CoA Memo. No. 102

The College of Aeronautics, Cranfield

Department of Production and Industrial Administration

The numerical evaluation of the grinding process and the basic mechanics of grinding wheel wear.

by

John Purcell, C.Eng., A.M.I.Prod.E., A.M.I.Plant.E.

Contents

Introduction

During the production process development for the manufacture of an experimental supersonic aircraft , an unusual and difficult grinding problem was encountered.

Arising from the xperimental work carried out to solve this problem, a method of numerically evaluating the efficiency of grinding wheels and coolants, was developed. This evaluation is based on the fact that under constant and limited grit load conditions which can be set up in a surface grinding operation, the edge of the grinding wheel which makes initial contact with the workpiece breaks down and forms an approach angle as shown in Fig. 1. Once this angle is established, its dimensions remain almost constant, and with continued use of the wheel the angle recedes across the face of the wheel. It is the recognition of the variables which control the dimensions of this approach angle (alpha) together with the rate at which it recedes across the wheel face, and the amount of work done at each increment of recession, on which the numerical evaluation of the efficiency of the grinding wheel and the causes of the limitations are based.

A description of the methods used for determining the characteristics of grinding wheels and coolants are included together with the calculations which are necessary when the data obtained from tests carried out on the surface grinding machine are to be interpreted and applied to the cylinder grinding internal grinding or form grinding processes.

1. Numerical evaluation of the grinding process

The method of evaluation is centred upon the recognition of the variables which control the proportions of the triangle containing alpha, the leading edge approach angle (Fig 1). The surface grinding process is considered.

(a) The two methods of measuring the approach angle on the leading edge of the wheel

The measurement of the approach angle is achieved in two ways.

1. By smearing a thin layer of engineers marking blue on the surface of the workpiece and bringing the grinding wheel down just to remove this along the path the wheel makes when the table is longitudinally traversed with no cross feed. Fig 2 shows this method. From Fig 2 it is seen that, using a pair of sharp dividers, the width of the wheel path can be measured to less than 0.010 ins., which is less than one grit width in a 60 grit wheel.

This initial measurement is made before the test commences and gives the width of the redressed wheel face. It has been found that, due to the cutting forces being applied to the hypotenuse of the approach angle alpha, the wheel is deflected in a way which lifts the dressed wheel face and trailing edge of the wheel from contact with the workpiece. Only the grits on alpha and those at the apex are responsible for metal removal.

The above observations suggest that the grinding wheel suffers no loss in diameter, and that if the cutting forces are removed, the wheel face will return to the no load position in which it was first redressed. After work has been done, any loss from the leading edge of the wheel can be measured by repeating the marking blue technique described above.

The wheel face loss is found by subtracting the second measurement from that taken before the wheel was used. This difference (given the symbol B in Fig 1) is the length of the base of the approach angle alpha, a further side being D, the applied depth of cut. As the angle B.D. is a right angled triangle, the remaining values may be calculated.

Note:- When the leading edge of the grinding wheel cross traverses over the side of the workpiece, the cutting forces are removed, allowing the dressed wheel face to return to normal no load position. Close observation of the surface of a workpiece which has been surface ground will show evidence of this wheel return. A very light plunge cut mark will be left down the edge of the workpiece surface, equal to the unworn width of the wheel face. This can be used to check the blue method of measurement.

2. The second method of measurement of alpha is to stop the machine table during a cutting pass, and make a trace of the form left by the grinding wheel face on the surface of the workpiece. The Taylor, Taylor Hobson machine (supplied by Alfred Herbert Coventry) is ideal for this purpose. Fig 3 is a photocopy of a Talisurf trace. This shows alpha proportions and enables the chip size calculations to be checked as shown on the tracing using the symbols as given in Fig 1.

The basic calculations for the chip shown on the trace (Fig 3) would be as follows.