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A progress report on the evaluation

of metal cutting coolants

- by -

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Introduction

An intensive investigation into the grinding process was carried out in The College of Aeronautics Machine Tools Laboratory during 1955-6. The outcome of this work was a method of evaluating the efficiency of grinding wheel specifications. Briefly, this consists of holding all other conditions constant and changing the grinding wheel specification from the grinding tests made then the rate of grinding wheel wear and the maximum metal removal rate is ascertained. This data may be used to compare one specification to another.

The method has been used to select the best wheel specification for a wide range of materials, especially the more difficult machinable alloys - examples being the stainless steel and the alloys intended for use at high temperatures.

During the ten years since 1956 the method has been further developed by retaining the grinding wheel specification constant and varying the work piece material to determine the grinding machinability of alloys, and also a much more valuable criteria of the grinding process - the efficiency of coolants when used in the grinding process.

This work on coolant evaluation has received detailed and extensive attention. The results of tests carried out on more than 300 coolant samples ranging from oil based and water soluble coolants with varying percentages of additive has revealed that the coolant can increase the life of the grinding wheel face by 10 times. All results found from the method of evaluation are expressed in terms of maximum metal removal rate and volume of metal which may be removed at maximum rate.

The present investigation

In view of the repeatable results which have been obtained when evaluating the efficiency of coolants and the demonstrated ability to show the effect of varying the percentage of additives in a base carrier the grinding method is to be used to evaluate the effect of various additives, carried in a base oil. This grinding evaluation to be followed by a programme of tests carried out on the drilling and turning processes. Using the same oil samples as on grinding, the results from these tests will be compared to determine the correlation between the results obtained from the three processes. Should the grinding process be found to be a reliable indication of the efficiency of a coolant when applied to the drilling and turning processes a contribution to the development of coolants will be made by providing a short and inexpensive method of testing coolant samples in a practical application.

The programme

The grinding process.

The samples of coolants will be applied to the grinding process.

All conditions will be held as constant as possible, but the process will not be varied in any way from a similar grinding process on any workshop floor. The rate of metal removal and the life of the dressed wheel face in cubic ins. removed per redress will be recorded, when each coolant sample is used.

The Drilling process.

The determination of the life of a drill between redressing is not easily achieved. There are many criteria which may be considered in the determination of when a drill point has reached the end of its useful life, some of these are as follows:

(a) The hole drilled is outside the limits as declared by the work specification. This criteria is possibly the most important and practical in view of the fact that the production of acceptable holes is the reason for the use of the drill and until the holes produced are not within the limit then the drill is performing satisfactory.

The most important criteria against taking the above hole quality as the only measure of drill life is that the chisel point of the drill, may be in a very depreciated condition, while the radial points of the flutes may be in a useable state of wear, and as these points produce the surface finish, and the chisel point wear is symmetrical about the drill axis then the hole could be produced within limit.

It is desirable to use the same drill to obtain a number of life results. This suggests that depreciation of the drill should be kept to a minimum to allow redressing to be carried out with minimum loss from the tool.

(b) The cutting forces imposed upon a cutting tool and the equal and opposite reaction on part of the workpiece change as the cutting tool edge wears. Usually an increase in these forces occurs. The workpiece or the cutting tool may be carried by a force sensitive dynamometer and the change in force measured, the life of the drill or cutting tool can be assumed to have reached its useful conclusion at some predetermined value of increase over the initial cutting force when the drill point or cutting edge was in the newly dressed condition.

(c) When two dissimilar metals are brought into intimate contact with each other, electro chemical action takes place. This action depends on the extent of the dissimilarity and the chemical composition of the metals and is stimulated by temperature.

The metal cutting process is performed using a hard material to cut a softer material and their chemical composition are usually dissimilar.

The cutting action causes friction which generates elevated temperatures, thus stimulating the electro-chemical action (EMF). As the magnitude of the

EMF generated is initially dependent on chemical composition when the material of the tool and workpiece are ferrite (iron) based, the dissimilarity arises only in the alloying elements and hence EMF plotted against temperature is very small and for the drill workpiece material which is being used in these tests it is in the order of 3mV for a temperature of approximately 700°C . This calibration has not been made, but will be included in a later stage report.

(d) Tool wear progresses on the amount of work carried out increases. The wear is measured in three positions. On a drill or a turning tool, these are the chisel point and the corners of the drill and along the radial cutting edges; on the lathe tool point, its clearance flanks and top face crating.

It is usual to limit the extent to which wear should be allowed to reach for if wear becomes excessive the tool forces may become high and there will be a positive danger of the tool breaking, if the wear is limited to a reasonable extent re-servicing will recover the tool for further service, several times, limiting the tool wear also influences the error produced by the tool on the workpiece due to the truth of cutting path being maintained and the deflection due to increased cutting forces being restricted to predetermined magnitude and direction.

Report of work carried out to date

All the above methods of determination of drill life are in use but to date the drill wear criteria is proving most valuable. The wear on a drill is being allowed to reach a magnitude of approximately 0.030 inches either on its radial points, the chisel point or cutting edges. At this magnitude the tool is deemed to have reached the end of its life and is redressed. All drills are hardness tested before each test. The Vickers Diamond pyramid number is used. It is intended that 2 drills shall be used for each coolant sample, each drill being redressed 3 times, i.e. 6 tests on each coolant.

Results

The grinding tests were carried out at an earlier date, and are to be repeated to enable the author of this report to become familiar with the method of evaluation, and also to develop the use of the method to evaluate coolants for use on materials in the soft condition, such as may be cut by HSS tools; this is necessary for the following reasons:

(1) The previous experience using the evaluation grinding method was gained on hardened, or difficult grinding material. The material of interest in the present programme is EN 24 in the annealed condition, and similar materials. If the past experience on grinding is used to choose the most efficient grinding wheel to be used on EN 24 annealed, it will carry out the task and the wheel face will perform a considerable amount of work between redressings and the test work will occupy a period of time in excess to that considered

necessary. Hence a variation in the method is being used to select a soft grinding wheel which will produce accurate results with shorter period tests.

The initial grinding tests carried out by one research engineer were completed in 20 working days covering 5 test runs on 5 different coolants. The volume of workpiece material consumed was 23 cubic inches, the total weight of material which has been made available to carry out the drilling and turning tests is approximately $1\frac{1}{2}$ tons. Hence, the value of the work proposed in this programme if resulting in the grinding process as acceptable for coolant efficiency evaluation will be appreciable and will make a valid contribution to efficient coolant technology.

Results of tests to date

Grinding results to be included in Report No. 2.
Drilling results in Progress Report No. 2.

References

On Tool Workpiece thermocouple

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2. Principles of Electricity and Electro Magnetism, C of Ae No. 537, page 202 to 207.
3. Also recent unpublished thesis, Birmingham University 1963-5.