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Problem 1:

The thickness of a roll gap during rolling process in a rolling mill stand can be calculated by the help of simplified coupled formulas

$$h_1 = s_0 + \frac{F}{C_M} \ , \qquad F = \sqrt{r(h_0 - h_1)}bk_W$$

which lead to

$$h_1 = s_0 - \frac{b^2 k_W^2 r}{2C_M^2} + \sqrt{(\frac{b^2 k_W^2 r}{2C_M^2} - s_0)^2 + \frac{b^2 k_W^2 r h_0}{C_M^2} - s_0^2}$$

The used variables and units are:

F	$[N]$	rolling force
s_0	$[mm]$	unloaded roll gap
b	$[mm]$	width of strip
r	$[mm]$	radius of work rolls
h_0	$[mm]$	input-thickness of strip
C_M	$[N/mm]$	mill (spring) module
k_W	$[N/mm^2]$	mean pressure

Show that the formula of the roll gap thickness h_1 is correctly evaluated and calculate the unit by checking the units of all elemets of the whole formula.

Problem 2:

The contact pressure of a fitting key connection can be calculated by

$$p = \frac{2T}{d(h - t_1)\ell_e ik}$$

if the torque T for example in $[kNm]$ and the key data

d	$[dm]$	shaft diameter
h	$[cm]$	key hight
t_1	$[cm]$	keyway depth in shaft
ℓ_e	$[m]$	effective length of key
i	$[-]$	number of keys
k	$[-]$	contact factor

are known.

Check the units in the formula and find the factor and/or the prefix of the pressure unit in $[N/mm^2]$.

Problem 3:

Given is the expression for longitudinal stress in a cylinder at radius r

$$\sigma_z(r) = \frac{\alpha E T_i}{1 - \nu}\Big[\frac{r_a + 2r_i}{2(r_a + r_i)} - \frac{r_a - r}{r_a - r_i}\Big]$$

subject to linear thermal temperature distribution throughout the wall thickness of the cylinder by using the equation

$$T(r) = T_i \frac{r_a - r}{r_a - r_i}$$

when the cylinder wall is small in comparison with the outside radius.

Calculate the stress for given values of variables

α	=	$15 * 10^{-6}$	$[1/K]$	thermal expansion coefficient
E	=	$210 * 10^3$	$[MPa]$	Young's modulus
T_i	=	200	$[^oC]$	temperature difference at inner surface
ν	=	0.3	$[-]$	Poisson number
r_a	=	80	$[cm]$	outer radius
r_i	=	760	$[mm]$	inner radius
r	=	7.9	$[dm]$	actual radius