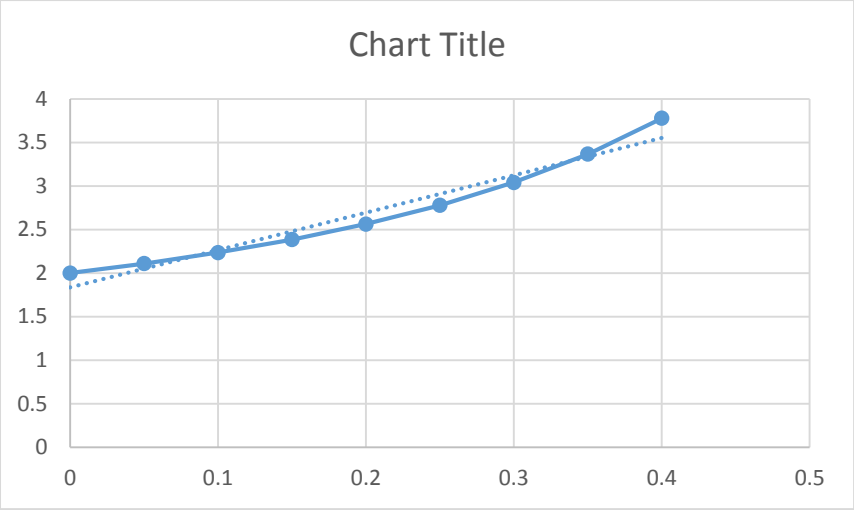
Stress linearization

Stress linearization is fundamentally based on the assumption that the stress is linearly distributed along the path and any stress deviated from the linear path is caused by stress concentration. With this fact, if the stress is highly nonlinearly distributed along the stress path, it is recommended not to use stress linearization method, as linearized stress is not conservative enough. An elasticplastic method is more appropriate. ASME BPVC Sec VIII Div 2 states that if the ratio of the thickness of the wall t to the insider radius R is larger than 0.25, then stress linearization method should not be used.

This can be verified by the thick wall stress equation under internal pressure

$$\sigma_\theta = \frac{P_i R_i^2}{R_o^2 - R_i^2}\left(1 + \frac{R_o^2}{r^2}\right) = \frac{P_i R_i^2}{R_o^2 - R_i^2}\left(1 + \frac{1}{\left(1 - \frac{x}{R_o}\right)^2}\right)$$

where x is the variable along the thickness, i.e., $x \in [0, t]$. When the ratio of t/R_i is less than 0.25, the stress distribution is nearly linear as shown below, and the stress deviated from the linear path is only on the edge which can be classified as peak stress.



When t/R_i is larger than 0.25, say 0.5, the stress distribution can't be approximated as linear, and linearization would leave a large part of stress as peak stress as shown below. This is not conservative as we only assess linearized stress in a non-fatigue evaluation. The stress can't be classified as peak any more, because it is actually part of the non-peak stress that may cause plastic collapse.

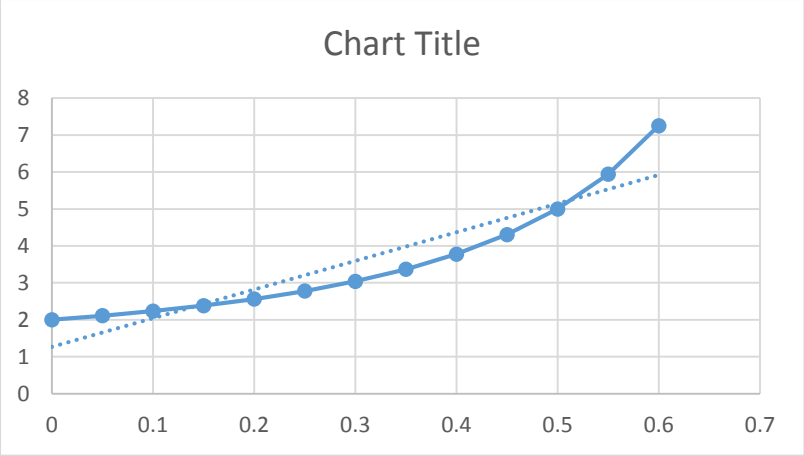


Chart Title
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