THE EFFICIENCY OF A TWO-EDGED TOOL AND ITS IMPROVEMENT

By: J.R. Masuha*

1. Introduction

The modern manufacturing technology aims at manufacturing a given product in the shortest possible time and incurring the lowest possible manufacturing costs. The quality of the product is kept at a level just enough to make the product competative. This aspiration can be best achieved by streamlining the different manufacturing processes and most important by improving the efficiency of every manufacturing element involved in the system. Then by increasing the efficiency of the individual elements the efficiency of the whole system can be increased. Where this fails new methods of manufacturing and new tools have to be developed.

One of the weakest point is in-line transfer machine systems and indeed in many other metal cutting production systems, is the twist drill (two-edged tool). The twist drill, one of the oldest tool, suffers from the following handicaps: It has a complex tool geometry which leads to a unique chip formation; the cutting process cannot be observed; the flow of chips is not free; the cutting speed, the rake angle and the clearance angle vary along the cutting edge; both the primary and the feed motions are carried out by tool. Because of these handicaps very little progress has been achieved in drilling with a twist drill. The complexity of the twist drill defers many researchers from working in this field.

This paper attempts to introduce one of a few methods which could be applied to improve the machining ability of a twist drill. It analyses results of tests conducted to demonstrate the advantages obtained by using oil-hole drill cooling system instead of the conventional method - flood cooling system. In the latter system the cutting fluid is introduced to the cutting zone through the drill surface - mainly through the flutes. In the former system, however, the coolant is forced by a pump through two holes in the twist drill down to two openings in the major flank. The openings are so near to the cutting zone that the fluid experiences no difficulty in reaching all parts of the cutting edge. Because of this both the cooling and lubricating effects of the oil-hole drill cooling system are superior to those of the flood cooling system.

2. Experimental Procedure

The experiments were carried out on a single spindle upright drilling machine, type KS 80, manufactured by Herman Kolb, West Germany. The machine has a very stable design with a motor of 12 kW. It is equipped with a stepped speed spindle drive covering a spindle speed range of $n = 27$ to $n = 900$ rpm, in 12 steps. There were 12 feeds available, from $s = 0.07$ up to $s = 3.00$ mm/rev.

The tools used in all tests were taper shank twist drills type N DIN 1412 and DIN 1414 with a diameter of 18 mm, a point angle of 118°, a helix angle of 30° and a clearance angle of about 9°. All of them were made out of high speed steel (HSS) and manufactured by Rhode & Doerrenberg, West Germany.

Two types of materials were used, a tempered carbon steel Ck 45 with a tensile strength ranging from 650 to 800 N/mm^2 and a tempered stainless Chrom-Nickel Steel with a tensile strength ranging from 500 to 750 N/mm^2. Samples of 30 mm diameter and 110 mm length were cut out of the parent round bars and were faced on both ends. During the drilling process, holes of depth $l = 2.5d = 45$ mm were drilled on both ends. This depth was chosen to eliminate the effect of deep hole drilling which would have introduced another parameter.

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*Lecturer, Mechanical Engineering Department, University of Dar es Salaam.

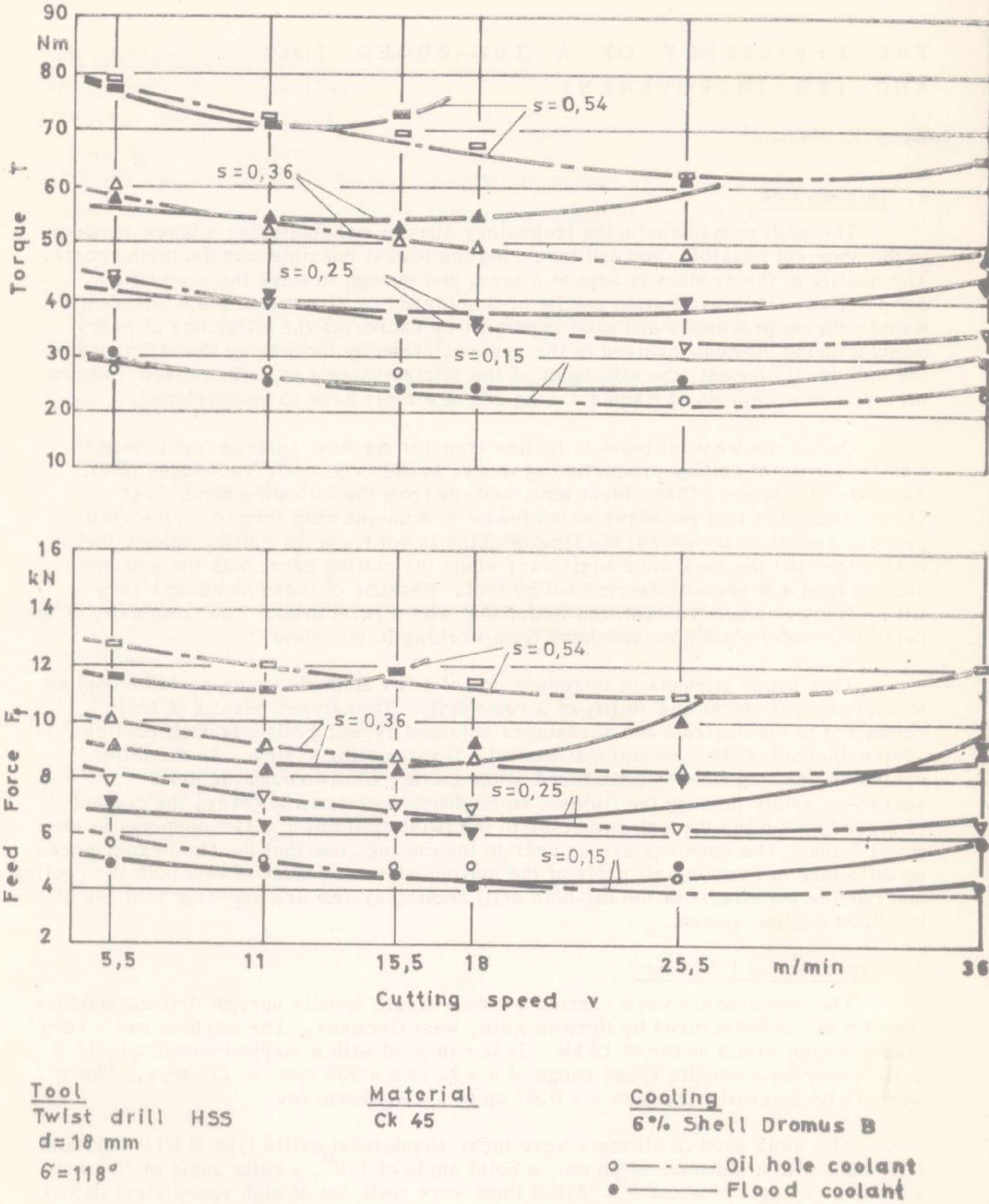

Figure 2: The effect of cooling on drilling forces

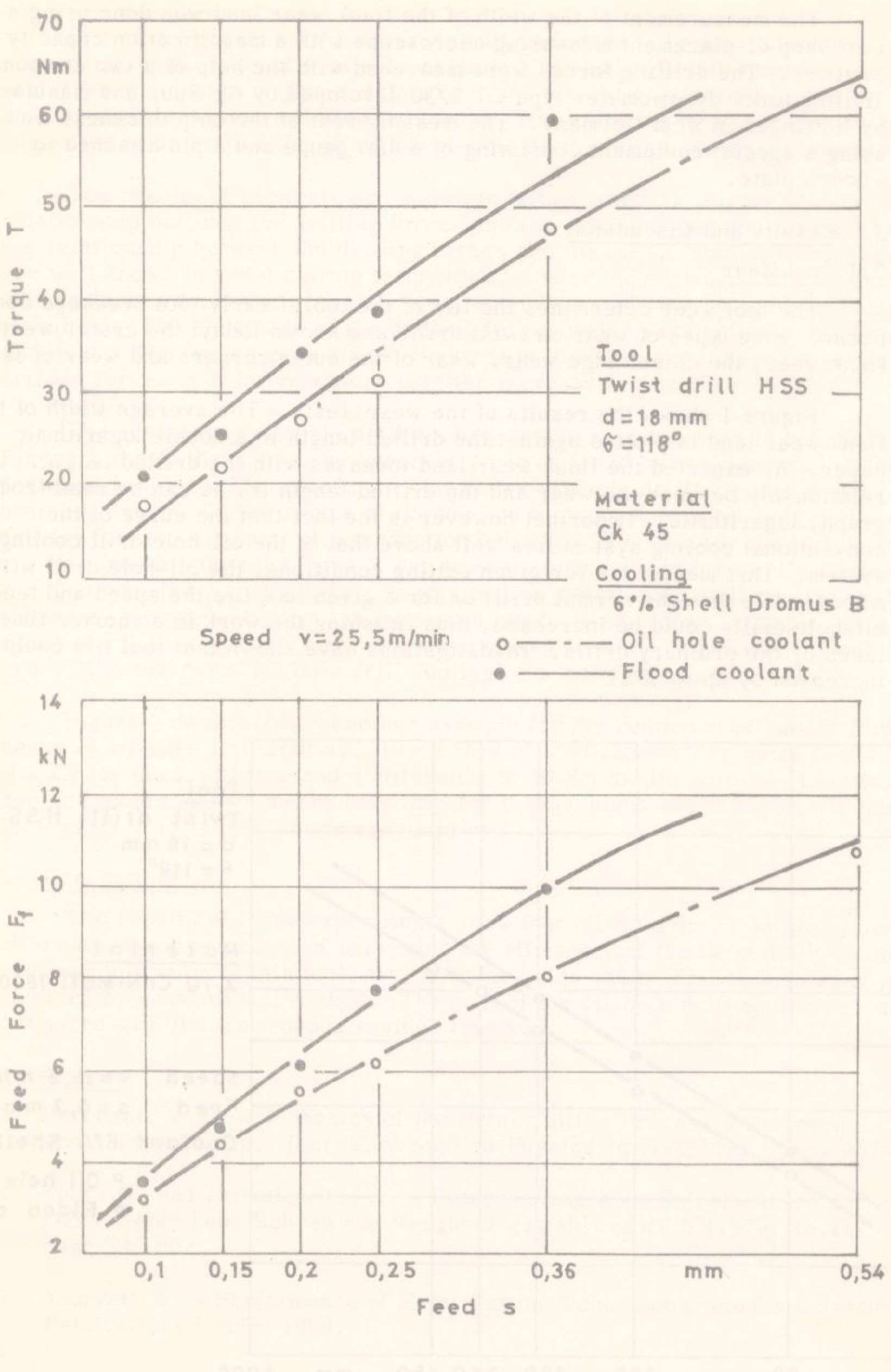

Figure 3 : The effect of cooling on drilling forces

The measurement of the width of the flank wear land was done using a workshop displacement measuring microscope with a magnification capacity of 30 times. The drilling forces were measured with the help of a two component drilling force dynamometer type CT 2/30 developed by G. Spur and manufactured by Hottinger in West Germany. The measurement of the chip thickness was done using a special equipment consisting of a dial gauge and a pin attached to wooden plate.

3. Results and Discussion

3.1 Tool Wear

The tool wear determines the life of the tool if early tool breakage does not occur. Five types of wear on twist drills are known today: the crater wear, the flank wear, the chisel edge wear, wear of the outer corners and wear of land.

Figure 1 shows the results of the wear tests. The average width of the flank wear land is plotted against the drilled length in a double logarithmic paper. As expected the flank wear land inreases with the drilled length. The relationship between the wear and the drilled length is, as can be read from the graph, logarithmic. Importnat however is the fact that the curve of the conventional cooling system lies well above that of the oil-hole drill cooling system. This means that for given cutting conditions, the oil-hole drill will have a longer life than the normal drill; or for a given tool life the speed and feed for the oil-hole drills could be increased, thus finishing the work in a shorter time than that taken by the ordinary drills. Investigations have shown that tool life could be increased by up to 50%.

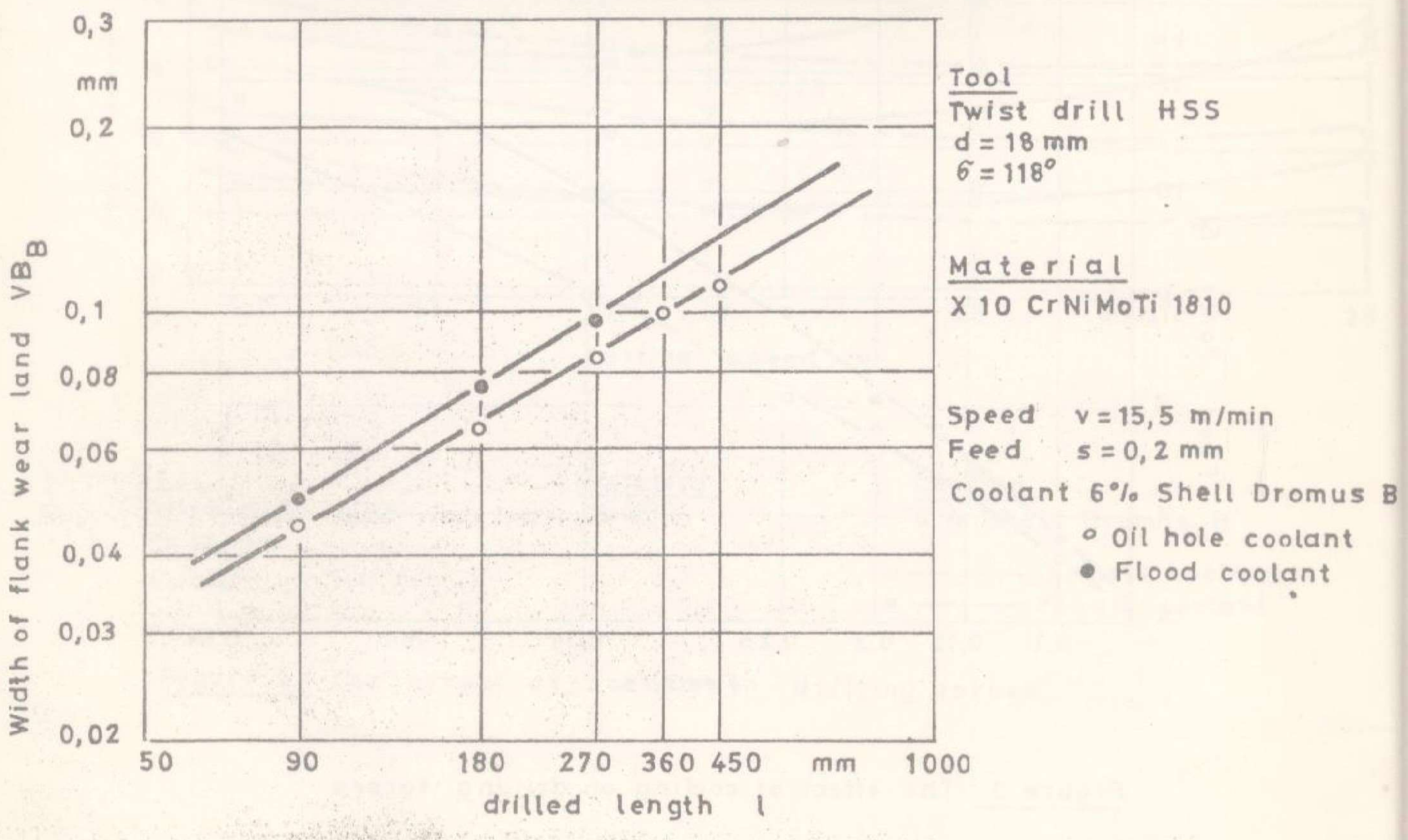

Figure 1: The effect of cooling on tool wear

3.2 Cutting forces

One of the reasons for measuring cutting forces is to determine the economical application of available machine tools and to obtain informations useful for the design of jigs and fixture. The two most important forces in drilling are the torque and the feed force. The following is an account of tests conducted to determine the effect of oil-hole drill cooling system on these forces.

The results of the tests are shown in figure 2 and 3. Figure 2 shows the basic relationship between the drilling forces and the cutting speed and figure 3 shows the relationship between the drilling forces and the feed. Both of these relationships are well known in metal cutting technology. Under inc reasing cutting speed, the cutting forces decrease gradually up to a minimum and rise up again up to the point of failure. The behaviour of the drilling forces under varying feeds is somehow different. The forces vary almost linear with the feed, i.e. the increase in the drilling forces is relatively more than the increase in feed.

The advantages oil-hole drill cooling system is again seen in both diagrams. Figure 2 shows that there are apparently two fields to be considered. In the region of lower cutting speeds the curves for oil-hole drills lie above those of the ordinary drills. In the region of normal and higher speeds, oil-hole drills give lower drilling forces, the point of intersection being v = 12 m/min for the torque and v = 16 m/min for the feed force. The normal cutting speed for the Ck 45 lies between v = 16 m/min and v = 20 m/min. In this region the oil-hole drill cooling system proves superior, giving more room for increased productivity. For example, by a cutting speed of v = 18 m/min the feed can be increased from s = 0.2 mm/rev (flood cooling) to s = 0.54 mm/rev. (oil-hole drill cooling) - a tremendous gain.

Figure 3 demonstrates another example for the reduction of cutting forces by means of ail-hole drill cooling. For a feed of s = 0.25 mm/rev there is a difference of 2 kN for the feed force and a difference of 10 Nm for the torque. In terms of machine tools this means less load for the machines and workpiece holding devices as well as less power consumption.

4. Conclusion

The results of these experiments show that oil-hole drill cooling system offers an effective method of improving the efficiency of the twist drill. With proper application of this tool, two or three holes can be drilled instead of one hole obtained by conventional method. The cost of the oil-hole drill equipments are low compared with the tremendous savings involved.

References

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