1) The photograph below shows a standard type of lathe tool which consists of a tungsten carbide cutting element (disk shaped) mounted to a steel tool holder.
Someone has invented a new type of lathe tool schematically pictured below. It consists of a disk-shaped cutting element of tungsten carbide which is fixed to a steel shaft. The tungsten carbide cutting element and shaft are free to rotate in the steel toolholder. The idea is that the cutting element is continuously rotated during cutting. In this way, the surface of the tungsten carbide cutting element is constantly “refreshed”.

In addressing the questions below, do not worry about the details of how the rotation of the element is effected. Also, do not worry about the details of the bearings between the rotating element/shaft and the toolholder. Certainly, these would be critical to the operation, and would represent significant challenges, but we will disregard these issues in this question.
The inventor claims that this new type of “rotating element” tool will be capable of sustaining higher material removal rates than the standard “fixed element” tool without “burning up”. The inventor further asserts that “flood” coolant will be critical to the function of this device (Coolant which flows freely over the tool and workpiece).

a) Under what circumstances would the inventors claim to higher material removal rates be credible? Derive “1st order” expressions which define the regime of operation where this might be true. Are there regimes of operation where the rotating element tool might not be able to match the fixed element tool in material removal rate?

b) Do you agree that flood coolant is central to the function of this concept? Explain.

c) Derive an expression for the power required to turn the cutting element. Is it likely to be greater than the spindle power required on the lathe or less?
The inventor points out that for occasions when a non-circular cross section is desired in the
turned part, the rotating element tool is ideal. For example, using an elliptical element as
shown below, an elliptically shaped part can be turned.

The inventor claims that this is superior to an alternative technique using conventional tools
mounted on a cross-slide with a servo actuator for moving the tool in and out as the work
piece rotates as shown below:

d) Compare the two approaches from the point of view of flexibility and responsiveness.
   Explain.

e) Which would allow higher spindle speeds? Explain. Is there a relationship between this
   question and question “d”?

f) Compare the two approaches from a point of view of process control. Which is likely to
   produce more accurate parts? Which method is more robust? Explain.