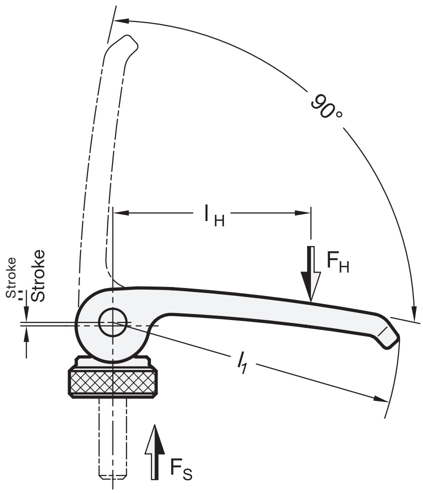
Clamping and manual forces in clamping levers with eccentrical cam

Force details, calculation

General information



The eccentric principle has two advantages: A large clamping force F_S and a self-locking mechanism as soon as the dead centre is exceeded.

All theoretical attempts to describe the ratio between manual and clamping force will ultimately rest only on assumptions in some parameters. The actually prevailing conditions are influenced by a number of different factors.

The values given in the tables below are therefore based on practical specifications and findings and rest on test series which have shown which clamping forces can be achieved by applying the specified manual forces.

The maximum permitted pretensioning force of each thread size will not be exceeded by operating the lever.

Clamping and manual forces

l_1 Lever size	≈ F_H Manual force in N	≈ l_H Lever, manual force	≈ F_S Screw force / Clamping force in N		
			GN 927 / 927.4	GN 927.3 / 927.5	GN 927.2 / GN 927.7
44	75	33	1250	1750	1450
63	125	47	2250	3100	2600
82	200	62	3700	5000	4300
101	350	76	6100	8000	7000

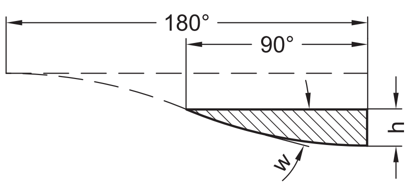
Calculation

To account for the above theoretical and arithmetical alternative for determining clamping and manual forces, a potential solution will be shown below which will ultimately also prove the plausibility of the values given in the table using a calculation example.

When theoretically determining the clamping force F_S resulting from the manual force F_H, two points must be observed in particular:

First, there are the geometrical conditions existing at the eccentric which call for an arithmetically complex approach if one wishes to take account of the exact conditions. Secondly, the friction occurring at several points will have a strong impact on the achievable clamping force

1st alternative, eccentric



Looking at the developed view arising in an eccentric through the rolling motion, one will find that this is caused by a sinusoidal curve.

The result is that the gradient angle w above the swivel range changes permanently, causing an extension of the self-locking range and of the force transmission.

However, the arithmetical description of this approach is highly complex.

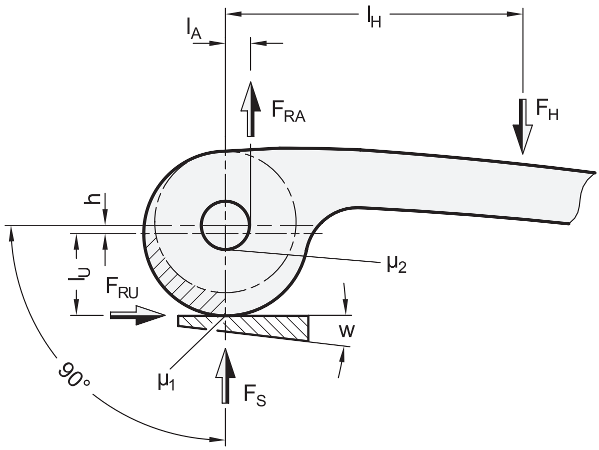
Substitute calculation model

In simple terms and assuming a constant gradient, the existing sine curve may be seen as a wedge which will result in a sufficiently accurate and approximate substitute calculation model which is a great deal less complex.

A friction value will be assumed for the axis of rotation and the circumference of the eccentric, which will in reality be strongly influenced by external factors and may therefore diverge accordingly.

2nd alternative, eccentric

A 90° motion of the manual level covers the stroke h.



Legend	
F_S	Screw force / clamping force (resulting)
F_h	Manual force
l_H	Lever arm of the manual force
F_{RU}	Friction force at circumf.
l_U	Lever arm at circumference
F_{RA}	Friction force at the axis
l_A	Lever arm at the axis
w	Substitute wedge angle
h	Stroke at 90° rotation of the lever
μ_1	Friction coefficient at circumf.
μ_2	Friction coefficient at the axis

Equations and model calculations

Clamping force	Friction coefficient (wedge angle, ¼ circle)
$F_s = F_H \times l_H \,/\, ((l_U \times (\mu_w + \mu_1)) + (l_A \times \mu_2))$	$\mu_w = h \times 4 \,/\, \pi \times 2 \times l_U$

Example

Clamping lever with eccentrical cam GN 927.7-101-M8-B
with manual force F_H = 350 N, friction coefficient $\mu_1 = 0.2$ and $\mu_2 = 0.1$ plus lever arm l_A = 5 mm and l_U =11.5 mm

F_s = 350 N x 76 mm / ((11.5 mm x (0.083 + 0.2)) + (5 mm x 0.1)) = **7000 N**

The following friction coefficients μ may be used for potential friction pairings:

Plastic / Plastic ≈ 0.25	Steel / Steel (lubricatedd) ≈ 0.1	Stainless Steel / Stainless Steel ≈ 0.2
Plastic / Steel ≈ 0.15	Stainless Steel / Stainless Steel (lubricated) ≈ 0.1	

Safety notices

The design of applications involving clamping levers with eccentrical cam should always be made including an adequate safety factor. Usual safety factors are for static load 1.2 to 1.5, pulsating load 1.8 to 2.4 and alternating load 3 to 4. To be increased proportionally in applications with higher safety requirements.

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