As a manager in a manufacturing organization there is a three word chant that we will always hear coming from the boss, no matter how good a job we are doing, . . . it is: Better, Faster, Cheaper! These are the never ending goals of a manager in the pursuit of excellence in the manufacturing process. Continued improvement in the areas of Quality (Better), Increased Product Throughput (Faster) and Cost Controls (Cheaper) are the keys to progress in any organization, especially a manufacturing organization. Any manager who adopts these goals as his own and finds ways to progress toward these goals will ultimately find success in the organization. The primary focus of this paper is the “Better” (Quality Improvement) part of this triad. Furthermore, this paper will show how quality improvements can also positively effect the other two areas of “Faster” and “Cheaper”.

First, we need to define what it is that we mean by “Better”. As we have already indicated this means “Quality Improvement”, but even this term is not descriptive enough to help us in any meaningful way. If your boss said that he wants to “improve the finish of your aluminum extrusion, . . . or your steel stamping, . . . or you zinc die cast (or whatever part you are finishing) he could mean one of two things: (1) Improving the “Appearance” of the part, which usually means reducing the surface roughness, or (2) Increasing the Consistency of the part . . . from batch to batch, week to week and month to month.

We will first consider methods to reduce the Surface Roughness of the part in order to increase the appearance of the part. For most metals this will require mechanical finishing such as polishing or buffing in order to produce a higher luster to the part. This can then either be the final finish of the part or the last step before plating the metal.

A. Reducing Surface Roughness

While the bulk of this paper will deal with buffing the work piece, it is critical that the condition of the part prior to buffing be addressed first. The largest single contributor to surface finish is the preparation of the part before it is buffed:

1. Preparation of the Work Piece

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In many applications it is necessary to polish the part before it can be buffed (i.e. use an abrasive that will actually do stock removal -- this is often an abrasive belt or FLAPWHEEL). This abrasive operation can make the buffing steps considerably more effective and efficient if they are done properly, but it can also be the cause of potential problems. In order to keep these problems from occurring there are several pitfalls to be careful to avoid:

**Right Sizing**

- “Right Sizing” is a term borrowed from the computer industry that counters the long time axiom in the industry that “bigger is better”. “Right Sizing” suggests that the components of a system be large enough for the job that they are intended *(and no larger)*, while keeping flexible to possible future changes with a minimum of extra expense. In applying this idea to metal finishing, it becomes clear that it is critical to use the correct grit size to do the job -- too large and the grit lines produced in the part will be much more difficult to get back out -- too small and it will take too long to do the necessary job. Therefore, every stage in the finishing operation becomes critical, needing to take out the “scratches” from the previous stage and prepare the part for the next stage. If any of the components fail, then it will produce a less than desired finish on the part.

**Do Not Skip Steps**

- One of the easiest mistakes to make in the finishing operation is to skip polishing steps in order to save time. For example, you find that by using a 150 grit abrasive belt you are able to easily remove all of the grain marks from your stainless work piece. Then, you try to use a 320 grit belt to remove the 150 grit lines from the previous step. Often in this situation the operator looks at the part, sees a uniform finish and therefore feels that all the heavy (150) grit lines are removed... but they are really only masked by the 320 grit lines. Then, when the part is buffed some deep scratches appear in the surface of the metal. This is often interpreted as "the buff is being too aggressive" or "the compound must have some cut grain in it". It is easy to see that an unfortunate “short-cut” made early in the process may confuse and complicate the process much further down stream. Actually, what is needed is an intermediate polishing step (say a 220 grit belt) to truly take out all of the 150 grit lines and prepare the part for the 320 grit step.

A typical comparison of these two finishing operations is indicated below, the left column is using the method that does not produce an acceptable finish and the column on the right does produce a good part.
Above is a chart that shows how it may be possible to not only improve your finish but also decrease the cycle time (i.e. the time of the longest step in the process) for the finishing operation by using the proper polishing sequences. So an effort to save time truly caused the cycle time for the part to be finished to be increased. It takes some effort to find the proper steps to minimize cycle time, but this type of "balancing" of the finishing steps can lead to significant increases in production, especially for automatic equipment.

### Chart #1

<table>
<thead>
<tr>
<th>Unacceptable Finish</th>
<th>Time</th>
<th>Acceptable Finish</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 150 grit belt</td>
<td>25 sec</td>
<td>1. 150 grit belt</td>
<td>25 sec</td>
</tr>
<tr>
<td>2. 320 grit belt</td>
<td>20 sec</td>
<td>2. 220 grit belt</td>
<td>15 sec</td>
</tr>
<tr>
<td>3. Cut Buff</td>
<td>45 sec</td>
<td>3. 320 grit belt</td>
<td>15 sec</td>
</tr>
<tr>
<td>5. Color Buff</td>
<td></td>
<td>5. Color Buff</td>
<td>5 sec</td>
</tr>
</tbody>
</table>

**Total Time** 100 sec

**Cycle Time** 45 sec

**Total Time** 90 sec

**Cycle Time** 30 sec

2. **Adjusting the buff operation**

After the part is properly polished before the buffing operation then it becomes the job of the buffs and compound to remove the final scratches and bring up the natural reflectivity (color) of the part. This is easily accomplished by using various buffing wheels and buffing compound; while this is important, do not overlook the effect of buff direction on the metal finish as well.

**Remember "Cut" and "Color" Strokes**

- A simple but extremely important method of improving the surface finish of the part is to remember to use cut and color motions whenever possible. This refers to the direction that the work piece is moving with respect to the rotation of the buffing wheel. Moving the work piece in one direction can produce a very different result when compared to moving the work piece in the opposite direction. When this is properly understood it can be applied to all types of buffing operations, whether off-hand or on an automatic buffing machine these basic principles still apply.
Cut Buff Operation

Cut Buffing - This type of buffing is very aggressive in removing fine grit lines and it leaves the surface of the metal smooth and dull. It also may leave noticeable amounts of compound residue on the part. A firm buff is usually used for this operation.

Color Buff Operation

Color Buffing - This type of buffing can achieve a high luster with a very clean work piece surface. Even when using the same buffs and compound that were
used in the cut buff operation, a very significant luster improvement can be achieved by changing the rotation of the buffing head (or the direction of the work piece). Most often, though, a soft buff (80/80 cotton or flannel) is used in this operation.

B. A More Consistent Finish

Many times when you are asked for a "better finish" you are really being asked to provide a more consistent finish. By providing a more consistent finish you will be eliminating the production of parts on the finishing extremes . . . both "lower" and "higher" than the specification as shown below.

Typical Surface Finish Curve

Tightening the Specification

You will note that because of the skewed Surface Finish curve in most buffing operations, a more consistent finish will reduce far more of the "poorly finished" parts than the "highly finished" parts.

It is not difficult to get everyone to agree that a more consistent part is desirable, but the problem is how to get the increased consistency. The key to any effort to improving consistency or quality must be implemented through a comprehensive Quality Control Program. While many of the factors surrounding the surface finishing techniques (as described in section “A”) are very dependent on the technical abilities of the operator doing the finishing, the factors to produce a
consistent part lie squarely in the hands of the manager. He is responsible for setting the specifications and making sure that they are properly followed. He is also responsible for maintaining and interpreting the data that is collected from the quality process. He is also responsible for taking the appropriate action(s) when an "out of control" or "out of specification" condition arises.

George Urban, an expert in implementing Quality Control Programs into small and medium sized operations has estimated that only 40% to 50% of the total quality of a manufactured product can be controlled by the typical manufacturer within his own processes. The other 50% to 60% is controlled by his vendors. This means that even if you had complete control of the quality within your plant, you would be doing at best only half the job. It would be like fixing only half the holes in your boat before you take it for a ride out in the lake. Until you fix all the holes the result is always the same . . . you get wet! That is why it is important to extend your Quality Control program to your vendors -- to plug all the holes.

In order to start implementing a Quality Control Program it is important to first set the specifications that are necessary toward accomplishing your goals. Closely working with your vendors will go a long way toward accomplishing this goal. Your supplier should be willing to work with you in setting up the vendor Quality Program because you are a more valuable customer if you remain competitive, strong and growing.

What then are some of the ways that you can begin to implement a more comprehensive Quality Control Program? What are the functions and important characteristics of buffing wheels? What is the best way to measure these characteristics?

There are several parts to a buffing wheel, but none is more critical than the cloth used in making the buff. Therefore, there are two primary aspects to consider when checking the quality of a buffing wheel: (1) the cloth itself, and (2) the amount of cloth per buff. First, we will look at the specific cloth used in buffing wheels. There are many different types of cloth being used in buffing today. Some materials are good for one type of application and some are good for others. There is to date no single cloth that will "do it all"! In fact the trend is to use a specific type of cloth that works best for you. This is where Quality Control Cloth Tests come in to assist you.

1. The Type of Cloth

-There are basically three components of cloth that should be measured on a statistical basis: (1) thread count, (2) cloth "hand" or stiffness, and (3) the
people use a specific magnifying glass with a 1" rule marked on the base and a sliding pointer to help follow the threads. While this is quick and simple, there are some things to watch out for when checking thread count. For example, when most cloth is treated, it will either shrink or expand depending on the treatment and processing. Therefore, it is helpful to develop a data base over time before setting any specific parameters. In this way, the control parameters that are established can be much more meaningful.

The stiffness (or hand) is probably the most difficult to accurately measure. But, as discussed earlier, the stiffness of the buff has a direct relationship on buffing efficiency. Therefore, it is important to find a meaningful way of measuring this cloth characteristic.

Dr. Christine Jarvis, from the School of Textiles at Clemson University, indicates that the Shirley Stiffness Test is one of the most acceptable methods of testing stiffness. This test measures the length of cantilevered cloth it takes to drop a specified amount. Many things can effect the results, such as folds in the cloth, temperature and humidity. Special care should be taken to make this test meaningful.

![Diagram](attachment://shirley_stiffness_tester.png)

Figure 6
Twenty years ago most buffing wheels were made of 100% cotton cloth. But today, with the heavy use of different materials (especially various polyester/cotton blends), it becomes important to verify the composition of the buff cloth. There are several accepted and easily performed "Wet Lab" Methods for testing buff cloth composition.

For example, ASTM #D62907.02 can determine a cloth's polyester content in a few minutes. Most of these tests are very accurate and repeatable; therefore, the control parameters can be set up easily. After checking the specified buff cloth, it is then important to verify that there is a consistent amount of material in the buffing wheels.

2. The Amount of Cloth

-There are three steps to verifying the amount of cloth in a buff. First, measure the outside diameter of the buff to compare it to the specification. This is obviously quick and easy. Second, count the number of plys of cloth in the buff. Again, very easy to do (remember to count at an area other than the tail of the buff to keep any small overlap or underlap from confusing the count). Third, the amount of pleating (sometimes called "S" size or Pack) in the buff should be determined. This is accomplished by cutting out a strip of cloth along one ply exactly one revolution around the buff. Next, lay this strip of cloth out flat and measure its length. Divide this number by pi which will result in a number indicating the diameter of the mandrel used to make the buff. Finally, subtract the buff diameter from the calculated number to get a number that indicates the amount of pleating in the buff. The higher this number, the more pleating (or puckers) a buff will have. A higher number will also indicate more cloth was used to make the buff.

For example, a 16" diameter buff made on an 18" mandrel will have a pleating number of "2". However, a 16" diameter buff made on a 20" mandrel will have a higher pleating number - 4" (it will also have more cloth and more pleats/puckers than the other buff).

Conclusion

We have considered several practical methods that can help improve the quality of your work piece. We first defined "quality" from two different perspectives (1) "improving the surface roughness" and (2) "improving the consistency". It is important for managers to know which of these is required, then the proper approach can be better applied to the situation.
When trying to improve the overall surface roughness or appearance of the metal, it is just as important to analyze the preparation steps before it gets to the buffing operation as it is to apply the proper buffing techniques. In this way you can better ensure that the buffing operation is able to deliver the expected final finish.

Most often, though, a "quality" finish is defined more appropriately as a more consistent finish. Again, an effective manager will look beyond the consistency of the internal processes and techniques in the buff operation, to the consistency of the raw materials used in the operation. Establishing specifications for these raw materials is critical for a high quality, efficient manufacturing operation that desires to run well into the 21st century.

While it is at times helpful to review the successes that we have accomplished in the past, it is probably much more beneficial to adopt the call of "Faster, Better, Cheaper" for ourselves. This call holds as its most basic assumption that no matter how good a part we can produce . . . there is always room for improvement. Whether this improvement is through the application of a recent technology or good old ingenuity, the need for excellent people to manage the processes, people and products has never been greater.