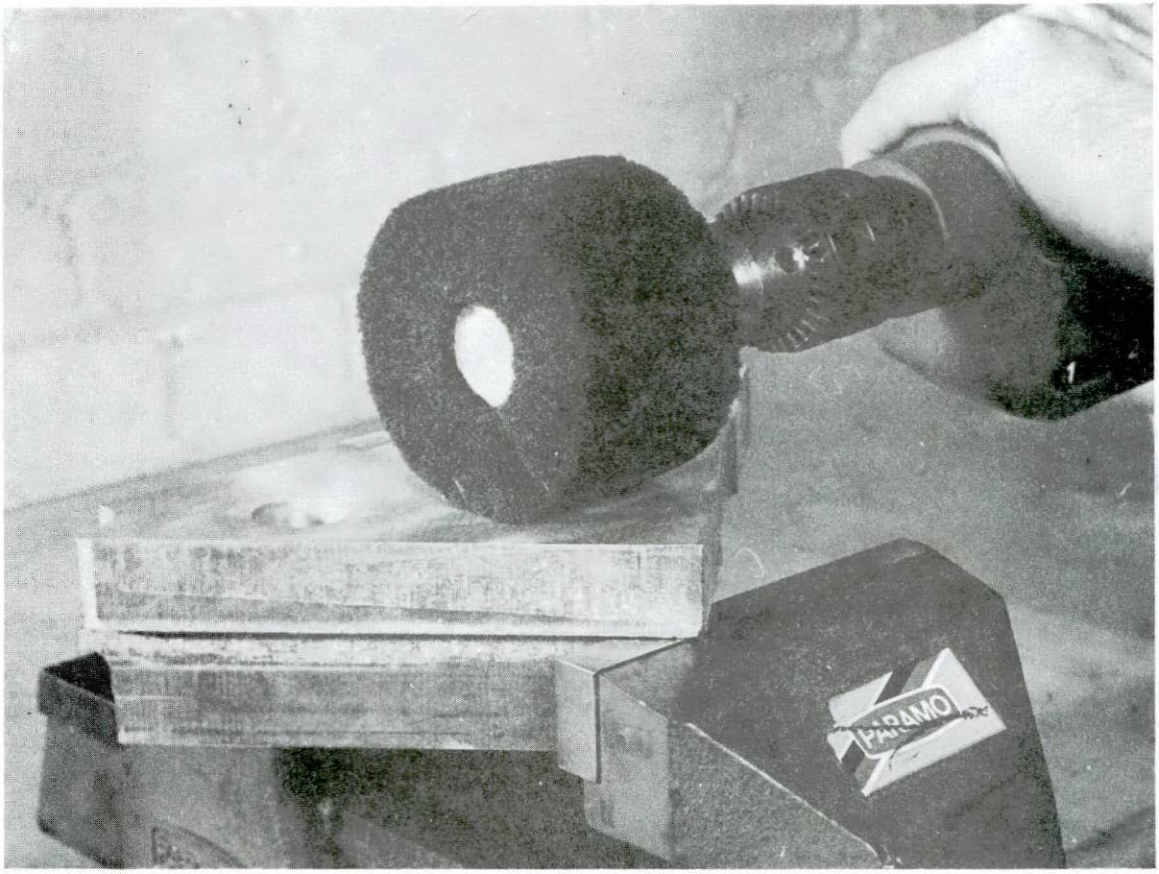


Illustration 10

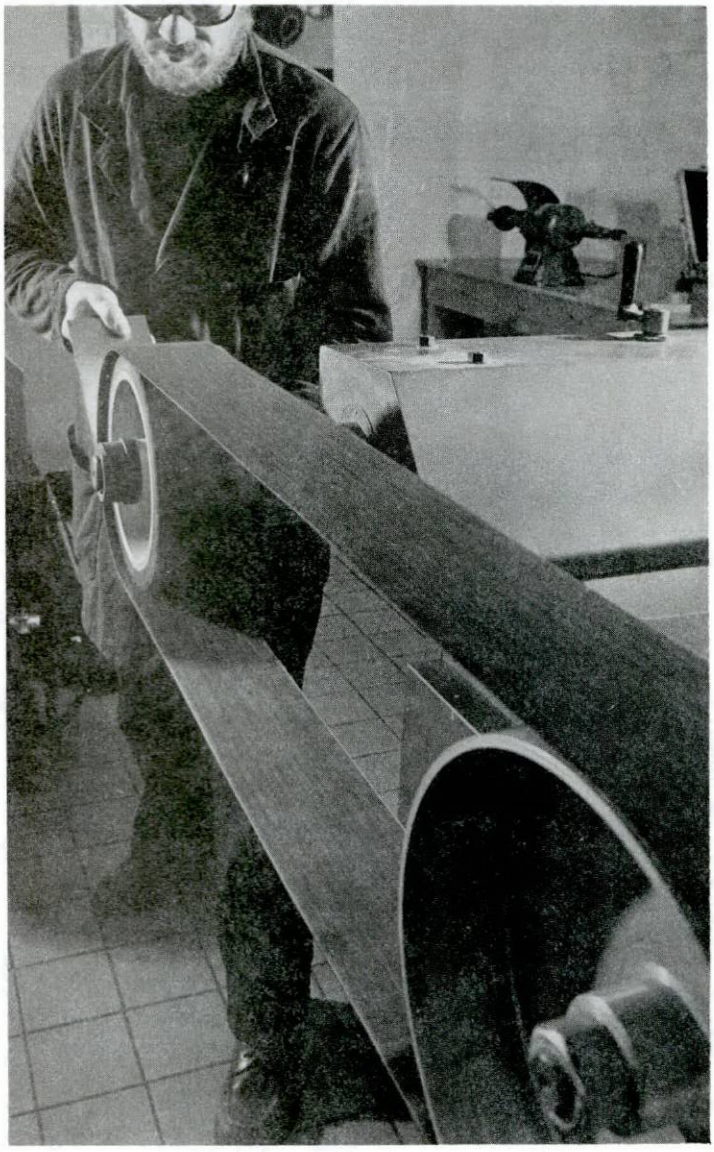


Illustration 11



Illustration 12

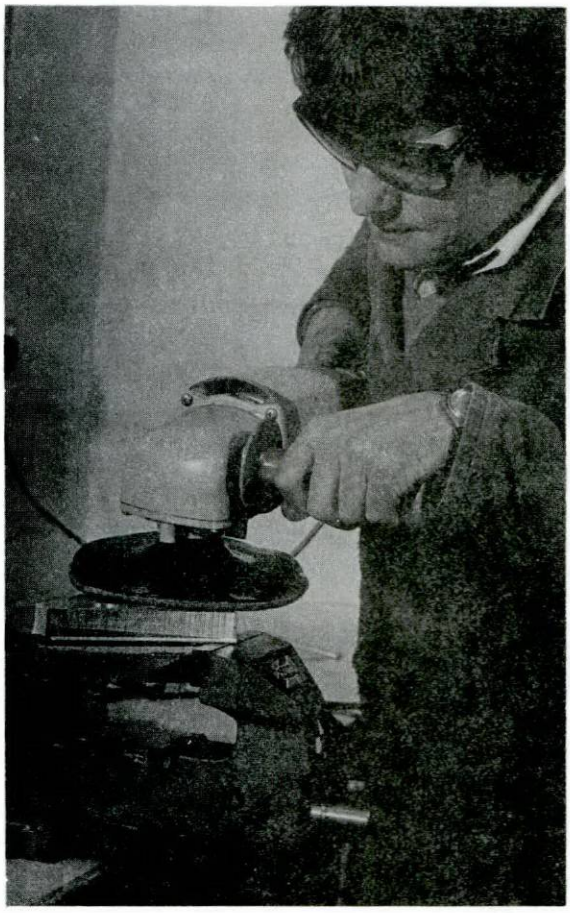


Illustration 13

P-3

Mechanical Finishing Session P

The Basic Guide for Buff Selection, Horsepower Required, Compound to Use

William A. Spicer
Jackson Buff Corp.
Conover, NC

THE BASIC GUIDE FOR BUFF SELECTION, HORSEPOWER REQUIRED, COMPOUND TO USE

William A. Spicer, Technical Engineer
Jackson Buff Corp., Conover, NC

The higher thread counts are used for heavy cut down work-
Thread Counts: 86/82, 80/80, 68/72

The lower thread counts are used for coloring, wiping or cleaning operations -
Thread Counts: 64/64, 64/68, 60/60, 48/48

Exceptions: Depending upon buff construction, some lower thread counts down to 50/60 3.15 weight are used for heavy cut on all metals. These constructions would be in the full disc variety with spiral or concentric sewing for an all purpose buff, but not always the best for high production efficiency.

Also, lower thread counts down to 48/48 are used in most constructions for plastics.

Constructions:	Bias Type	(Airway)
	Full Disc	(Conventional)
	Sewing	1/8, 1/4, 3/8, 1/2
	Density	(Type or Pack) Amount of cloth in each section.

Theory: The more cloth pulled over a given area at a given time, the more cut. (Example: The higher the ply, density, wheel speed and buff diameter, and thread count the more cut.

These materials are used for all metals on production items.

Use tripoli based compound on all cotton buffs and non-ferrous metals.

Cotton, polyester, rayon or cloth buffs are used on non-ferrous metals; such as: zinc die cast, brass, bronze, pewter, lead, copper, and most aluminum alloys, plastics, and for buffing nickle chrome and silver.

Sisal is a hemp material used mainly for buffing all ferrous metals. In theory, the higher the content of sisal the more cut. If used on stainless, normally all sisal is used. For cold roll, hot roll, carbon steels, blends of cotton and sisal are used. On cold roll, cast iron, semi steel, and softer metals use blends of cotton and sisal. On hot roll and carbon steels start increasing sisal content and wipe clean with an all cotton buff.

Compound: Use aluminum oxide based stainless steel compounds on all sisal and cotton and sisal blend buff for ferrous metals.

Treatments: Selection of treatments from soft to extra hard is basically the same guide as non treated buffs. The softest treatments are for extra body and thread lubrication to avoid thread breakdown under severe flexing and lapping for depth of cut up to 2-1/2 to 3 inches of over lap on multiple surfaces of edges, tops, protrusions on part to be hit with same buff at one pass. The less lap required the harder the treatment, in degrees, to correspond with the shape of part to be buffed. A flat surface with no overlap would require the hardest treatment. In most cases a dip treated buff has shown better compound holding qualities.

In selection of buff construction, treatments, diameter, center hole size, ply, and density, all important in efficiency - consider first - Quality desired, size and shape of part. Best equipment for the part considering hourly, weekly or monthly, or possibly annual requirements. After selection of equipment, consider best size (diameter) and construction of buff to perform the task.

Treatments are color coded, as in dip treatments:

Golden	Soft, Medium, Hard
Red W.S.	Soft
Yellow W.S.	Medium
Blue W.S.	Hard
*Black	Extra Hard

All treatments are used for cloth, or cloth and any mixture of sisal or all sisal except Black treated. *For sisal only.

P-4

Mechanical Finishing Session P

Mass Finishing Update on Pre-Plate Processes

John Coffield
Osro, Inc.
East Hartford, CT

MASS FINISHING UPDATE ON PRE-PLATE PROCESSES

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