# Selection of Process Parameters in Precision Grinding

The productivity, accuracy and cost of grinding processes depend to a considerable extent on the correct choice of process parameters, as the advantages of a good machine and a correct wheel can be lost by operating them under unfavourable conditions. The purpose of this article is to impart some basic information on selection of process parameters and tips on solutions to common grinding problems encountered on the shop-floor.

The standard process parameters for cylindrical, internal, centreless and surface grinding operations are given in the annexures.

The wheels used in precision grinding operations are normally not self-dressing – i.e. wheel wear in grinding is quite small and the cutting efficiency tends to gradually decrease. This means that the wheels should be dressed periodically to restore cutting efficiency and accuracy. Since considerable time and wheel wear is involved in dressing, it is necessary to optimise conditions in such a way as to maximise the period between dressings.

The problem at the shop-floor level is to determine the factors that lead to frequent dressings. These factors are discussed below:

## A. LOSS OF CUTTING EFFICIENCY

The cutting efficiency of a wheel is its ability to remove material at a sufficiently fast rate without causing problems of burns, cracks or excessive deflections (resulting in form errors). The cutting efficiency of a wheel is maintained by the process of abrasive fracture and exposure of fresh cutting edges. Rapid loss of cutting efficiency due to wheel glazing can be combated by increasing the severity of the operation – i.e. by increasing the feeds, depth-of-cut, etc. In extreme cases it may be necessary to use a softer wheel and simultaneously use a coarser grit size if finish is not a criterion.

Quite often, loss of cutting efficiency is accompanied by the appearance of chatter marks on the job surface, after grinding a few pieces. This is sometimes due to a ‘hard’ wheel. However, the presence of chatter marks immediately after dressing indicates that the wheel is not balanced properly.

## B. LOSS OF FORM AND ACCURACY

When grinding profiled jobs, the wheel is dressed to the required form. This form is gradually distorted due to uneven wear and necessitates redressing. In such cases, the frequency of dressing can be minimised by reducing the grinding allowance and the severity of the operation. It should be appreciated that the frequency of dressing is always more when profiled jobs are ground and this is unavoidable.

A few specific problems that occur in precision grinding are discussed below:

## DRESSING

A point which should be noted is that wheel wear in dressing is substantially more than wheel wear in grinding. Most operators have a tendency to dress the wheel more than is necessary and this only results in reduced wheel life. It is recommended to remove only about 0.1 mm radial depth in dressing by taking two or three cuts of 0.02 – 0.03 mm depth after the diamond dressing tool touches the wheel throughout its width.

An important aspect of the dressing operation is that it can be modified, to alter the cutting efficiency of the wheel and surface finish on the job. Thus, coarse dressing with a diamond traverse rate of 400-500 mm/min will result in a wheel with fast cutting action and a rough finish, while fine dressing with a traverse rate of 100-200 mm/min will result in a better finish. It is also possible to make a number of diamond passes at rates of 50-100 mm/min without infeed to produce a wheel-condition giving a very fine finish. The latter approach is particularly useful when only a few special parts have to be made to the best surface finish in a tool room or maintenance shop. An important corollary to the above statements is that fine dressing should not be done when a free cutting wheel is required for production grinding.

## BALANCING

Proper balancing of the grinding wheel is an essential prerequisite if good results are to be obtained in precision grinding. This is because an imbalanced wheel rotating at high speeds causes severe vibrations of the spindle and leads to chatter marks on the job, damage to spindle bearings, etc. Modern machines are sometimes equipped with automatic balancing devices. However, static balancing stands are still widely used. Experience has shown that much time is lost on balancing if operators are not trained in correct balancing techniques.

## SURFACE FINISH

One of the main considerations in the choice of precision grinding processes is the required surface finish on the job. There is a widespread belief that jobs should always be ground to a very fine finish. This is totally unwarranted and can be compared to a statement that all parts should be ground to a tolerance of, say, 5 microns. Such arbitrary job specifications only create difficulties during manufacture without contributing to the functional quality of the parts. The problems are further compounded by the absence of reliable evaluation methods on the shop-floor and the consequent dependence on the subjective views of the operator.

It is extremely important to specify surface finish in quantitative terms, i.e., in microns Ra or microinches CLA, so that a proper evaluation can be made on the relevant instruments at least on a sampling basis.

Quite often, problems are encountered on the shop-floor in achieving the desired finish. This parameter is no doubt considered when choosing the wheel specification, but the end result is dependant on the operating conditions. The factors affecting surface finish are discussed below.

### a. Spark-out

It has been found that surface finish is inversely proportional to the depth-of-cut in grinding i.e., low depth-of-cut results in a better finish and vice-versa. Therefore, the obvious way to improve finish is to reduce the depth-of-cut to a minimum value. However, in practice, the machine-tool feed mechanisms cannot give very low infeed values owing to various design constraints. This problem can be overcome by the process of "spark-out".

During grinding, the entire system is subjected to deformations under the action of the cutting forces. Thus, for example, the job deflects considerably in cylindrical grinding, and the wheel spindle deflects appreciably in internal grinding. Even if wheel infeed is stopped at a given moment, material removal continues due to a gradual reduction in the deflections of various parts. This process is called "spark-out". As the deflections are quite small, the corresponding depth-of-cut during spark-out is also small and gradually reduces to zero. This explains why spark-out is extremely effective in improving surface finish.

### b. Dressing

The influence of dressing has been discussed earlier. A typical study showed that a 46-grit cylindrical grinding wheel produced a surface finish of 30 microinches CLA when dressed at a diamond traverse rate of 500 mm/min. Reduction of the traverse rate to 100 mm/min. resulted in a 12 microinch CLA finish.

### c. Cutting Parameters

Beside the depth-of-cut, surface finish is also influenced by the other cutting parameters. The finish can be improved somewhat by reducing the job speed (rotation speed in OD grinding and reciprocation speed in surface grinding) and reducing the traverse feed (table traverse in OD grinding, cross-feed in surface grinding, longitudinal feed in centreless grinding etc.)

### d. Cutting Fluids

The influence of cutting fluids on surface finish is relatively small and, in general fluids with greater lubricating action impart a somewhat better finish. The more important point is to ensure proper filtration of the fluid because suspended particles of abrasive and metal can cause deep scratches. Isolated scratch marks are a sure sign of dirty fluid. The remedy in such cases is to clean the tank and use magnetic separators at frequent intervals.