General information and guidelines

Power-operated clamping devices

To ensure safe operation of power-operated clamping devices, particularly of chucks, on heavy-duty lathes with high speeds certain criteria must be observed:

1. When mounting the power chuck and the clamping cylinder on the lathe, the following safety requirements must be met:
   1.1 The machine spindle may only start when the clamping pressure has been built up in the actuating cylinder and the clamping has been carried out in the permissible working area.
   1.2 Unclamping may only be possible when the machine spindle has completely stopped.
   1.3 In case of a clamping energy failure, the workpiece must be firmly clamped until the spindle is completely stopped. (The Röhm safety cylinders meet this requirement.)
   1.4 In case of a current failure and upon return of the current supply the actual control position may not be changed.
   1.5 In case of a clamping energy failure the machine spindle must be stopped by a signal.

2. The safety instructions given in the respective operation manual must be precisely followed.

3. After having mounted the chuck and before starting the operation, the function of the chuck must be checked. **Two important points are:**
   3.1 **Clamping force**
   The clamping force (±15%) stated for the clamping device must be reached at max. actuating force/pressure.
   3.2 **Stroke control**
   A safety range must be provided for the stroke of the clamping piston in the front and rear end position. The machine spindle may only start after the clamping piston has crossed the safety range.
   Only limit switches meeting the requirements for safety limit switches in accordance with VDE 0113/12.73 section 7.1.3 may be used for monitoring the clamping path.

4. If the max. speed of the lathe exceeds the max. speed of the clamping device or clamping cylinder, the machine must be equipped with a speed limitation device.

5. When the clamping device has been changed, the stroke control must be adjusted to the new condition.

6. When calculating the required clamping force for machining a workpiece, the centrifugal force of the clamping jaws must be considered.

7. A reliable operation of the power chuck can only be guaranteed when the maintenance instructions contained in the instruction manual are precisely followed. **In particular the following points must be observed:**
   7.1 For the lubrication only the lubricants recommended in the operation manual shall be used. (An unsuitable lubricant can reduce the clamping force by more than 50%).
   7.2 The lubrication must reach all surfaces to be lubricated.
   (At the narrow fits of the mounting parts a high pressure is required for pressing-in the lubricant. For those purpose a pressure gun must be used).
   7.3 In order to distribute the grease evenly, actuate the clamping piston several times to its end positions, repeat the lubrication and then check the clamping force.
8. Before restarting a serial machining operation and in between the maintenance intervals the clamping force should be checked by means of a load cell. "Only regular checks ensure optimum reliability".

9. It is recommended to move the clamping piston several times to its end positions after 500 clamping strokes at the latest. (In this way any lubricant pushed away will be returned to the pressure surfaces. The pressure force is thus maintained for a longer period of time.)

10. When using special clamping jaws the following instructions must be observed:
   10.1 The clamping jaws should be designed in such a way that their weight and height is as low as possible. The clamping point should as possible be as close to the frontside of the chuck. (Clamping points at a larger distance may cause a higher surface pressure in the jaw guiding mechanism and may thus reduce the clamping force considerably.)
   10.2 In case the special jaws are for constructional reasons wider and/or higher than the step jaws assigned to the clamping device, the resulting higher centrifugal forces must be considered when calculating the required clamping pressure and the rated speed.

For calculating the rated speed for a certain machining task the following formula is to be applied:

\[
\frac{n_{\text{max.}}}{\min} = \sqrt{\frac{F_{\text{spo}} - F_{\text{spz}}}{m \cdot r_c \cdot a}} \cdot \frac{30}{\pi}
\]

- \(F_{\text{spo}}\) = initial clamping force with the chuck at standstill (N)
- \(F_{\text{spz}}\) = required clamping force with the chuck at standstill for a certain machining task (N)
- \(n_{\text{max.}}\) = max. admissible speed (min 1)
- \(m\) = mass of the entire jaw unit (kg) (base and top jaw)
- \(r_c\) = center of gravity radius of the entire jaw unit (m)
- \(a\) = number of jaws

10.3 Welded jaws should not be used. If required, the welding seams must be checked as to their centrifugal and clamping force capacity.

10.4 The mounting screws must be arranged in such a way that the highest possible useful moment is reached.

11. The max. speed may only be used at max. applied actuating force and with properly functioning chucks.
12. In case of high speeds the chucks may only be used below a protective hood with sufficiently large dimensions.
13. For power chucks with a jaw quick-change feature internal to the chuck a safety device is required which revents the machine spindle from rotating when the clamping jaws are released.
14. After a collision the clamping device must be checked for fissures before being used again.
15. Worn or damaged jaw fixing bolts must be replaced. Only use bolts of quality 12.9.
Determining the required gripping force of a power chuck

Power-operated clamping devices

Determining the required gripping force of a power chuck and the corresponding operating power

I) Calculating the gripping force $F_{spz}$ (without considering the effects of angular speed) required for the job (machining operation).

II) Determining the chuck’s initial gripping force $F_{spo}$ with spindle stationary (taking into account the centrifugal forces of the jaws).

III) Determining the operating power required to provide the initial gripping force $F_{spo}$.

Definition of gripping force

Progress in machining techniques has made it necessary for safety reasons not only to determine the necessary gripping force but also to know and consider its change with increasing angular speed.

The forces and moments generated by the machining operation must be properly absorbed and transmitted by the chuck. The chuck accomplishes this task mainly by producing a gripping force:

This gripping force is the arithmetic sum of the radial forces exerted on the workpiece by the jaws. The initial gripping force $F_{spo}$ produced when the chuck is stationary can be measured at any time and is therefore controllable. (Denoted by ‘total gripping force’ in the gripping force / operating power diagrams).

The figures given in the catalogue refer only to chucks that are fully and correctly lubricated and in a properly serviced condition. Many factors act on the clamping point during any machining operation. A precise specification of these factors in the form of universally applicable tables is not possible in this context.

In most cases it is sufficient in practice to use a simplified formula containing the fundamental determining factors (crude determination).

\[ F_s = \text{Main cutting force on radially applied tool} \]
\[ F_{sBo} = \text{Cutting force on axially applied tool (drill)} \]
\[ F_{vax} = \text{Feeding force on axially applied tool} \]
\[ F_{spz} = \text{Required total gripping force (without considering the effects of angular speed)} \]
\[ F_c = \text{Centrifugal force of the jaws} \]
\[ F_{spo} = \text{(Total) initial gripping force with the chuck stationary} \]
\[ l_z = \text{Distance between machining and clamping points} \]
\[ d_z = \text{Machining diameter} \]
\[ d_{sp} = \text{Chucking diameter} \]
\[ l_{sp} = \text{Chucking length} \]
Determining the required gripping force of a power chuck

Power-operated clamping devices

I) Calculating the required gripping force \( F_{spz} \)

The gripping force required depends on the type of work to be performed. The cutting force on the turning tool has three basic components:

Main cutting force \( F_s \) - feeding force \( F_v \) - passive force (static force) \( F_p \).

During turning, the feeding force \( F_v \) and the passive force (static force) \( F_p \) are mainly absorbed by the jaw faces in contact with the seated workpiece. The remaining main cutting force produces a moment \( (F_s \times dz/2) \) which must be absorbed by the chuck and transmitted by friction at the clamping point. The moment produced by the main cutting force during turning determines the gripping force required:

\[
F_{spz} = \frac{F_s \cdot S_z}{\mu sp} \cdot \frac{dz}{d_{sp}}
\]

where:

- \( F_{spz} \) = gripping force required for a specific job with the chuck stationary
- \( F_s \) = main cutting force
- \( dz \) = machining diameter
- \( d_{sp} \) = chucking diameter
- \( \mu sp \) = chucking coefficient (friction between jaw and workpiece)
- \( S_z \) = safety factor

The feeding force and passive components, \( F_v \) and \( F_p \), are not included in this formula. If necessary for extreme conditions, they are included in the safety factor \( S_z \).

The main cutting force \( F_s \) is calculated from feed, depth of cut and material.

\[
F_s = s \cdot t \cdot k_c
\]

where:

- \( s \) = feed, mm/rev.
- \( t \) = depth of cut, mm
- \( k_c \) = specific cutting force, kN/mm2

The product \( s \times t \) (feed.depth of cut) = chip cross-section (cross-sectional area of cut) can be obtained from Table 1.

Determining the chip cross section [mm2] Table 1

<table>
<thead>
<tr>
<th>Feed (mm)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.16</td>
<td>0.8</td>
<td>0.96</td>
<td>1.12</td>
<td>1.28</td>
<td>1.44</td>
<td>1.6</td>
<td>1.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0.75</td>
<td>1.0</td>
<td>1.25</td>
<td>1.5</td>
<td>1.75</td>
<td>2.0</td>
<td>2.25</td>
<td>2.5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>0.32</td>
<td>0.64</td>
<td>0.96</td>
<td>1.28</td>
<td>1.6</td>
<td>1.96</td>
<td>2.24</td>
<td>2.56</td>
<td>2.88</td>
<td>3.2</td>
<td>3.84</td>
</tr>
<tr>
<td>0.40</td>
<td>0.8</td>
<td>1.2</td>
<td>1.6</td>
<td>2.0</td>
<td>2.4</td>
<td>2.8</td>
<td>3.2</td>
<td>3.6</td>
<td>4.0</td>
<td>4.8</td>
</tr>
<tr>
<td>0.50</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>4.0</td>
<td>4.5</td>
<td>5.0</td>
<td>6.0</td>
</tr>
<tr>
<td>0.63</td>
<td>1.26</td>
<td>1.89</td>
<td>2.52</td>
<td>3.15</td>
<td>3.78</td>
<td>4.41</td>
<td>5.04</td>
<td>5.67</td>
<td>6.3</td>
<td>7.56</td>
</tr>
<tr>
<td>0.80</td>
<td>1.6</td>
<td>2.4</td>
<td>3.2</td>
<td>4.0</td>
<td>4.8</td>
<td>5.6</td>
<td>6.4</td>
<td>7.2</td>
<td>8.0</td>
<td>9.6</td>
</tr>
<tr>
<td>1.0</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
<td>6.0</td>
<td>7.0</td>
<td>8.0</td>
<td>9.0</td>
<td>10.0</td>
<td>12.0</td>
</tr>
<tr>
<td>1.25</td>
<td>2.5</td>
<td>3.75</td>
<td>5.0</td>
<td>6.25</td>
<td>7.5</td>
<td>8.75</td>
<td>10.0</td>
<td>11.25</td>
<td>12.5</td>
<td>15.0</td>
</tr>
<tr>
<td>1.60</td>
<td>3.2</td>
<td>4.8</td>
<td>6.4</td>
<td>8.0</td>
<td>9.6</td>
<td>11.2</td>
<td>12.8</td>
<td>14.4</td>
<td>16.0</td>
<td>19.2</td>
</tr>
</tbody>
</table>

The specific cutting force \( k_c \) as a function of feed can be obtained from Table 2.
Determining the required gripping force of a power chuck

Power-operated clamping devices

Specific cutting force \( k_c \) [kN/mm²] Table 2

<table>
<thead>
<tr>
<th>Material</th>
<th>Strength ( \sigma_B ) [kN/mm²]</th>
<th>Feed ( s ) [mm]</th>
<th>0,16</th>
<th>0,25</th>
<th>0,4</th>
<th>0,63</th>
<th>1,0</th>
<th>1,6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St 42</td>
<td>0,50</td>
<td>2,60</td>
<td>2,40</td>
<td>2,20</td>
<td>2,05</td>
<td>1,90</td>
<td>1,80</td>
<td></td>
</tr>
<tr>
<td>St 50</td>
<td>0,52</td>
<td>3,50</td>
<td>3,10</td>
<td>2,75</td>
<td>2,45</td>
<td>2,15</td>
<td>1,95</td>
<td></td>
</tr>
<tr>
<td>St 60</td>
<td>0,62</td>
<td>4,05</td>
<td>3,05</td>
<td>2,60</td>
<td>2,40</td>
<td>2,20</td>
<td>2,05</td>
<td></td>
</tr>
<tr>
<td>C 45</td>
<td>0,67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 60</td>
<td>0,77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St 70</td>
<td>0,72</td>
<td>4,35</td>
<td>3,80</td>
<td>3,30</td>
<td>2,90</td>
<td>2,50</td>
<td>2,20</td>
<td></td>
</tr>
<tr>
<td>18 CrNi 6</td>
<td>0,63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42 CrMo 4</td>
<td>0,73</td>
<td>4,35</td>
<td>3,90</td>
<td>3,45</td>
<td>3,10</td>
<td>2,75</td>
<td>2,45</td>
<td></td>
</tr>
<tr>
<td>16 MnCr 5</td>
<td>0,77</td>
<td>3,75</td>
<td>3,30</td>
<td>2,95</td>
<td>2,60</td>
<td>2,30</td>
<td>2,05</td>
<td></td>
</tr>
<tr>
<td>Mn-CrNi</td>
<td>0,83-1,00</td>
<td>3,70</td>
<td>3,40</td>
<td>3,10</td>
<td>2,80</td>
<td>2,55</td>
<td>2,35</td>
<td></td>
</tr>
<tr>
<td>Hc-austent.</td>
<td>0,80</td>
<td>5,40</td>
<td>4,90</td>
<td>4,40</td>
<td>4,00</td>
<td>3,60</td>
<td>3,30</td>
<td></td>
</tr>
<tr>
<td>Cast iron</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St 42</td>
<td>0,30-0,50</td>
<td>2,30</td>
<td>2,10</td>
<td>1,95</td>
<td>1,80</td>
<td>1,70</td>
<td>1,60</td>
<td></td>
</tr>
<tr>
<td>St 42</td>
<td>0,50-0,70</td>
<td>2,55</td>
<td>2,35</td>
<td>2,20</td>
<td>2,05</td>
<td>1,90</td>
<td>1,80</td>
<td></td>
</tr>
<tr>
<td>St 42</td>
<td>HB 2,00-2,50</td>
<td>1,50</td>
<td>1,35</td>
<td>1,20</td>
<td>1,10</td>
<td>1,00</td>
<td>0,90</td>
<td></td>
</tr>
<tr>
<td>St 42</td>
<td>HB 2,00-2,50</td>
<td>2,05</td>
<td>1,80</td>
<td>1,60</td>
<td>1,46</td>
<td>1,30</td>
<td>1,15</td>
<td></td>
</tr>
<tr>
<td>NE-ferrous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cast bronze</td>
<td>0,55</td>
<td>2,55</td>
<td>2,33</td>
<td>2,20</td>
<td>2,05</td>
<td>1,90</td>
<td>1,80</td>
<td></td>
</tr>
<tr>
<td>Gunmetal</td>
<td>0,10</td>
<td>1,10</td>
<td>1,00</td>
<td>0,90</td>
<td>0,80</td>
<td>0,70</td>
<td>0,65</td>
<td></td>
</tr>
<tr>
<td>Brass</td>
<td>0,80-1,20</td>
<td>1,20</td>
<td>1,10</td>
<td>1,00</td>
<td>0,90</td>
<td>0,80</td>
<td>0,75</td>
<td></td>
</tr>
<tr>
<td>CAST ALUM.</td>
<td>0,30-0,422-60</td>
<td>1,10</td>
<td>1,00</td>
<td>0,90</td>
<td>0,80</td>
<td>0,70</td>
<td>0,65</td>
<td></td>
</tr>
</tbody>
</table>

The chucking ratio \( \frac{d_2}{d_{sp}} \) can either be determined from the specified working conditions or obtaines from Table 3.

Chucking ratio Table 3

| Feed-Ø (mm) | 20 | 40 | 60 | 80 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 500 | 600 | 700 | 800 |
|-------------|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 20          | 1,0 | 2,0 | 3,0 | 4,0 |     |     |     |     |     |     |     |     |     |     |     |     |
| 40          | 0,5 | 1,0 | 1,5 | 2,0 | 2,5 | 3,0 |     |     |     |     |     |     |     |     |     |
| 60          | 0,33 | 0,67 | 1,0 | 1,3 | 1,7 | 2,5 | 3,3 | 4,2 |     |     |     |     |     |     |     |
| 80          | 0,25 | 0,5 | 0,75 | 1,0 | 1,3 | 1,9 | 2,5 | 3,1 | 3,8 | 4,4 |     |     |     |     |     |
| 100         | 0,2 | 0,4 | 0,6 | 0,8 | 1,0 | 1,5 | 2,0 | 2,5 | 3,0 | 3,5 | 4,0 |     |     |     |     |
| 150         | 0,13 | 0,27 | 0,4 | 0,53 | 0,67 | 1,0 | 1,3 | 1,7 | 2,0 | 2,3 | 2,7 | 3,3 | 4,0 |     |     |
| 200         | 0,2 | 0,3 | 0,4 | 0,5 | 0,75 | 1,0 | 1,3 | 1,5 | 1,8 | 2,0 | 2,5 | 3,0 | 3,5 | 4,0 |     |
| 250         | 0,16 | 0,24 | 0,32 | 0,4 | 0,6 | 0,8 | 1,0 | 1,2 | 1,4 | 1,6 | 2,0 | 2,4 | 2,8 | 3,2 |     |
| 300         | 0,12 | 0,27 | 0,33 | 0,5 | 0,67 | 0,83 | 1,0 | 1,2 | 1,3 | 1,7 | 2,0 | 2,3 | 2,7 |     |     |
| 350         | 0,17 | 0,23 | 0,29 | 0,43 | 0,57 | 0,72 | 0,86 | 1,0 | 1,1 | 1,4 | 1,7 | 2,0 | 2,3 |     |     |
| 400         | 0,2 | 0,25 | 0,38 | 0,5 | 0,62 | 0,75 | 0,87 | 1,0 | 1,3 | 1,5 | 1,8 | 2,0 |     |     |     |
| 500         | 0,16 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 1,0 | 1,2 | 1,4 | 1,6 |     |     |     |
| 600         | 0,17 | 0,25 | 0,33 | 0,42 | 0,5 | 0,58 | 0,67 | 0,83 | 1,0 | 1,2 | 1,3 |     |     |     |     |
| 700         | 0,21 | 0,29 | 0,36 | 0,43 | 0,5 | 0,57 | 0,71 | 0,86 | 1,0 |     |     |     |     |     |     |
| 800         | 0,19 | 0,25 | 0,31 | 0,37 | 0,44 | 0,5 | 0,62 | 0,75 | 0,87 | 1,0 |     |     |     |     |     |

The chucking coefficient \( \mu_{sp} \) accounts for the friction existing between the gripping surface of the jaws and the workpiece in the zone of contact. It is influenced by:
- the pattern of the gripping surfaces of the jaws
- the surface quality of the workpiece
- the material.

The chucking coefficient can be obtained from Table 4.

Note:
Forces are more efficiently transmitted by a snug fit than by edge or saddle-Typee seats.

Chucking coefficient \( \mu_{sp} \) for steel parts Table 4

<table>
<thead>
<tr>
<th>Surface workpiece</th>
<th>smooth</th>
<th>Gripping surface of jaws</th>
<th>Serrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>smooth machine finish ground</td>
<td>0,07</td>
<td>0,12</td>
<td>0,20</td>
</tr>
<tr>
<td>rough to medium machine finish</td>
<td>0,10</td>
<td>0,20</td>
<td>0,35</td>
</tr>
<tr>
<td>unmachined</td>
<td>0,15</td>
<td>0,30</td>
<td>0,45</td>
</tr>
</tbody>
</table>

Corrections:
- Al, alloy = 0,95
- Brass = 0,90
- Gray cast iron = 0,80
Determining the required gripping force of a power chuck

Power-operated clamping devices

Safety factor $S_z$

The magnitude of the safety factor $S_z$ depends on the degree of accuracy with which the influencing parameters, such as load, chucking coefficient etc., can be determined and on the degree of safety required. It should be $\geq 2$ wherever possible.

Safety factor $S_z$ (approximate)

Table 5

<table>
<thead>
<tr>
<th>Influencing parameters</th>
<th>Safety factor $S_z$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New chucks</td>
</tr>
<tr>
<td>a) overhung chucking $l_z \leq d_{sp}$</td>
<td>$\geq 2.0$</td>
</tr>
<tr>
<td>b) no radial support from tailstock</td>
<td></td>
</tr>
<tr>
<td>c) tool applied radially</td>
<td></td>
</tr>
<tr>
<td>d) no axial seating of workpiece against jaws</td>
<td></td>
</tr>
<tr>
<td>e) ratio: chucking length to distance between cutting and clamping points $l_z \leq 3$</td>
<td>$\geq 4.0^*$</td>
</tr>
<tr>
<td>$l_z \geq 3 \leq 6$</td>
<td></td>
</tr>
</tbody>
</table>

* Lower safety factors can be applied if the workpiece is supported in the tailstock or axially seated against the jaws.

Superimpositions of alternating forces are neglected because their influence is very small in comparison with the total gripping force required.

The safety factors so determined are applicable if the following requirements are met:
Chuck in perfect condition, no damage, adequately lubricated (operating instructions followed to the letter).

No allowance has been made for the following loads acting on the chuck:

a) Unbalanced forces and moments produced by unsymmetrical workpieces
b) Weight of workpiece

For a precise calculation of the gripping force required for a given job, use VDI Recommendation 3106. Available from:
Beuth-Verlag GmbH, Kamekestraße 8, D-50672 Köln, Germany.

II)

At high speeds, the gripping force of the rotating lathe chuck is greatly influenced by the centrifugal forces of the jaws. These forces must be taken into account when determining the initial gripping force $F_{spo}$

The applicable formula is:

$$F_{spo} = S_{sp} \times (F_{spz} \pm F_c)$$

The + sign applies to external gripping.
The - sign applies to internal gripping.

6228
Determining the required gripping force of a power chuck

Power-operated clamping devices

Where:

\[ F_c = \text{experimentally determined total centrifugal force of the chuck jaws obtained from the gripping force-speed diagram. The gripping force curves refer to the hard, stepped jaws of the chuck.} \]

\[ S_{sp} = \text{safety factor for the initial gripping force in accordance with VDI Recommendation 3106} \geq 1,5 \]

If extremely heavy top jaws (special jaws) are used, the centrifugal forces \( F_c \) can be calculated using VDI Recommendation 3106.

III)

The operating power bears a given relationship to the total gripping force, depending on the type of chuck employed. The values for the operating power can be obtained from the gripping force/operating power diagram.

In special cases where the centrifugal forces of the jaws are very high in comparison with the initial gripping force and power chucks with standard top jaws cannot be used, certain operations can be done with aluminium top jaws of special strength.

Calculation (example)

Having:

1. Workpiece and machining data:

   | Material               | C 45       |
   | Chucking diameter:    | \( d_{sp} \) 60 mm Ø (roughed) |
   | Machining diameter:    | \( d_z \) 20 mm Ø |
   | Feed:                 | \( s \) 0.5 mm |
   | Depth of cut:          | \( t \) 5 mm |
   | Distance cutting/clamp. points: | \( l_z \) 50 mm |
   | Speed:                | \( n \) 3000 min\(^{-1}\) |

2. Chuck data:

   KFD 200 power chuck
   Jaws with diamond style gripping surface Condition of chuck: new (no special influencing parameters)
   External gripping with UB-538-04 top jaws at mid-position of gripping range.

Find:

1) Required gripping force \( F_{spz} = \) total gripping force required (without the effect of angular speed

2) Initial gripping force \( F_{spo} = \) (total) initial gripping force with the chuck stationary

3) Operating power
Determining the required gripping force of a power chuck

Power-operated clamping devices

Solution

1) Main cutting force
(Formula 2)
\[ F_s = s \cdot t \cdot k_c \]
= 0.5 \cdot 5 \cdot 2.50 = 6.25 kN

2) Required gripping force
(Formula 1)
\[ F_{spz} = \frac{F_s \cdot S_z}{\mu_{sp}} \cdot \frac{d_z}{d_{sp}} \]
= \frac{6.25 \text{ kN} \cdot 2.0 \cdot 0.33}{0.20} \approx 21.00 \text{ kN}

Safety factor \( S_z \) = from Table 5
Chucking coeff. \( \mu_{sp} \) = from Table 4
Chucking ratio \( \frac{d_z}{d_{sp}} \) = from Table 3

3) Obtain the loss of the gripping force from the gripping force speed diagram for KFD 200. At a speed of 3000 rpm: \( F_c = 18 \text{ kN} \). See diagram below.

4) Initial gripping force \( F_{spo} = S_{sp} \cdot (F_{spz} + F_c) \) (Formula 3) = 1.5 \cdot (21 kN + 18 kN) = 58.50 kN
\( S_{sp} \) determined in accordance with VDI Recommendation 3106 \( F_c \) obtained from diagram below

5) Obtain operating power from "gripping force/operating power" diagram for KFD 200. For a gripping force of 58.50 kN the operating power is \( \approx 29.00 \text{ kN} \) (next page)

Gripping force/speed diagram for KFD 3-jaw chucks

- upper curve: min. centrifugal force of top jaw
- lower curve: max. centrifugal force of top jaw

Loss of gripping force = \( F_c \) (~ 18 kN)
B. Drilling

1. Drilling in solid material (Top lip twist drill, point angle ≥ 120°)

The gripping force required is determined by the type of work to be performed. The calculation described below applies to freely chucked work, i.e., workpieces which are not axially seated against the jaws. In this situation the components \( F_{sB0} \) (cutting force) and \( F_{vax} \) (feeding force) acting on the workpiece give the resultant \( F_R \) to determine the gripping force.

The cutting force \( F_{sB0} \) can be calculated from

\[
F_{sB0} = s \cdot t \cdot k_c
\]

where:

- \( s \) = feed, mm/rev.
- \( t \) = depth of cut, mm = \( \frac{\text{drill diameter}}{2} \)
- \( k_c \) = specific cutting force kN/mm²

The feeding force \( F_{vax} \) bears a given relationship to the cutting force and can be directly obtained from Table 6.

Feeding force \( F_{vax} \)

**Table 6**
The two components $F_{SBo}$ and $F_{vax}$ give the resultant force $FR$

$$FR = \sqrt{F_{SBo}^2 + F_{vax}^2}$$

The amount of the resultant force $FR$ can be obtained directly from Table 7. Intermediate values will have to be determined by interpolation.

**Resultant force $FR$ KN**

![Diagram showing the relationship between cutting force, feeding force, and resultant force]

Place resultant force $FR$ for drilling in solid material in the known formula for determining the required gripping force $F_{spsz}$:

$$F_{spsz} = \frac{FR \cdot S_z \cdot d_z}{\mu_{sp} \cdot d_{sp}}$$

where:

- $F_{spsz}$ = gripping force required for a given job with the chuck stationary.
- $FR$ = resultant force of cutting force and feeding force

Chucking ratio $\frac{d_z}{d_{sp}} = \frac{\text{cutting dia.}}{\text{chucking dia.}}$ where $d_z = \frac{\text{drill dia.}}{2}$

- $\mu_{sp}$ = chucking coefficient (friction between jaw and workpiece)
- $S_z$ = safety factor

II and III
Continue the calculation - from determination of the initial gripping force $F_{spo}$ to determination of operating power and the pressure required - exactly as described in Section A) Turning, II) and III).
Determining the required gripping force of a power chuck

Power-operated clamping devices

Calculation (example):

Having:

1. Workpiece and machining data.
   Material = C 45
   Chucking dia. \(d_{sp}\) (roughed) = 60 mm
   Drill dia. (in solid mat.) = 30 mm
   Feed \(s\) = 0,3 mm
   Depth of cut \(t\) = 15 mm
   Speed \(n\) = 200 min\(^{-1}\)

2. Chuck data
   Power chuck KFD 200
   Jaws with diamond style gripping surface
   External gripping with UB 538-04 top jaws at mid position of gripping range
   Chuck in new condition (no special influencing parameters)

Find:
1. Required gripping force \(F_{spz}\)
2. Initial gripping force \(F_{spo}\)
3. Operating power

Solution:

1. Cutting force (Formula 4)
   \(F_{Bo} = s \cdot t \cdot k_c = 0,3 \cdot 15 \cdot 2,70 = 12,10 \text{ kN}\)
   \(s \cdot t\) from Table 1 (or calculated)
   \(k_c\) from Table 2

2. Required gripping force
   \[F_{spz} = \frac{F_R \cdot S_Z}{\mu_{sp}} \cdot \frac{d_z}{d_{sp}} = \frac{15,70 \cdot 2,0}{0,2} \cdot 0,25 = 39,25 \text{ kN}\]

   Obtain resultant force \(F_R\)
   from Table 7
   (after first obtaining \(F\)
   Chucking ratio \(\frac{d_z}{d_{sp}}\) from Table 3 (or calculated).

3. Check if any effective centrifugal forces act on the jaws at a speed of \(n = 200 \text{ min}^{-1}\).
   As this is not the case in this example, we have:

4. Initial gripping force \(F_{spo} = S_{sp} \cdot F_{spz} = 1,5 \cdot 39,25 \text{ kN}\)
   \(S_{sp}\) from VDI recommendation 3106 = 59,00 \text{ kN}\)

5. Obtain operating power from the "gripping force/operating power" diagram for KFD 200.
   For a gripping force of 59,00 \text{ kN} the operating power is 29 \text{ kN}\)

6. For boring (using a boring cutter) the calculation described under "A. Turning" applies analogously.