Forming – Blanking, Fine Blanking and Stamping

Manufacturing Technology II
Exercise 6

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Table of Contents

Table of Contents ......................................................................................................2

1 Introduction .........................................................................................................3

2 Tasks ....................................................................................................................5
  2.1 Manufacture of a perforated plate .................................................................5
  2.2 Manufacturing disks in stamping and cutting operations .........................8
  2.3 Questions .....................................................................................................10
1 Introduction

Cutting and stamping are two of the most important sheet steel machining operations since the manufacture of a sheet steel part, almost always involves cutting. This applies both to the manufacture of the slug and to the generation of the contour of the sheet. This exercise will focus on the shearing operation. Other cutting methods include both mechanical cutting operations such as cutting with a blade, crushing or water jet cutting and thermal operations such as flame or laser cutting. Diagram 1 illustrates the shearing principle: The upper die cuts the sheet lying on a blanking die. The sheet material is formed in the cutting gap zone. As soon as the forming capacity of the metal is exhausted (c.f. Principles of analytical measurement in forming operations), cracks appear and the material is finally cut by the expansion of the cracks.

![Diagram of shearing principle](attachment:diagram.png)

**Fig. 1: Principles of shearing**

The main application for shearing is in the manufacture of contoured, two-dimensional parts. Increasingly, follow-on tools are being used in multi-stage operations to stamp the part, thus giving it further functional surfaces and characteristics.
Shearing has been expanded to produce the fine-blanking process. The set of tools used in fine blanking comprises those used in normal cutting operations plus a counter punch and a blank holder. This induces a state of stresses during the shearing operation, which should, if possible be in the compressive strain range. This increases the forming capacity of the material. Consequently, the cut edges of the part have no fracture surfaces, since the workpiece material can form plastically until the stamp has completely penetrated the sheet. As a result, the cut edges can also be used as functional surfaces without any need for further finishing.

The methods of estimating force and power are the basic principles underlying the design of the machines required for these operations. These methods will be presented in this exercise. Measures which can be applied in order to reduce the levels of force and power required in cutting operations, will also be described. This exercise concludes with questions relating to cutting.
2 Tasks

2.1 Manufacture of a perforated plate

Square perforated plates (Fig. 3) are to be produced in a combined blanking and piercing tool.

Data relating to the perforated plate:

- Breadth: \( b = 150 \, \text{mm} \)
- Diameter of holes: \( d = 20 \, \text{mm} \)
- No. of holes: \( 25 \)
- Sheet thickness: \( s = 20 \, \text{mm} \)
- Tensile strength of the material: \( R_m = 800 \, \text{N} / \text{mm}^2 \)
- Shearing strength factor: $c_s = 0.8$

a) Is the maximum pressing force of the available press, $F_{P_{\text{max}}} = 1500 \text{ kN}$ sufficient?

b) Punching dies of different lengths, corresponding to the symmetrical arrangement shown, can be used in order to reduce the maximum cutting force.

![Arrangement of cutting force reducing fine-blanking dies](image)

*Fig. 4: Arrangement of cutting force reducing fine-blanking dies*

How high is the reduction in cutting force (in %), assuming that the friction of the surface area of blanking die in the finish-cut perforated wall of the sheet, is approx. $F_{\text{Reib}} = 0.2 F_{\text{St_{max}}}$?

Account is taken of the proportion of friction of the cutting die by the shearing strength factor, which was determined experimentally ($c_s = 0.8$).

c) A further means of reducing the cutting force is to chamfer the face of the punch, which reduces the instantaneous shearing section and thus the cutting force.
Determine the angle of inclination $\alpha$ required in each case in order to achieve reductions of 10% and 50% in the cutting force of the hole punch.

Assume that the amount of cutting work remains constant despite the reduction in cutting force. This hypothesis is permissible when it is assumed that the theoretical cutting path (for $\alpha = 0^\circ$, $H_s = s$) is extended accordingly.

Note: Correction value $x = \text{constant}$. 

**d) How high is the cutting capacity when 25 chamfered punching dies, angled at $\alpha = 1^\circ$ are used and the number of strokes per minute has been set to 500 min$^{-1}$ (correction value $x = 0.5$)?**
2.2 Manufacturing disks in stamping and cutting operations

Fig. 6: Sequence of stages piercing - stamping - piercing

The disk shown below is produced in normal cutting and stamping operations performed using three hydraulic presses which are linked via handling systems.

Press 1:  Blanks out the unmachined part from the sheet and simultaneously punches holes (d₁ = 42 mm)

Press 2:  Stamps the inner surface of the ring.
Assume for the sake of simplicity, that the material flow runs only radially inwards in the stamping operation.

Press 3:  
1) Trims the inner hole \(d_i = 40 \text{ mm}\)  
2) Cuts the eight outer holes \(d_i = 10 \text{ mm}\)

Assumptions: The friction forces and the shearing action when \(r = 25 \text{ mm}\) are negligible.

Data: Flow curve

![Flow curve](graph.png)

- a) Estimate roughly the maximum stamping force
- b) Determine the level of cutting force required by Press 3.
2.3 Questions

1. List three differences between fine blanking and normal cutting which relate to the workpiece and three relating to the tool.

2. List the requirements which the fine-blanking operation imposes on the workpiece material in terms of mechanical properties and the microstructure.

3. List four measured variables used to evaluate the quality of parts produced in a fine-blanking operation.

4. Explain briefly what is meant by the term multistage operation die and list its advantages and disadvantages.

5. List the four different types of feed limitation and their areas of application.

6. List two of the principal forms of wear which affect upper dies/punches and state which forms of wear occur predominantly when thin are cut and when thick sheets are cut.

7. List two effects of tool wear on the machining outcome (workpiece) as a function of the predominant wear mechanism.

8. List the mechanical load to which the punch is subjected in the cutting operation.