ME-3901. Engineering Experimentation

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Initial variables:

$E := 12.7\cdot 10^{6}$ $\qquad \delta E := 0.1\cdot E$ $\qquad \delta E = 1.27\times 10^{6}$

$\nu := 0.3$ $\qquad \delta\nu := 0.05$

$t := 0.003$ $\qquad \delta t := 5\cdot 10^{-4}$

$r := 1.288$ $\qquad \delta r := 5\cdot 10^{-3}$ $\qquad \delta\varepsilon s := 25\cdot 10^{-6}$

Define range for strain:

$\varepsilon s := 5\cdot 10^{-6}, 10\cdot 10^{-6} .. 2000\cdot 10^{-6}$ $\qquad P(\varepsilon s) := E\cdot t\cdot \dfrac{\varepsilon s}{\left(1-\dfrac{\nu}{2}\right)\cdot r}$

Define partial derivatives functions:

$fE(\varepsilon s) := t\cdot \dfrac{\varepsilon s}{r\cdot\left(1-\dfrac{1}{2}\cdot\nu\right)}$ $\qquad fth(\varepsilon s) := E\cdot \dfrac{\varepsilon s}{r\cdot\left(1-\dfrac{1}{2}\cdot\nu\right)}$

$f\varepsilon s(\varepsilon s) := E\cdot \dfrac{t}{r\cdot\left(1-\dfrac{1}{2}\cdot\nu\right)}$ $\qquad fra(\varepsilon s) := -E\cdot t\cdot \dfrac{\varepsilon s}{r^{2}\cdot\left(1-\dfrac{1}{2}\cdot\nu\right)}$

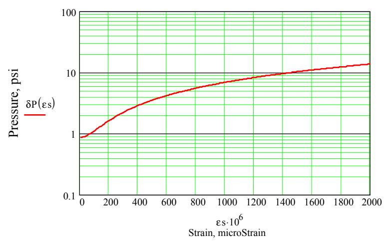
$f\nu(\varepsilon s) := \dfrac{1}{2}\cdot E\cdot t\cdot \dfrac{\varepsilon s}{r\cdot\left(1-\dfrac{1}{2}\cdot\nu\right)^{2}}$

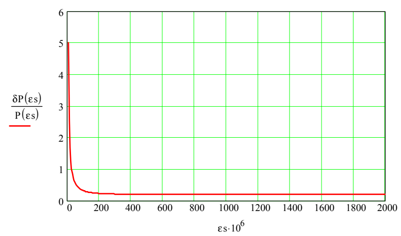
Uncertainty in pressure as a function of strain:

$\delta P1(\varepsilon s) := (fE(\varepsilon s)\cdot\delta E)^2 + (fth(\varepsilon s)\cdot\delta t)^2 + (f\varepsilon s(\varepsilon s)\cdot\delta\varepsilon s)^2 + (fra(\varepsilon s)\cdot\delta r)^2 + (f\nu(\varepsilon s)\cdot\delta\nu)^2$

$\delta P(\varepsilon s) := \delta P1(\varepsilon s)^{0.5}$

$\delta P(1370\cdot 10^{-6}) = 9.414$ (Example: strain at 1370 microstrains)





$PIE(\varepsilon s) := \left(\dfrac{fE(\varepsilon s)\cdot\delta E}{\delta P(\varepsilon s)}\right)^2$ $\qquad PIth(\varepsilon s) := \left(\dfrac{fth(\varepsilon s)\cdot\delta t}{\delta P(\varepsilon s)}\right)^2$ $\qquad PI\varepsilon s(\varepsilon s) := \left(\dfrac{f\varepsilon s(\varepsilon s)\cdot\delta\varepsilon s}{\delta P(\varepsilon s)}\right)^2$

$PIra(\varepsilon s) := \left(\dfrac{fra(\varepsilon s)\cdot\delta r}{\delta P(\varepsilon s)}\right)^2$ $\qquad PI\nu(\varepsilon s) := \left(\dfrac{f\nu(\varepsilon s)\cdot\delta\nu}{\delta P(\varepsilon s)}\right)^2$

$TU(\varepsilon s) := PIE(\varepsilon s) + PIth(\varepsilon s) + PI\varepsilon s(\varepsilon s) + PIra(\varepsilon s) + PI\nu(\varepsilon s)$

$PcPIE(\varepsilon s) := 100\cdot\dfrac{PIE(\varepsilon s)}{TU(\varepsilon s)}$ $\qquad PcPIth(\varepsilon s) := 100\cdot\dfrac{PIth(\varepsilon s)}{TU(\varepsilon s)}$ $\qquad PcPI\varepsilon s(\varepsilon s) := 100\cdot\dfrac{PI\varepsilon s(\varepsilon s)}{TU(\varepsilon s)}$

$PcPIra(\varepsilon s) := 100\cdot\dfrac{PIra(\varepsilon s)}{TU(\varepsilon s)}$ $\qquad PcPI\nu(\varepsilon s) := 100\cdot\dfrac{PI\nu(\varepsilon s)}{TU(\varepsilon s)}$

$Check(\varepsilon s) := PcPIE(\varepsilon s) + PcPIth(\varepsilon s) + PcPI\varepsilon s(\varepsilon s) + PcPIra(\varepsilon s) + PcPI\nu(\varepsilon s)$

(to make sure it adds 100 %)

Order of importance for the numerical data used:

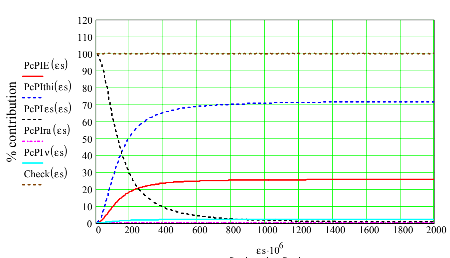
$PcPIth(600\cdot 10^{-6}) = 68.767$

$PcPIE(600\cdot 10^{-6}) = 24.756$

$PcPI\varepsilon s(600\cdot 10^{-6}) = 4.298$ (Example: evaluated at 600 microstrains)

$PcPI\nu(600\cdot 10^{-6}) = 2.142$

$PcPIra(600\cdot 10^{-6}) = 0.037$



Order of importance for the numerical data used:

$PcPI\varepsilon s(100\cdot 10^{-6}) = 61.785$

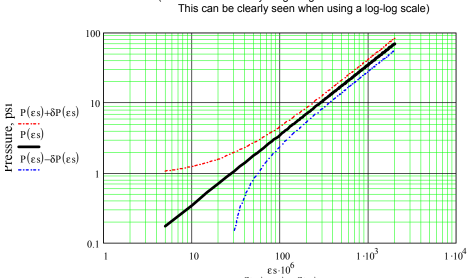
$PcPIth(100\cdot 10^{-6}) = 27.46$

$PcPIE(100\cdot 10^{-6}) = 9.886$ (Example: evaluated at 100 microstrains)

$PcPI\nu(100\cdot 10^{-6}) = 0.855$

$PcPIra(100\cdot 10^{-6}) = 0.015$

(Note that uncertainity range is greater at low values of strain.
This can be clearly seen when using a log-log scale)



$\delta P(200\cdot 10^{-6}) = 1.622$

$P(200\cdot 10^{-6}) = 6.96$ $\qquad \dfrac{\delta P(200\cdot 10^{-6})}{P(200\cdot 10^{-6})} = 0.233$

$\delta P(1600\cdot 10^{-6}) = 10.982$

$P(1600\cdot 10^{-6}) = 55.681$ $\qquad \dfrac{\delta P(1500\cdot 10^{-6})}{P(1500\cdot 10^{-6})} = 0.197$