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GRINDING AND POLISHING ARTICLES IN BULK:
Burnishing

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GRINDING AND POLISHING IN BULK

Burnishing

Under the general classification of "burnishing", the following techniques are included: the procedure of barrel burnishing, grinding, the newer procedures of pressure grinding in vibrators and centrifugal vortex installations. The older designation of "barrel grinding" no longer applies in the current state of the art. Each of the processes named above is based on the principle of friction between the work piece and the grinding body. The individual processes differ basically in terms of rubbing speeds. */818

One finds this surface processing form for metals, plastics and other materials, for the processing of individual pieces as well as production parts, not only in the galvanotechnical industries, but also in machining industry and metal working industries. Burnishing has found great use in the bulk finishing field and has been found to be economical (Figures 1-4).

The use of drum- and vibration installations has led to cost advantages in the processing stages of deburring, descaling, leveling of surface roughnesses, grinding and polishing, especially in terms of the consistency of results.

The development of drum polishing goes back into the past century. The requirements prevalent at that time for surface conditions were, of course, not as demanding as they are today. At that time, the processes were carried out dry with sand, lubricating oil, shredded wood (saw dust), and leather waste, or with the addition of petroleum or water. Now, generally the processes are carried out using water chemical solutions, so-called compounds, for the most part in single stages, but sometimes in multiple working processes.

Partly- or fully automatic processes are carried out in row,

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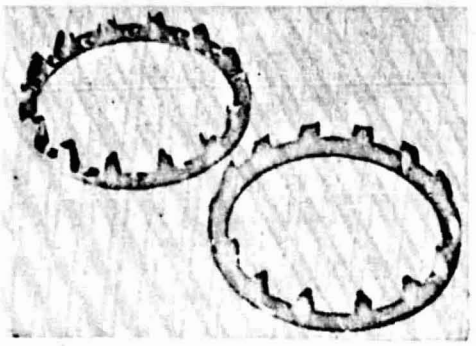

Figure 1. Parts after and before treatment in the Trowal process (Walther-Trowal)

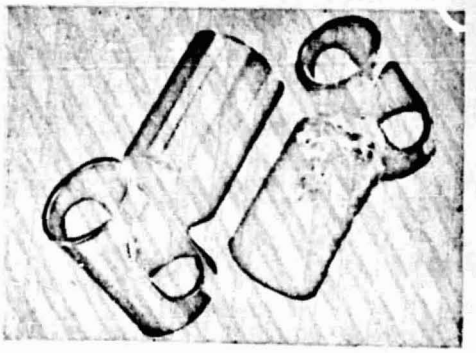

Figure 2. Sample of a Trowal processed part (Walther-Trowal, Wuppertal)

chain, or through-flow installations, in conjunction with separator- and drying installations. The requirement of the industry for efficient machines for burnishing its products is remaining strong.

Burnishing can be used for the processing of the smallest to the most complicated working pieces.

Which are some of the systems available?

Bells (also called tulips)

Table bells, mostly used for grinding and deburring of very small quantity-produced parts.

Drums

A system available either individually or in row-installations (Figure 5). Depending on the requirement and properties of the installation, drum installations can be utilized in the most widely differing dimensions for entire processing stages (Figure 6). The construction of the drums can be adapted either to very small or to very large production parts.

Vibration installations

Self-contained circular containers and troughs, as well as successive or jointly operated installations equipped with conveyor systems, both for single-charge operation, or for continuous operation for processing bulk quantities.

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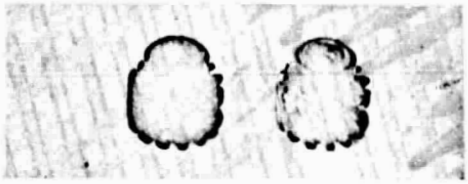

Figure 3. Deburring and descaling of drive gears in through-flow vibrators (Metal Company AG)

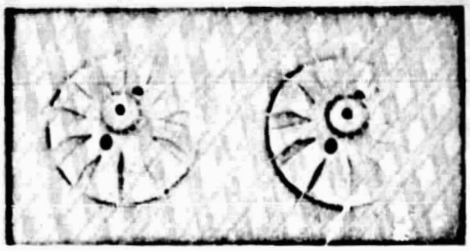

Figure 4. Zinc pressure casting (fan blade) processed in a roto-finish installation (Metal Company, Inc)

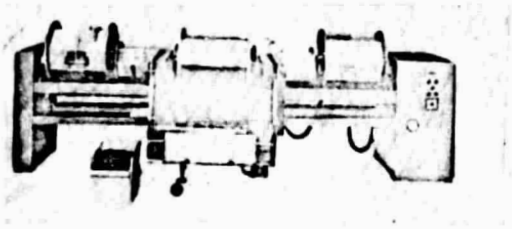

Figure 5. Drum installation (Dr. Engineer Manfrid Dreher)

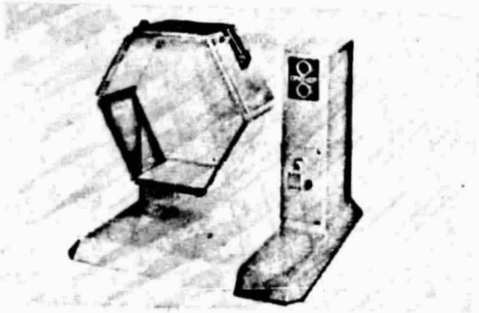

Figure 6. Laboratory Drum in a transparent cover version (Dr. Engineer Manfrid Dreher)

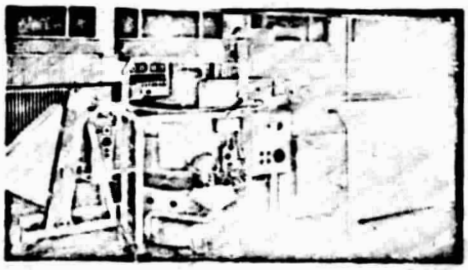

Figure 7. Vibrator with conveyer and separator/dryer (Walther-Trowal)

Figure 8. Roto finish-Osronaut (virbulator, centrifugal force installation, Metal Company, Inc)

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Figure 8a. The grinding and polishing drum installations of Menzerna, in the standard model, have a capacity of 120 liter. The burnishing vibrators are produced with capacity of 5 to 250 liters. Our photo shows the apparatus in the display at the Hannover Fair.

The availability of successively linked installations offers the advantage that it reduces the often substantial waiting time for filling, loading, emptying and separating. These times can easily exceed the actual operating time for individual machines and this time can be quite expensive (Figure 7).

Centrifugal Installations

These installations consist of a circular container with a rotating bottom (Figure 8). Centrifugal forces press the working piece masses against the wall of the container. In this field there is an indirect further development of circular container vibrators with almost double the working capacity.

A further doubling of the working capacity is achievable in connection with the centrifugal drum process (Figure 9). As a rule, there are four drums on a rotor plate, fastened in contra-rotating directions (cf. also Figure 19). Drum loading is carried out, in contrast to the ordinary procedure, by means of a quadratic container.

Drum installations

are furnished with chucks on their interiors which hold the work piece in place.

General process technology

It is the movement of the container that the difference among the various processes lies for the sake of achieving the grinding and polishing work. With each of the processes, one can determine the work capacity. The answer to the question as to whether a corresponding reduction of working time can be achieved economically through more highly developed burnishing machines, can only be obtained from the utility of the surface condition which is achieved.

In very general terms, virtually all materials and working pieces are suited for processing in burnishing procedures, limited only by the size and shape of the installation.

As a practical matter, one cannot always accurately predict how a raw part will behave in a particular grinding or burnishing operation, that is, whether it is suited for a particular operation. Fine and usable surface qualities can only be achieved when the rotating speeds of the drums or the superimposed vibrations are exactly adjusted for the material to be processed.

There is substantial importance in the choice of burnishing material (grinding objects or chemicals), the type and form of the grinding bodies and the composition of the chemical additives used for the material. These together have a bearing on the success of burnishing.

A particular burnishing operation requires, depending on the necessary surface quality of the finished piece, one to three processing stages. For example, it is possible to go from preliminary grinding to final grinding without removing the pieces from the apparatus, but simply by filling and changing chemicals. The grinding bodies themselves may remain.

It should be noted that for an individual process, a qualitatively good surface depends on the intensity of the grinding, burnishing or polishing, as well as on the interaction of mechanics and chemicals

and on the type of the installation (Figure 10).

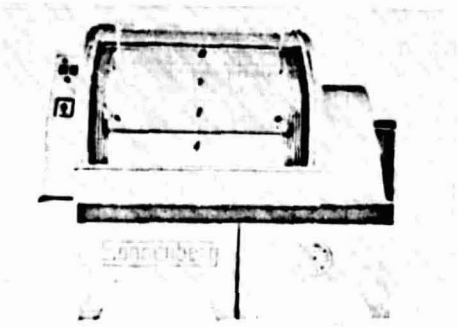

Figure 9. Large centrifugal drum machine (Sonnenberg, Pforzheim)

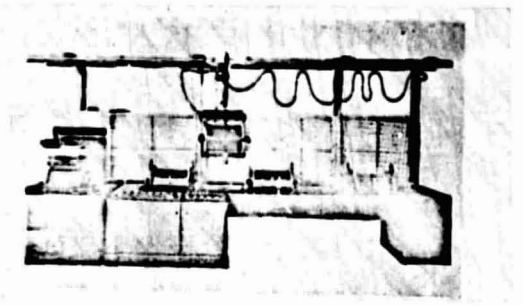

Figure 10. Partially automatic drum path with crane lifter, loading apparatus and separator stretch (Dr. Engineer Manfrid Dreher)

In drum burnishing, the working process is decisive more than the length of the process. Insofar as running times play a subordinate role, the drum installations are not inferior to the centrifugal or vibration installations (Diagram 11).

Servicing, filling, emptying and separating is generally carried out well with the aid of special servicing apparatus (servicing scales Figure 12).

The operational flexibility of the multiple drum installation is clearly evident in the fact that the most disparate work pieces can be processed simultaneously. In each individual drum, different form parts can be held for processing. It is possible to take any individual drum of a multiple drum installation out of operation at a predetermined time, without affecting the other drums, and then to put that drum back into operation.

This basic process of burnishing generally furnishes a visibly finer surface condition than is the case for objects processed in vibrator installations. The more gentle working process speaks in favor of the drum process. The drum shape (four- and six- cornered form) and the rotating speed can be selected according to the type of effectiveness which is desired.

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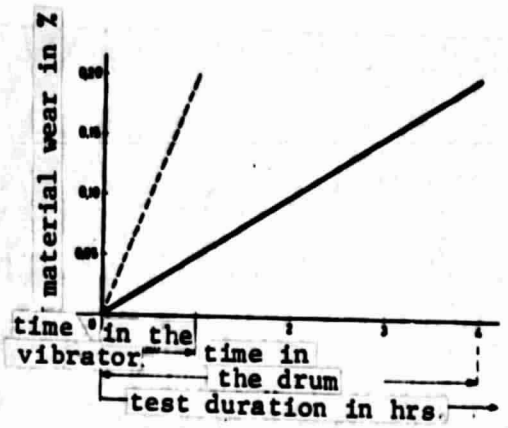

Figure 11. Comparison of results after tests in the drum and in the vibrator

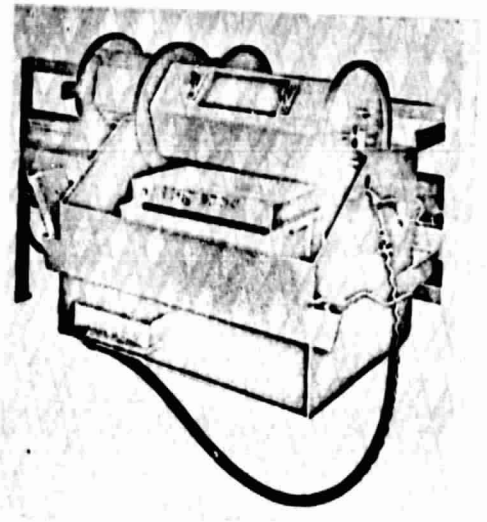

Figure 12. Filling a drum taken out of the installation, with the aid of the servicing cart (Dr. Engineer Manfrid Dreher)

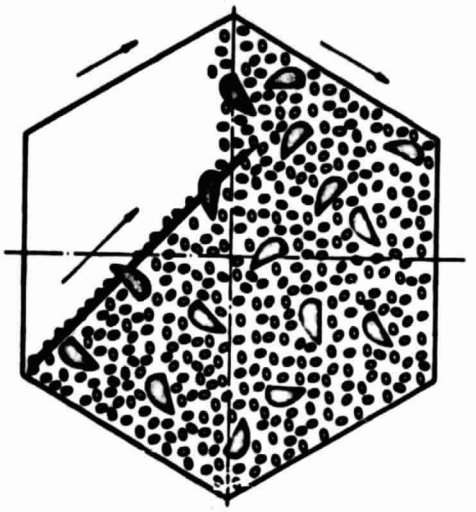

Figure 13. Schematic diagram. The shaded area is where the work is actually carried out

The smaller the dimensions are, the smaller the dead zone in the drum. The dead zone is, of course, unavoidable for purely physical reasons and cannot be eliminated completely. Work is carried out only in the rolling zone of the drum (Figure 13). Smaller drum dimensions provide an advantage because they are able to work with higher rotating speeds. It remains unalterably true that no burnishing action takes place in the rest zone area, due to the laws of physics and the movement properties of the masses. The contents of the drum are lifted by the turning movement of the drum and only a portion of the contents slides back down after reaching the angle of repose.

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In order to achieve the highest possible efficiency in the drum, it is necessary to know exactly what takes place in the drum. The working material--total filling volume--works most intensively at a fullness level between 60 and 70%. Of course, smaller or larger loads can also be used. Series of tests, using the most disparate forms of pieces and processing stages, including the most favorable rotating speeds, led to the conclusion of how the apparatus can be used most efficiently.

An indisputable "correspondence relationship" is exhibited by the bell drum which is sometimes known as a "tulip" (Figure 14).

These devices, which usually exhibit an eight-sided, double-cone form, possess efficiency advantages in comparison to the usual individual drum, advantages which originally are attributed to the form of the bell drum and to the fact that the rotating axis is tilted. The material being processed is lifted both by the slanted running direction and also by the trapezoid form of the sidewalls. An additional falling together takes place after the collapse of the material into a middle rubbing area. This interaction necessarily increases the abrasive effect.

A direct increase of grinding pressure can be brought about by increasing the rotating speed. Staged controlled drives make possible speeds between 15-60 rpm. Emptying the bell is easy to accomplish by simply tipping the contents out. This drum form is utilized commonly as a dryer, among other uses.

Distinct differences in material wear are exhibited by the individual processes. Thus, there is approximately twice as much material rubbed away in a unit of time in a bell drum as in the other type of drum. A further significant acceleration of rubbing away is caused by vibration.

The rubbing movement in the vibrator, as well as the required pressure between the working piece and the grinding bodies, causes

Figure 14. Bell drum

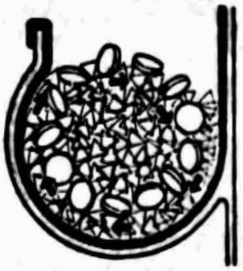

Figure 16. Transport scheme of a circular container, vibrator (Metal Company, Inc)

Figure 18. Direction of movement in the virbulator

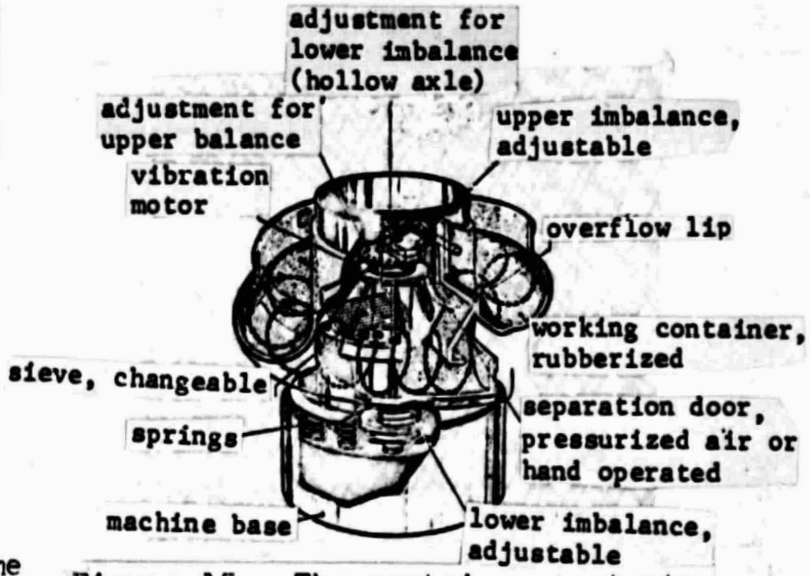

Figure 15. The container contents move in a spiral form form in the direction of the arrows (Metal Company, Inc.

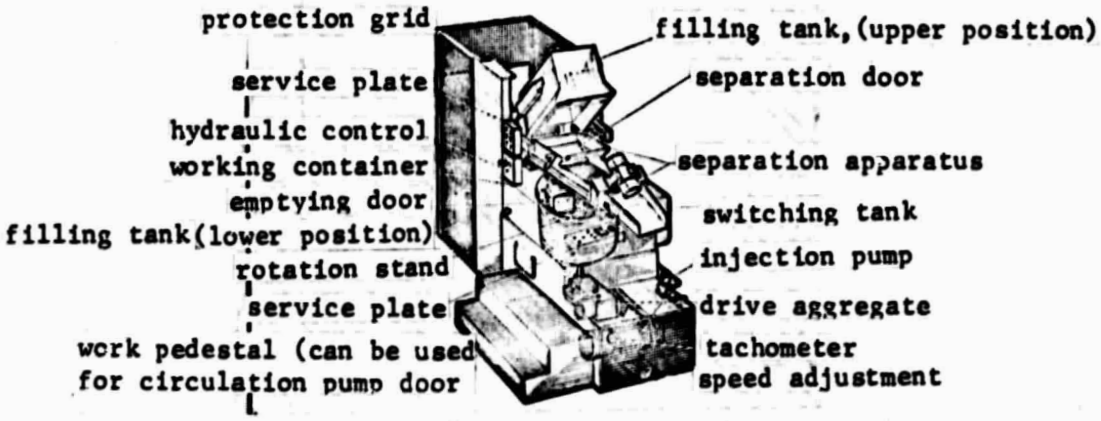

Figure 17. Schematic diagram of a virbulator (centrifugal burnishing installation Roto-Finish-Osronaut)

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a further acceleration of material rubbing away. The filling of the apparatus with work material and grinding material does not lead to any direct rotation in contrast to the drum. For this reason, the containers are given a movement rhythm by means of vibration. This is generated by a movement device with an adjustable imbalance (Figure 15). By this means, the grinding bodies and the work pieces are set into movement as a whole (Figure 16). Grinding material and the working pieces vibrate against each other and thus abrade one another.

Therefore, the efficiency is substantially higher than for the drum process. The oscillating movement of the grinding bodies and the work pieces against each other causes the entire contents of the installation to work interactively and causes the entire contents to rotate slowly through the container at a speed determined by the rolling movement, by the imbalance frequency and by the vibration amplitude. In contrast to the ratio in the drum, there must be a higher percentage of grinding material surrounding the work pieces. The increased intensity of the grinding capacity causes the danger of possible hammer impact in the microscopic range on the surface of the working parts, or even so-called scaling. That means for inexact adjustments, a very high pressure is brought to bear on the working part masses and this can lead to surface damage. It is absolutely necessary to have a careful adjustment of vibration frequency and imbalance, especially in the case of sensitive working parts. Purely from an economic point of view, it is necessary to work with high vibration frequencies. The container is attached to a rotating floor. The rotation of the container floor causes a flow of the container contents toward the container wall. The work piece masses are thus pulled to the wall and delayed and, simultaneously, they are set into a rolling movement by the subsequent forcing of other radial forces from the rotating floor. The requisite grinding pressure between working piece and grinding material is supplemented by the centrifugal force (Figure 18). The high intensity of grinding power generated in this way is especially well suited for the deburring of hard metal parts.

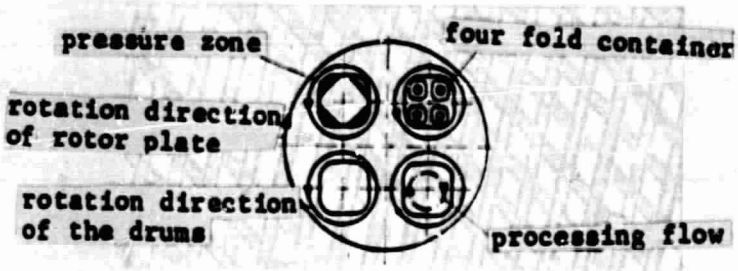

Figure 19. Working principle of a centrifugal-drum installation (cf. also Figure 9). Key: 1--pressure zone; 2--rotation direction of rotor plate; 3--rotation direction of the drums; 4--four fold container; 5--processing flow

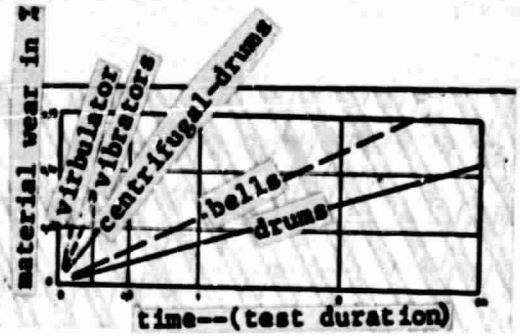

Figure 20. Efficiency diagram of the various burnishing methods Key: 1--material wear in %; 2--virbulator; 3--vibrators; 4--centrifugal-drums; 5--bells; 6--drums; 7--time (test duration)

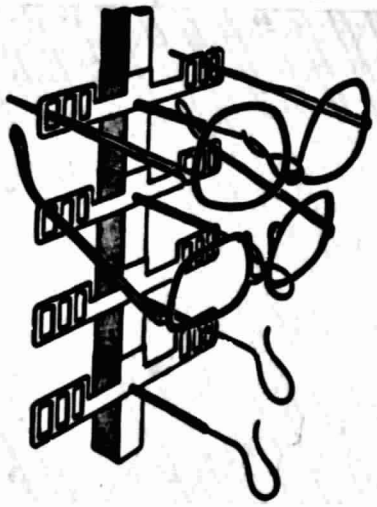

Figure 20a. Multiple holder for eyeglass frames (Menzerna Works, Karlsruhe)

Figure 21. Forms of grinding bodies (Metallgesellschaft AG)

A further innovation in the last few years in the field of burnishing machines is provided by the centrifugal burnishing installations working on the drum principle. I mean to say that this is an important further development which shows special promise for processing in the sector of the most minute parts. This process is represented schematically in Figure 19. On a vertically running rotor plate, four drum containers are mounted in a radial array, each rotating in the contrary direction. While, for example, the rotor plate is rotating in a clockwise direction, the drums are rotating about their longitudinal axis in a counterclockwise direction. This contrarotating running movement causes an eccentric pressure

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of the contents of the drum on the container walls. The contents are folded into themselves by the rectangular form of the drums. The grinding work is caused, so to say, by pushing zones, generated by the rectangular form of the drum indirectly against the container sides. The tumbling which might be expected does not occur, since the parts are held against the walls by centrifugal force. It is true, however, that tumbling of the working parts cannot be avoided if rotating speeds are low. In the same way tumbling cannot be avoided if four small containers are used in the drum. In such installations it is important that the rotating speed (which is generally to be adjusted without any stages) be adapted to the mass weight of the volume of the drums.

The filling of such installations is also solved in an advantageous way. The working pieces are loaded into wide-necked flasks with corresponding grinding bodies and compounds. These are closed with screw caps and are placed into the horizontally lying drum containers. Four of these flask containers, carrying a proportional weight, can be loaded into each drum, that is to say, 16 can be loaded into the entire apparatus. During the time that one load is running, the next flasks can be in preparation. The interchange of the loaded flasks is carried out simply by the release of the safety catch. The flasks can be removed and reloaded without losing time for separation and filling. These work stages take place outside the machine's running time.

While the drum-centrifugal-installations rank behind the vibrators in terms of efficiency (by presently available standards), they do provide finer surface quality. And the virbulator ranks ahead of the vibrators (Figure 20).

Finally, it is necessary to mention the drums with work piece holders mounted on the interior of the housing. This is a special machine for the processing of very sensitive products, such as eyeglass frames among other things. The danger of deformation in such products is especially large and they are not well suited for simple tumbling action.

Auxiliary materials

As has already been mentioned, effective work in the burnishing process takes place as the grinding bodies abrade the work piece. The grinding body thus is the auxiliary tool for carrying out this work, as are the chemicals.

The selection of grinding body size, granulation and form, is made in the first place according to the grinding effect desired and the form and development of the tool itself. For each workpiece form range, and for each processing method--and it is inconsequential what kind of installation is being used--there is an ideal grinding body form (Figure 21). Type and size influence the course of the work and the abrasion. In addition to naturally formed shapes and bodies, there are ceramic and plastically formed grinding forms which are used. Generally, steel bodies are used for polishing, usually balls, but sometimes a communicating body made from a high value zinc alloy is used. These latter are used mostly for polishing products made of hard metals (hardened steel, etc.). The small brilliance yield for steel, even in case of very long running times, is greatly improved by the soft zinc material.

In general, plastic-bonded and ceramic-bonded grinding bodies are to be preferred to natural ones. Microfine metallic oxides are used in the manufacture of plastic grinding bodies. Sintered oxides on the other hand are used largely in the manufacture of ceramic bonded grinding bodies. According to the composition and size, the most varied imaginable grind values are attainable. One must add that the material transport, in the same way as the wear of the grinding body, is increased the higher the cutting speed is. The grinding body which keeps the same grinding properties in a certain size range, is to be differentiated from the new, even sharper edged chip which understandably acts more intensively.

Faulty results arise as a rule where overly used and badly maintained cutting bodies have been used. In this case prevention plays a very significant role. The best care for already used chips is

achieved by maintaining them in plastic containers with a weak wetting agent or compound solution. This also applies over the short term for steel grinding bodies. These need a "running feed" in a low percentage citric acid solution before being re-used.

Basically, the effectiveness of larger chips is always better than that of the smaller ones because it is possible with them to achieve a more rapid processing, that is, a quicker surface smoothing. It would be nothing new to remark at this point that the energy mass of larger bodies works more intensively than that of smaller bodies.

For sensitive parts, it is preferable, however, to utilize smaller mass weights. Certain problems always arise in the selection of grinding body sizes. These have to do with the form of the working piece.

For complicated work piece forms, it cannot always be prevented that the grinding bodies get caught in borings, cavities and passages. On the one hand the cutting bodies cannot be chosen so large that the hidden parts of the product are not reached. But, on the other hand, they cannot be too small lest the working duration become too long. In case of need, both large and small grinding bodies can be used together to achieve the desired result. One then achieves much better deburring results, and highly sensitive products thus maintain their precision. If one works only with larger grinding bodies, there is the danger that fine seams are the only ones really affected and hidden surfaces do not get touched at all.

In addition, it is sensible to separate out the grinding particles which have become too small over time--they are, of course, too small to be effective. In part, one can eliminate the addition of grinding bodies and simply add compounds. Then the product parts simply abrade against each other. The separation of working parts and processing bodies thus does not have to take place. Such a working process is not well suited for quality surfaces.

Also a part of the process are the chemicals, because burnishing is not only a purely mechanical but also a mechanical/chemical process. Chemical materials (compounds) can be weakened or strengthened according to the purpose for which they are used for grinding. Among their effects are a metallically pure surface and partially corrosion protection as well. They also bond and this is a substantial factor in the rubbing off of grinding bodies and of the metal. Furthermore, the compounds carry out further functions in the course of the process technology. For example, they serve for brightening surfaces, or even as grinding material. In the latter case, it is only finishing properties that are important.

The processing chemicals can be divided into

1. descaling concentrates
2. compounds with additives which increase grinding action
3. compounds without additives for increasing grinding action
4. shine and polishing materials

The pH values of the compounds are generally given for the individual processes, such as de-rusting, descaling, deburring, corner rounding, pre-grinding, fine grinding, brightening as well as shining and polishing, by the manufacturers themselves. They are adjusted for the metals or materials to be treated.

The grinding particles generally behave in a neutral manner to the chemicals. They neither change nor dissolve in their presence, but only in the course of grinding work. However, steel polishing bodies do react to chemical additives.

The chemical mixtures too are constantly being improved for almost all types of uses. Some of them are available as concentrates. The usual thinning ratio with water is 1:4 or 1:10 but this can be altered as needed. The correct dosage, storage and handling of the concentrates provides cost advantages.

Burnished products are not only galvanically processed, but also are soldered, welded or polished. Thus, the metal surface needs to be physically and chemically clean not only for optical reasons. If several processes are used one after another, the compound which has been used must be completely removed. The cleaning process must be carried out quickly in order to prevent chemical impurities and reactions on the working piece surface before the next processing stage.

In order to prevent corrosion formation between the individual work stages, wetting compounds are usually included in the compounds as emulsions. If this is not the case, it is sensible to add wetting agents onesself.

The buffering effect of water--since grinding particle mixtures contain water in prescribed quantities as well as the chemical processing agents--is required to a greater or lesser degree by the processing agent. For the burnishing of very sensitive materials, the buffering of the water is not in itself sufficient. For special work in this field, it is necessary to use special compounds which amplify the "buffering" of the water.

It should be noted at this point that in the vibration installations, the addition of too much water causes a floating and simultaneously a separation of the working material from the plastic chips. Movement, or rolling movement, or grinding, is effectively eliminated by the floating.

In the case of the addition of chemicals, waste water regulations must be observed. For this reason, chemical mixtures are being offered today which contain no poisons such as nitrites and chromates and which do not contain detergents which had until recently been included as inhibitors of the compounds. Today organic substances which are up to 80% biodegradable have replaced the damaging substances just mentioned. In this way, waste water treatment requirements have been reduced. Often it is sufficient just to treat the waste water with a neutralizer, chalk, for example, or soda, before

releasing into waste channels, especially in the case of descaling agents.

In vibrations- and in drum installations, work is generally carried out with fluid compounds in all stages; of course, powders can also be used. The chemical mixtures can be brought to the installations in various ways:

a) through a spray apparatus for fluid compounds, with the use of feed pumps,
b) by means of vibration feeds for pulverized compounds, and
c) by hand, with measurement scoops.

The re-use of compounds after they are first used, for the following work stage, does indeed save the cost of a second charging with new chemicals. But it has been shown that there is about a 40% reduction in effectiveness and a similar pollution of the materials, of the grinding bodies and of the installation. This has an effect not least of all on the waiting times and the accuracy of results. Thus for instance, there are additional cleaning stages necessary and if other machinery is operated so that its timing depends on the regular operation of the first machine, time is lost by irregular schedules. It is true that when fresh chemicals are used for each stage, it takes greater quantities of chemicals, but this cost is balanced out by the greater efficiency and machine life and smaller waiting time, where fresh chemicals are used.

The removal (separation) (Figure 22) of product parts from the various installations should be carried out quickly for the sake of avoiding lost time. In order to achieve a reliable separation of working pieces from grinding bodies, the sieve mesh must be so selected that the grinding body is smaller--in case of necessity, reversed--than the product. For the very smallest pieces--with the exception of nonferrous parts--separation by magnet is usual. The impact marks which are much feared on the surface of the product itself as well as occasional deformations, come about usually when the objects are poured into the containers, or when they are emptied

cut of the containers into the separator stretch. Therefore, the product pieces should not simply be poured out of the container ihto another container lying on the floor. If the pieces are rather poured out over a ramp, they will simply slide into place and most of the impact damage on the pieces is easily avoided (Figure 23).

Figure 22. Separating grinding bodies from work pieces directly above the work container (Metalgesellschaft AB)

Figure 23. Product pieces drawn out over sieve ramps in a fully automatic operation (Metalgesellschaft AG)

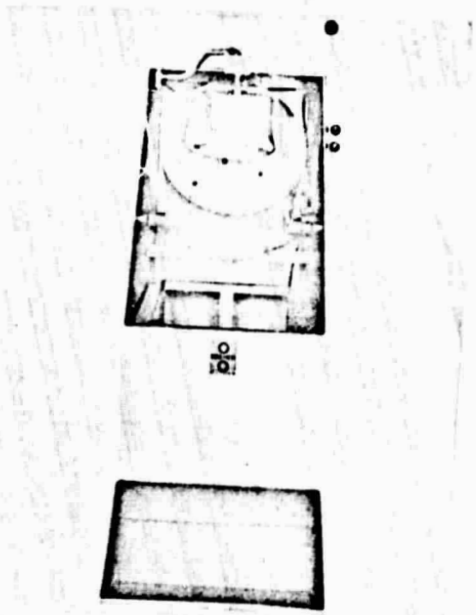

Figure 24. Infrared drier (Dr. Engineer Manfrid Dreher)

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For further processing of the product, it is not always necessary to have a drying process. Sometimes the objects are brought to the next stage in a wet condition. When the objects are presented wet, for instance, for galvanizing, there is the advantage that there is no corrosion, insofar as wetting agent solvents were used in the previous stage. This wet presentation may only be used where a short period ensues before the next stage. As a rule, the parts are dried after removal by means of shredded wood or hot air driers (Figure 24).

Often it is sufficient to have a dipping action into hot organic solvent (for example, perchloraethylene). If shredded wood driers are used, it is essential that dust-free and abrasive-free saw dust be used. These driers are either driven by hot air or by infrared radiation.

The processing of bulk parts, of course, involves questions of cost. The running costs for burnishing processes are usually composed as follows (without including investment in the installation) (without considering depreciation, interest and land costs):

Capacity data of the installation, etc.
Salary costs
Grinding material purchase and wear
Chemical additives and their loss
Water and power usage
Cost of materials for product
Processing time, separation and injection times, drying time

Further, the time segments for filling and emptying must be included.

Some additional points seem worthy of note in connection with the question of costs. As complication increases in individual installations, the expense also increases. It is true that in these cases grinding and polishing takes place at a faster rate.

But does this increased capacity stand in a favorable relationship to the increased investment? The form of the work piece is not always the deciding criterion for the choice of the installation. Rather, the series of production pieces which will be processed should be considered as being most significant.

In conclusion, it must be said that the most certain guarantee for the success of a burnishing operation is cleanliness. The vibrator of the drum is no cleaning apparatus. It is only designed to refine the outer surface. Failures in these opersations can also take place in event that chemical additives and grinding particles are used which are not sufficiently adapted for the work pieces.