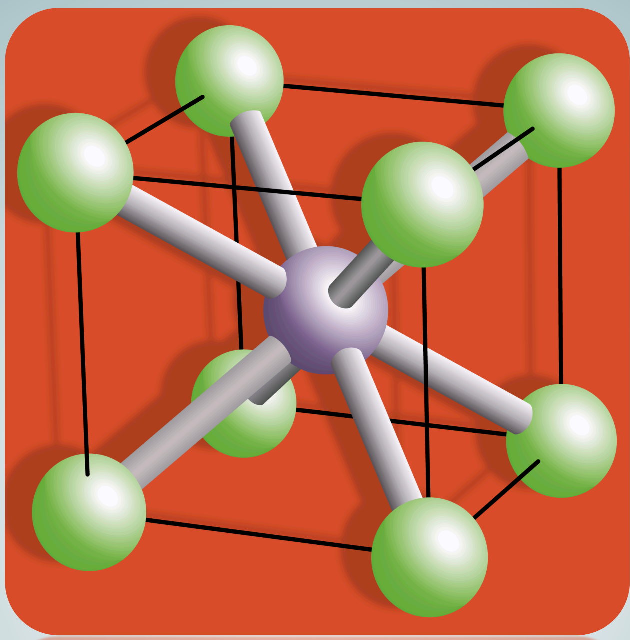
Materials

Exercises Topic 8. Creep



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Subject: MATERIALS
Degree: GRADO en INGENIERÍA MECÁNICA. 2[nd] Grade

CREEP

1. It is intended to install a stainless steel pipe in a chemical facility. The passage of liquid inside the pipe develops an internal preassure (P), in such a way that the stress (σ) in the pipe material is related to that pressure by the "thin tube formula":

$$\sigma = \frac{P\varnothing}{2e}$$ *Ø= 40 mm is the diameter of the pipe and e = 2 mm el espesor*

In anticipation of the existence of creep phenomena, lab tests had been carried out in order to determine the deformation rate by steady state creep at 200ºC; the results obtained are the following ones:

$(d\varepsilon/dt)_{SS}$ (years^{-1})	*$2{,}5\cdot10^{-3}$*	*$2{,}4\cdot10^{-2}$*
P (MPa)	*5,5*	*7,0*

The activation energy for this pehnomena, Q, is 140 KJ/mol and the creep law of the material is:

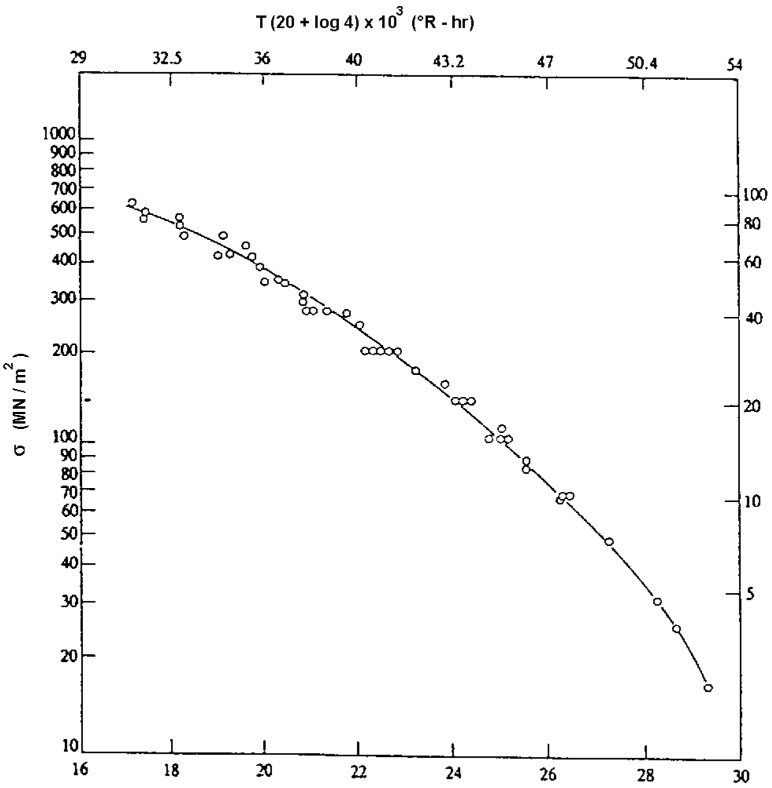
$(d\varepsilon/dt)_{SS} = A\sigma^n e^{-(Q/RT)}$ *A and n constants of the material and R = 8,3 J/mol·K Universal Gases constant.*

In these conditions, determine the life of the pipe if it works at 250ºC and 4,8 MPa, being the maximum permissible deformation 6%.

2. Estimate the allowable in-service stress for an structural element manufactured from an S590 alloy at a temperature of 1100ºC, if the lifetime of the structure must be at least tf = 10 hours.

If it is intended to fix the in-service stress in 500 MPa and prevent the failure of the component before 10.000 hours, determine the maximum working temperature that is permissible.

Calculate the lifetime if the applied stress were of 250 MPa and the working temperature of 870ºC.



T·(20+log t_f) · 10^3 (K· h)

3. It is suspected that a cooper plate of high conductivity can suffer an important overheating during its use in service. In order to figure out its creep behavior a cylindrical specimen of Ø = 5 mm diameter was prepared; it was tested at a fixed temperature of 327ºC. The initial length between the pins of the extensometer employed for this test were of 5Ø, and the specimen was subjected to a constant load of 152 Kg which produced an instantaneous elastic deformation ε_0. In the following table the registered data of the extensometer along the time are presented:
:

t (s)	0	60	180	300	420	540	660	780	900	1020
ℓ (mm)	25.201	25.258	25.305	25.335	25.360	25.381	25.400	25.419	25.435	25.452

t (s)	1260	1500	1740	1980	2220	2460	2700	2940	3180	3420
ℓ (mm)	25.482	25.512	25.541	25.569	25.598	25.628	25.658	25.690	25.723	25.759

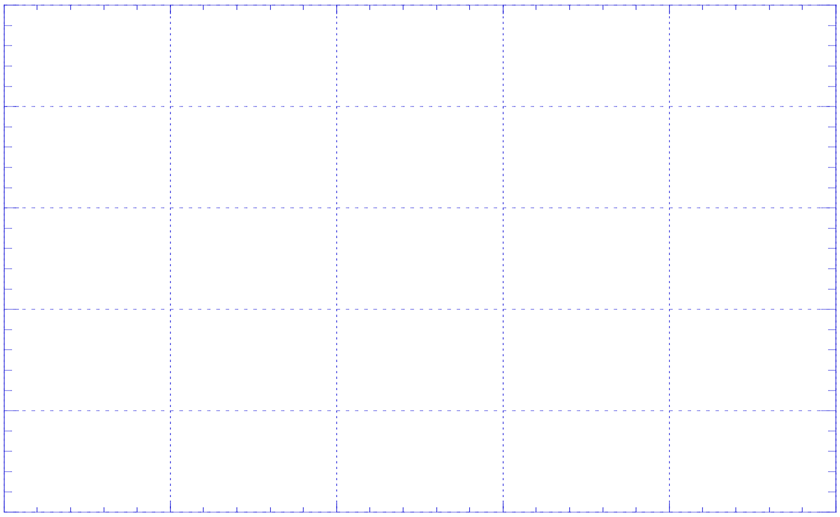
t (s)	3660	3900	4020	4140	4260	4380	4500	4620	4740	4800
ℓ (mm)	25.797	25.840	25.863	25.888	25.916	25.947	25.983	26.028	26.097	26.166

a) Determine the creep stress (σ) employed during the test.

b) Calculate the instantaneous initial deformation (ε_0).

c) Represent the graph "percentual deformation due exclusively to creep (%ε_F)" vs "the time (t)", ergo (%ε_F)-(t)", using for this the attached graph.

ε_F (%)



t (s)

d) From the previous representation, determine the minimum deformation rate. What is the name given to the creep stage where this phenomena occurs?

e) It is known that the constant for Weertman equation for this material is A = 0.0420 when the deformation is expressed in %, the stress in MPa and the time in seconds, and that the Activation Energy for the creep phenomena in this material is Q = 130 kJ/mol. Estimate the potential index (n) of the stress in the aforementioned equation.

f) Calculate the lifetime in service of the cooper plate if the final operating conditions will be 250ºC at a stress of 50 MPa, and the maximum admissible deformation caused by creep must be of 2%.

Tip:

1 kg = 9.81 N ; Ideal gases constant: R = 8.31 J/mol·K ; Weertman eq.: $\dot{\varepsilon}_{ss} = A\sigma^n e^{-Q/RT}$

t (s)	ℓ (mm)	Δℓ (mm)	ε_{TOTAL} (%)	$\varepsilon_{FLUENCIA}$ (%)
0	25.201			
60	25.258			
180	25.305			

300	25.335			
420	25.360			
540	25.381			
660	25.400			
780	25.419			
900	25.435			
1020	25.452			
1260	25.482			
1500	25.512			
1740	25.541			
1980	25.569			
2220	25.598			
2460	25.628			
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4140	25.888			
4260	25.916			
4380	25.947			
4500	25.983			
4620	26.028			
4740	26.097			
4800	26.166			