Gripping force setting of power chucks

Properly setting the gripping force of the chuck is very important for safe and high quality lathe machining.
If the gripping force is too high, there is a risk of causing harmful gripping distortion to the workpiece or damaging the chuck. On the other hand, if the gripping force is too low, the workpiece may scatter during machining.
You can easily calculate the appropriate gripping force by using the charts written in the instruction manual. (However, since it is a simplified one, please make a final decision after actually machining and checking.)
Step-by-step calculation is following, so please read it together with the instruction manual.

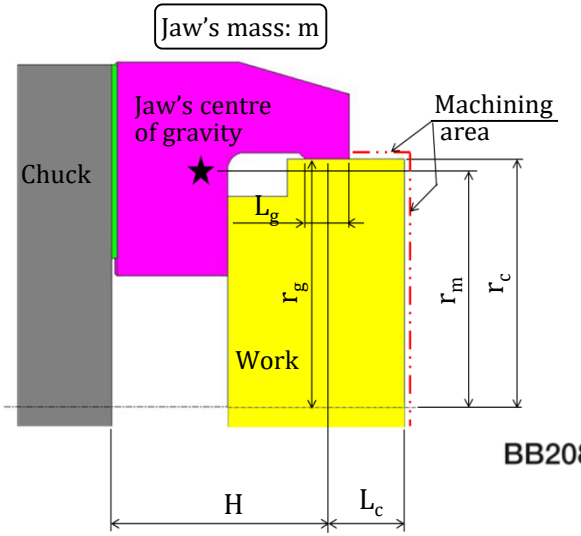
DANGER

To prevent serious personal injury due to scattering of chucks and workpieces

- The gripping force required for machining should be determined by the machine manufacturer or user by trial cut, and it should be confirmed that the gripping force required for machining is obtained. The gripping force at this time must not exceed the maximum gripping force.
- The rotation speed required for machining should be determined by the machine manufacturer or user by trial cut. The rotation speed at this time must not exceed the maximum speed.

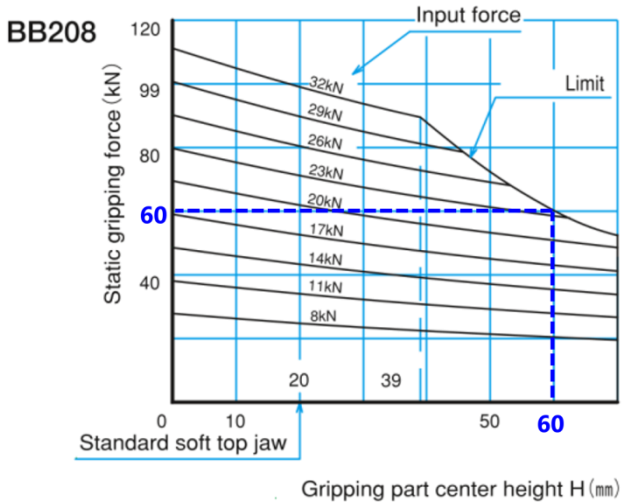
(1) Find the static gripping force from the height of the centre of the gripping part of jaw.

Note) If the gripping surface of the top jaw contacts the workpiece evenly, the mechanical centre point of the gripping force is the centre of the gripping surface. If the gripping surface contacts unevenly or estimation of the gripping centre height is difficult, the gripping force should be calculated using the distance from the top jaw top surface to the chuck surface so as to give priority to safety.



m : Jaw's mass (kg) m = 1.2kg
r_m : Radius of jaw's centre of gravity (mm) r_m = 72mm
H : Gripping centre height (mm) H = 60mm
L_c : Distance of machining position from gripping centre (mm) L_c = 20mm
L_g: Gripping length (mm) L_g = 15mm
r_g : Gripping radius (mm) r_g = 80mm
r_c : Machining radius (mm) r_c = 80mm

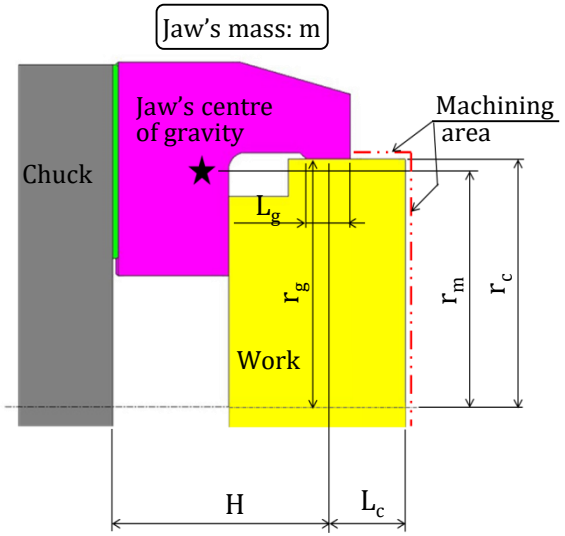
Note) Blue letters are the values used in the calculation sample. The same applies below.



In case of the above conditions with BB208

When the centre height of the gripping part is 60 mm, the maximum static gripping force is 60 kN, and the static gripping force is selected below this value.

(2) Calculate the mass moment from the mass of the jaw and the radius of the centre of gravity, and find the gripping force loss at the machining speed.



m : Jaw's mass (kg) $m = 1.2kg$
r_m : Radius of jaw's centre of gravity (mm) $r_m = 72mm$
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L_c : Distance of machining position from gripping centre (mm) $L_c = 20mm$
L_g: Gripping length (mm) $L_g = 15mm$
r_g : Gripping radius (mm) $r_g = 80mm$
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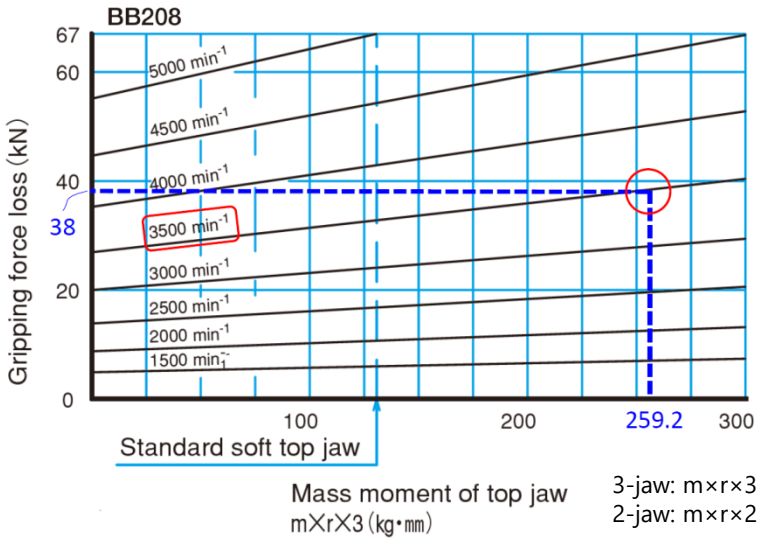
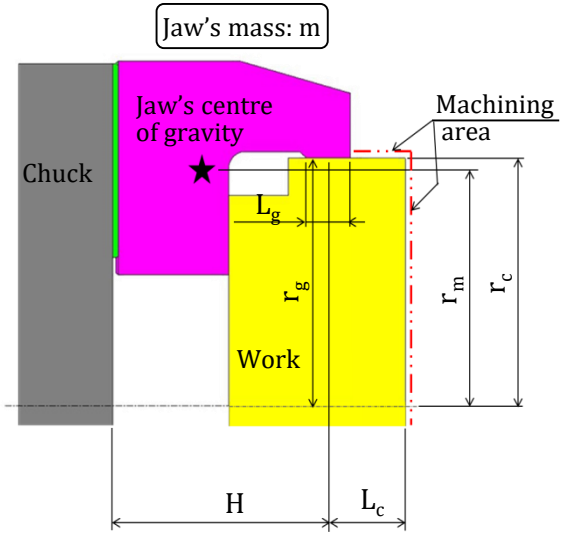
Mass moment = $m \times r_m \times 3$
= $1.2 \times 72 \times 3 = 259.2 kg \cdot mm$



In the example on the left, when the mass moment of the top jaw is 259.2 kg·mm and the rotation speed is 3500 min^{-1} in BB208, the gripping force loss is 38 kN.

(3) Subtract the gripping force loss obtained in (2) from the static gripping force obtained in (1) to calculate the dynamic gripping force at the machining speed, and then calculate the gripping torque and the overturning resistance moment.



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L_g: Gripping length (mm) $L_g = 15mm$
r_g : Gripping radius (mm) $r_g = 80mm$
r_c : Machining radius (mm) $r_c = 80mm$
F_{gD}: Dynamic gripping force (kN)
F_g: Static gripping force (kN) $F_g = 60kN$
F_c: Gripping force loss (kN) $F_c = 38kN$
μ: Coefficient of friction $\mu = 0.1$ (Determine by the actual surface of the jaw and workpiece)

Number of jaws	k
2 jaws	1/2
3 jaws	3/4
4 jaws	2

Dynamic gripping force $F_{gD} = F_g - F_c = 60 - 38 = 22kN$

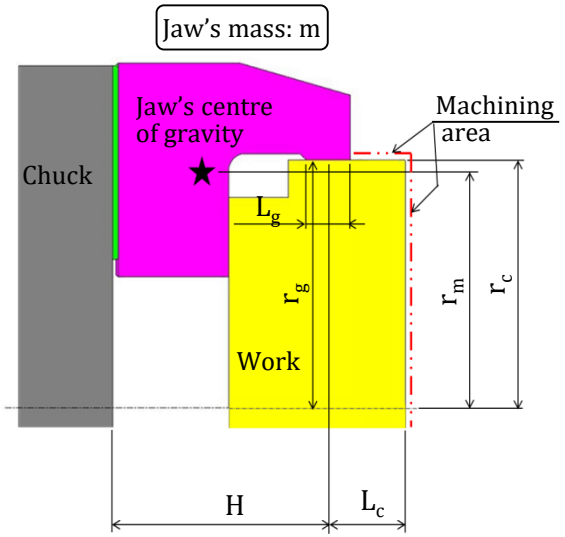
Gripping torque $= F_{gD} \times \mu \times r_g = 22 \times 1000 \times 0.1 \times 80 / 1000 = 176N \cdot m$

Overturning resistance moment $= F_{gD} / (\text{Number of jaws}) \times (2/3 \times L_g + k \times \mu \times 2r_g)$

$= 22 \times 1000 / 3 \times (2/3 \times 15 / 1000 + 3/4 \times 0.1 \times 2 \times 80 / 1000)$

$= 161.3N \cdot m$

(4) Calculate the cutting torque and the overturning moment due to machining.



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r_g : Gripping radius (mm) r_g = 80mm
r_c : Machining radius (mm) r_c = 80mm
M_c: Cutting torque (N·m)
M_o: Overturning moment (N·m)
ap: Cutting depth (mm) ap = 1.5mm
f: Feed (mm/rev) f = 0.2mm/rev
k_c: Specific cutting resistance (N/mm^2) k_c = 2100N/mm^2
(Determine by the actual surface of the jaw and workpiece)

Cutting torque

$$M_c = ap \times f \times k_c \times r_c = 1.5 \times 0.2 \times 2100 \times 80/1000$$
$$= 50.4 N \cdot m$$

Overturning moment

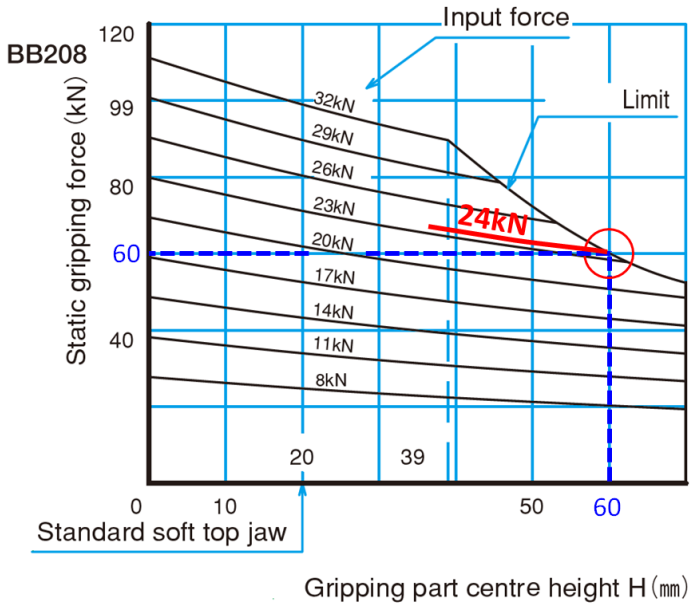
$$M_o = ap \times f \times k_c \times L_c = 1.5 \times 0.2 \times 2100 \times 20/1000$$
$$= 12.6 N \cdot m$$

(5) Make sure that the gripping torque and overturning resistance moment are sufficiently safe against cutting torque and overturning moment.

Gripping torque = 176N·m > Cutting torque = 50.4N·m --- OK
Generally, a safety factor of 2.5 or higher for continuous cutting and 3.5 or higher for intermittent cutting are recommended for the cutting torque.

Overturning resistance moment =161.3N·m > Overturning moment = 12.6N·m --- OK
Generally, a safety factor of 3.0 or higher for continuous cutting and 4.0 or higher for intermittent cutting are recommended for the overturning moment.

(6) Find the input force on the graph to obtain the required static gripping force.



In the example on the left, when the centre height of the gripping part is 60 mm and the required static gripping force is 60 kN, the input force is 24 kN.

(7) Calculate the hydraulic pressure to obtain the required input force according to the instruction manual of the cylinder.

In case SR1566 cylinder is used:

$Q = Q_{max} \times (P - 0.25) / (P_{max} - 0.25)$

Required piston thrust $Q = 24kN$

Max. piston thrust of SR1566 $Q_{max} = 45kN$

Max. operating pressure of SR1566 $P_{max} = 4.0MPa$

Operating pressure $P = Q / Q_{max} \times (P_{max} - 0.25) + 0.25$

$=24 / 45 \times (4.0 - 0.25) + 0.25 = 2.25MPa$

SR1566 cylinder's specifications

Max. piston thrust $Q_{max} = 45.0kN$
Max. operating pressure $P_{max} = 4.0MPa$

IMPORTANT

After setting the hydraulic pressure, be sure to perform a test cutting to confirm that an appropriate gripping force is obtained before starting the production.

The above calculation is for gripping the outer diameter, and when using it for gripping the inner diameter, the input should be 1/2 or less of the maximum allowable input.

Be sure to read the instruction manual before starting work. If you are not sure, please contact Kitagawa dealer where you purchased the product.