2. [illegible]

Fatigue[illegible]

2.1 [illegible]

[illegible](American Society for Testing and Materials, ASTM)[illegible]Nf[illegible]

[illegible]

1. [illegible]-[illegible]
2. [illegible]-[illegible]
3. [illegible]
4. [illegible]

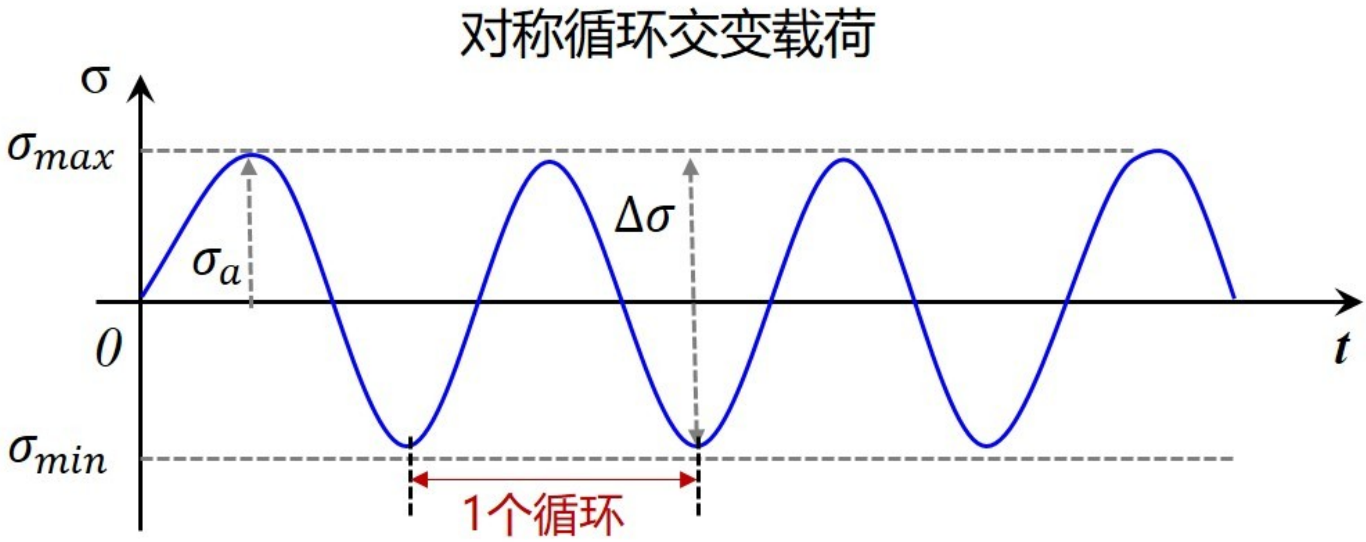
Fatigue **Fatigue** - [illegible]

[illegible]

- [1] https://en.wikipedia.org/wiki/Fatigue_(material)
- [2] Schijve J., Fatigue of structures and materials, 2nd ed., Springer, 2009.
- [3] Dowling, Mean Stress Effect in Stress-Life and Strain-Life Fatigue. In: SAE Paper No. 2004-01-2227, 2004.

2.2 [illegible]

[illegible]

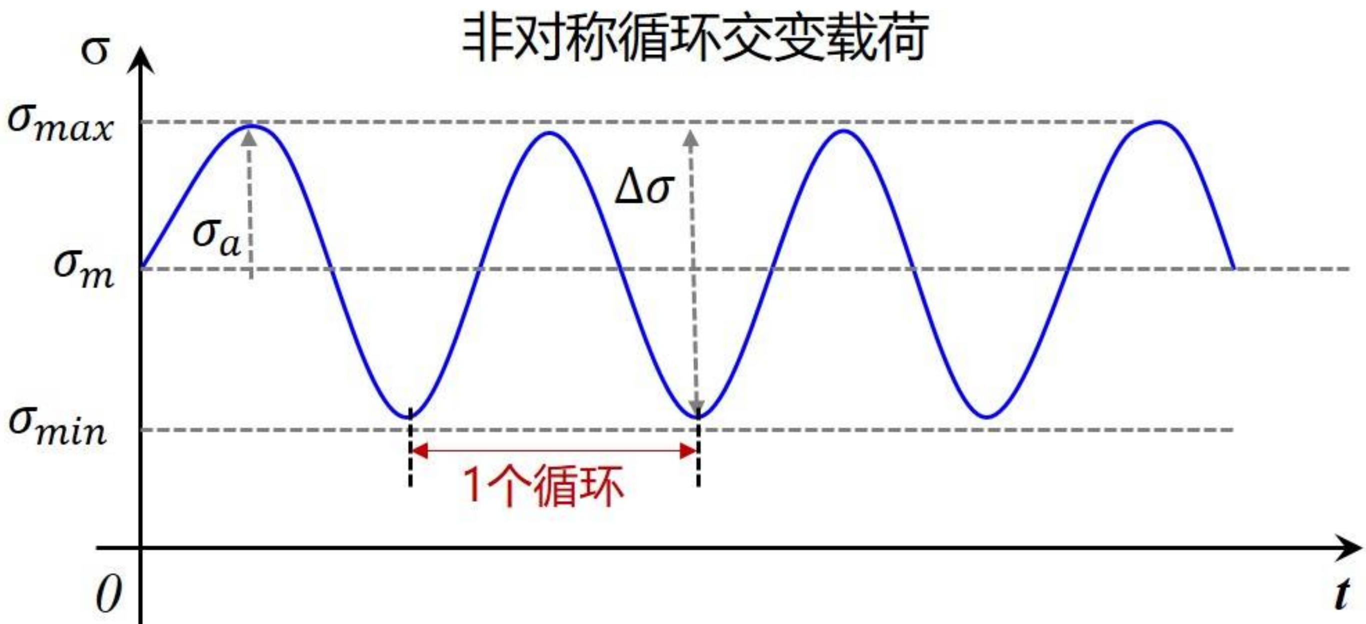


[illegible] *2.1* [illegible]

[illegible] 2.1[illegible]σmax[illegible]

[illegible]σa[illegible]Δσ[illegible] $$ \sigma_a=\frac{\sigma_{max}-\sigma_{min}}

[illegible]-[illegible]2.2[illegible]



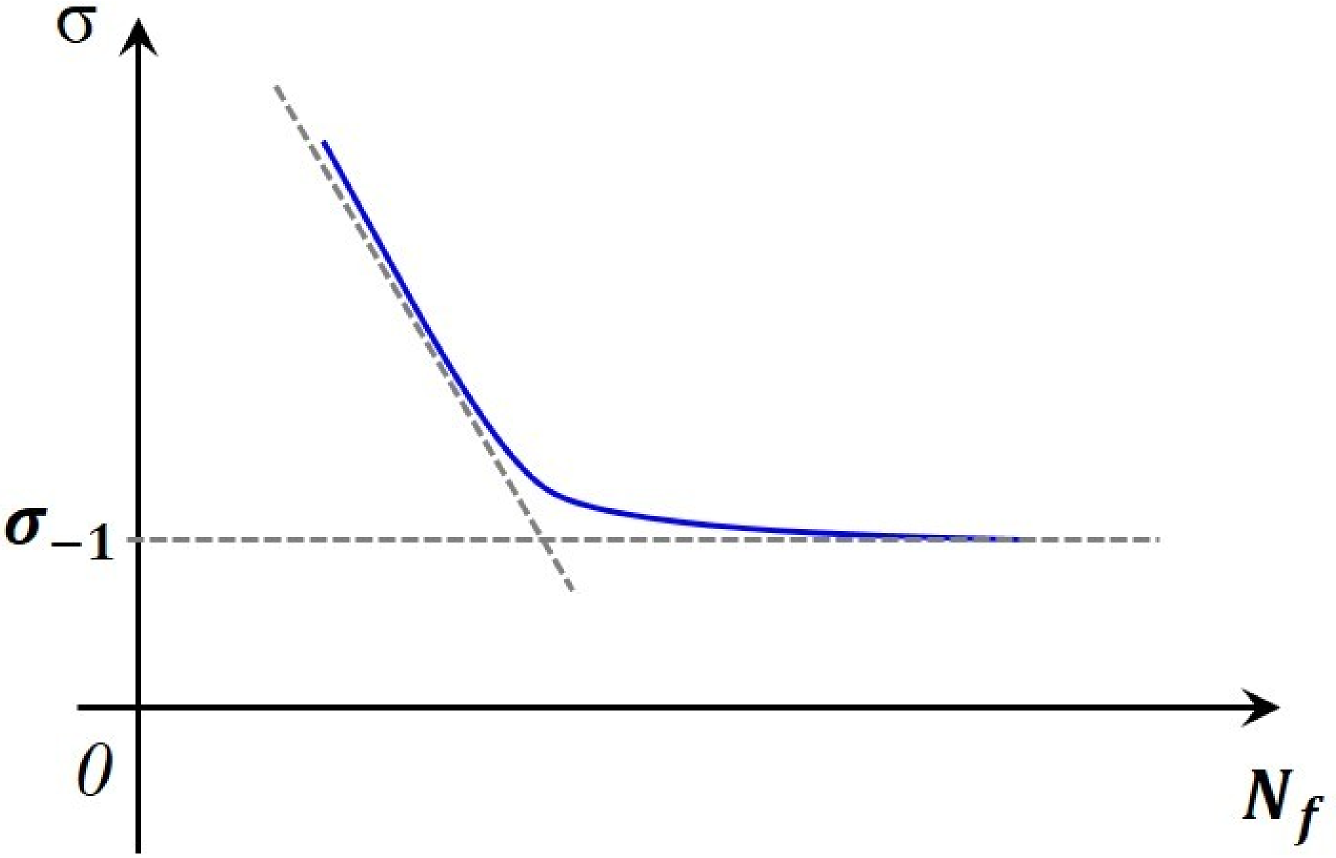
[illegible] *2.2* [illegible]

[illegible]-[illegible]2.1[illegible]R[illegible]R[illegible]
$$\sigma_m=\frac{\sigma_{max}+\sigma_{min}}{2}$$ [illegible]

[illegible]

2.3 [illegible]S-N[illegible]

[illegible]S-N[illegible]S-N[illegible]



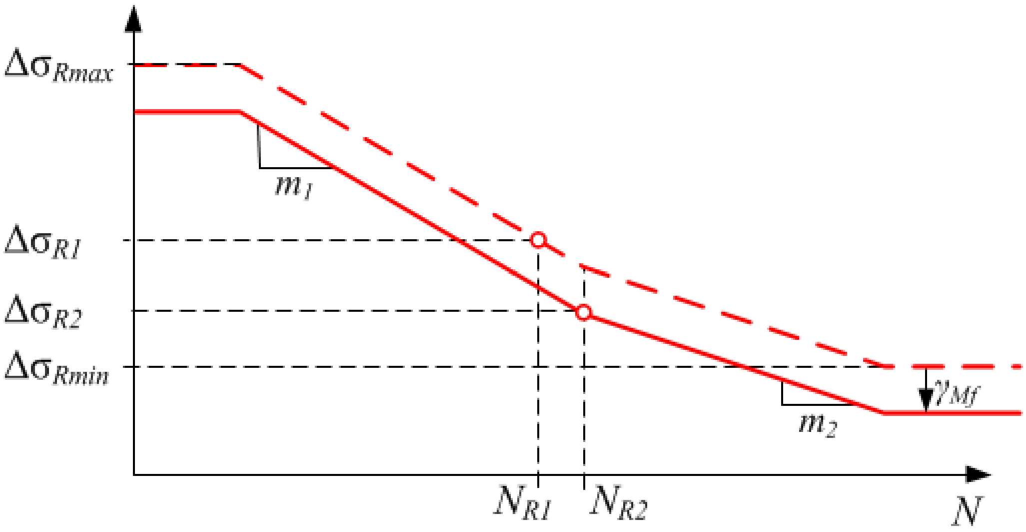
[illegible] 2.3 S-N[illegible]

S-N[illegible]“[illegible]”[illegible]10^7[illegible]

[illegible]S-N[illegible]

Fatigue [illegible]

[illegible]2.4[illegible]SN[illegible]SN[illegible]SN[illegible]$\gam
min}$[illegible]$\Delta\sigma_{Rmax}$[illegible]$\Delta\sigma_{Rmin}$[illegible]$\Delta\sigma_{Rmax}$
ma_{R2}$[illegible]**Fatigue**[illegible]SN[illegible]



[illegible] 2.4 [illegible]S-N[illegible]

2.4 [illegible]

[illegible]

[illegible]SN[illegible]$\sigma_{a,- **Fatigue** [illegible]$\sigma_m
Goodman[illegible]Soderberg[illegible]Gerber parabola[illegible]Smith-Watson-Topper[illegible]60%[illegible]IIW[illegible]FKM[illegible]

[illegible]

[illegible]SN[illegible]

[illegible]

[illegible] $$ \sigma_{a,R}=\sigma_{a,-1}-M\sigma_{m} $$ [illegible]M[illegible] $$ M=\f
1}}{\sigma_{a,0}}-1 $$ [illegible]$\sigma_{a,0}$[illegible]$R=0$[illegible]M[illegible]0.2[illegible]0.4[illegible]

[illegible]

[illegible]$R<0$[illegible]$R>0$[illegible]Goodman[illegible] $$ {\sigma_{a,R}} = \left\{ \begin{a
M{\sigma_m}, {\sigma_m} \le {\sigma_{a,0}} \\ \frac {\sigma_{a,0}(\sigma_u - \sigma_m)}
{\sigma_u - \sigma_{a,0}}, {\sigma_m} > \sigma_{a,0} \end{array} \right. $$
[illegible]$\sigma_{a,0}=\frac{\sigma_{a,-1}}{M+1}$[illegible]$\sigma_u$[illegible]

Modified Goodman[illegible]

Modified Goodman[illegible] $$ \sigma_{a,R}=\sigma_{a,-1}(1-\frac{\sigma_{m}}{\sigma_u}) $$ [illegible]

Soderberg[illegible]

Soderberg□□□□□□ $$ \sigma_{a,R}=\sigma_{a,-1}(1-\frac{\sigma_{m}}{\sigma_y}) $$ □□$\sigma_

Gerber parabola□□

Gerber parabola□□Modified Goodman□□□□□□□□□□□□□□ $$ \sigma_{a,R}=\sigma_{a,-1}(1-\frac{\s _u^2}) $$

Smith-Watson-Topper□□

Smith□Watson□Topper□□□□□□□□ $$ \sigma_{a,R}=-\frac {1}{2} \left({\sigma _m} - \sqrt {\sigma \sigma _{a, - 1}^2} \right) $$ □□□□□□□□□□

60%□□□□

□□□□□□□□□□□□□□□□

$$\sigma_{a,R} = \begin{cases} \sigma_{c,R} & \sigma_m \leq -\sigma_{c,R} \\ 1.25\sigma_{a,-1} - 0.5\sigma_m & -\sigma_{c,R} \leq \sigma_m \leq \sigma_{a,0} \\ \sigma_{a,-1} & \sigma_m > \sigma_{a,0} \end{cases}$$

□□$\sigma_{c,R}=\sigma_{a,-1}/0.6$□□□□□□□□□□□□

IIW□/□□□□□□□

□□□□□□□□□□□□□□□□□□□□□

- □□□□□□□□1.6
- □□□□□□□□1.3
- □□□□□□□

□□□□□□□Hobbacher A., IIW recommendations for fatigue design of welded joints and components, IIW-doc. XIII-2460-13, 2013.

FKM□□□□□

□□FKM□□□□□□□□□4□□□

$$\sigma_{a,R} = \begin{cases} \sigma_{a,-\infty} & \sigma_m \leq -\sigma_{a,-\infty} \\ \sigma_{a,-1} - M\sigma_m & -\sigma_{a,-\infty} < \sigma_m \leq \sigma_{a,0} \\ \sigma_{a,0}(1 + \frac{M}{3}) - \frac{M}{3}\sigma_m & \sigma_{a,0} < \sigma_m \leq \sigma_{a,0.5} \\ \sigma_{a,0.5}/3 & \sigma_m > \sigma_{a,0.5} \end{cases}$$

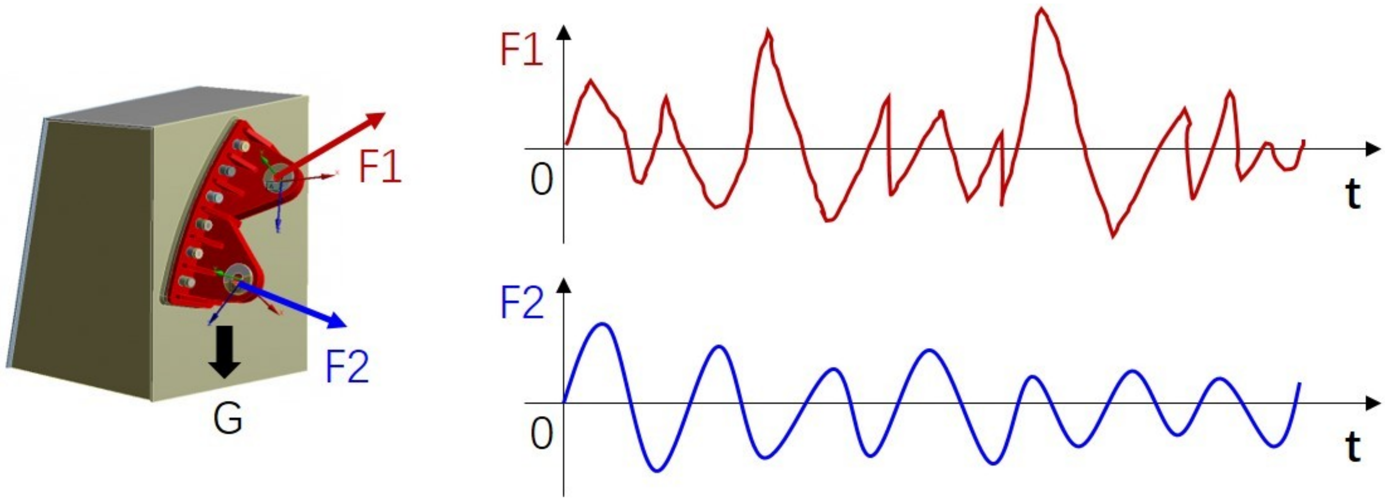
[illegible]$\sigma_{a, - \infty } = \frac{ \sigma_a} {1 - M}$[illegible]$\sigma_{a,0} = \frac{M + 3} {M + 1}$[illegible]

[illegible] FKM-Richtlinie: Rechnerischer Festigkeitsnachweis für Maschinenbauteile aus Stahl, Eisen Aluminiumwerkstoffe, 4. Ausgabe. VDMA-Verlag, Frankfurt/M. 2002

2.5 [illegible]

[illegible]2.5[illegible]F1[illegible]F2[illegible]F1[illegible]F2[illegible]

- [illegible]
- [illegible]

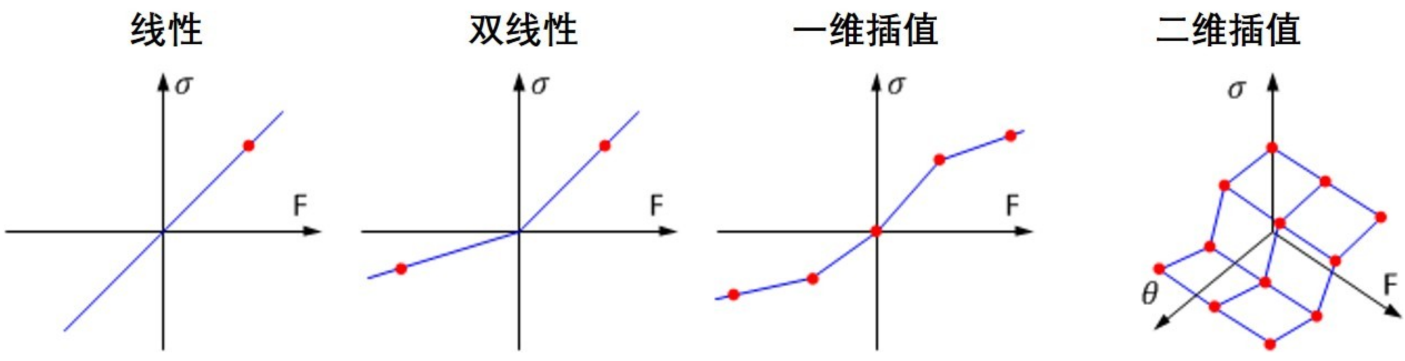


[illegible]2.5 [illegible]F1[illegible]F2[illegible]

[illegible]

[illegible]Load Cases[illegible]2.5[illegible]3[illegible]G[illegible]F1[illegible]F2[illegible]F1[illegible]F2[illegible]F

[illegible]N[illegible]$F_i(t)$[illegible]f_i^1[illegible]
[illegible]$F_i(t)$[illegible]**Fatigue**[illegible]



[illegible]2.6 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]2[illegible]

2.6 [illegible]

[illegible]SN[illegible]σ_a[illegible]σ_m[illegible]

Von Mises[illegible]

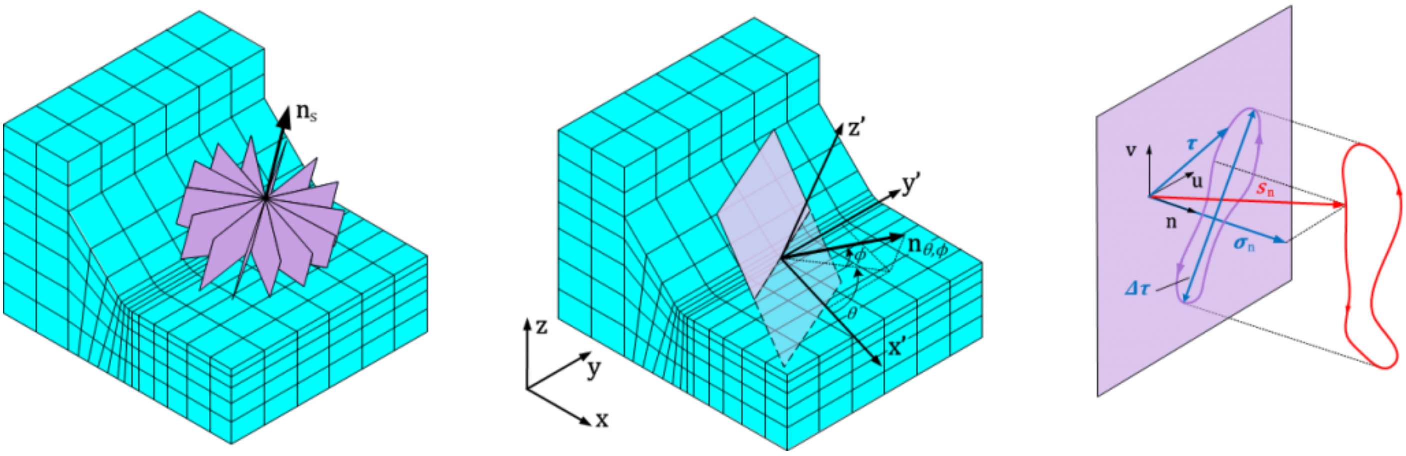
Von Mises[illegible] $$ \sigma_{vm}=\sqrt {\frac {1}{2}((\sigma_x-\sigma_y)^2+(\sigma_y-\sigma_z)^2+(\sigma_z-\sigma_x)^2+6(\tau_{xy}^2+\tau_{yz}^2+\tau_{xz}^2))} $$ [illegible]Vor
$$ \sigma_{svm}=sign(\sigma_x+\sigma_y+\sigma_z) \cdot \sigma_{vm} $$

[illegible]

[illegible]$\boldsymbol{\sigma}_p=eig(\sigma(t))$[illegible]$\sigma_1>\sigma_2>\sigma
\sigma_{pnmax}=\left\{ \begin{array}{l} \sigma_1, for \left| \sigma_1 \right| \ge \left| \sigma_3 \right| \\ \sigma_2, for \left| \sigma_3 \right| < \left| \sigma_3 \right| \end{array} \right. $$

[illegible]

[illegible]



[illegible]2.7 [illegible]

[illegible]**Fatigue**[illegible]IIW[illegible]Findley[illegible]$$\Delta \sigma_{CP-N} = \mathop {\max } \limit
\pi } \Delta {\sigma _n} $$ [illegible]

2.7 [illegible]

[illegible]**Fatigue**[illegible]S[illegible]N[illegible]

- [illegible]
- [illegible]
- [illegible]

[illegible], [illegible], [illegible]. [illegible]. [illegible], 9(11), 2012

2.8 [illegible]

1924[illegible]Palmgren[illegible]**Fatigue**[illegible]Palmgren1945[illegible]Miner[illegible]

[illegible]$\Delta\sigma_i$[illegible]n_i[illegible]SN[illegible]N_i[illegible]Palmgren-Miner
\leqslant {D_{al}} $$ [illegible]$D=1.0$[illegible]0.1-10[illegible]

2.9 [illegible]

[illegible]**Fatigue**[illegible]

[illegible]

[illegible] $$ N_{life}=\frac {N_{applied}} {D} $$ [illegible]

[illegible]

[illegible]S-N[illegible] $$ \Delta {\sigma_{eq}} = {\left({\frac{1}{{{D_{al}}}}\frac{{\
\sigma_{i,{\sigma_m} = 0}^{m1}} + \sigma_{R1}^{m1 - m2} \cdot \sum {{n_j}\Delta
\sigma_{j,{\sigma_m} = 0}^{m2}} }}{{\sum {{n_i}} + \sum {{n_j}} }}} \right)^{1/{m_1}}}
$$ [illegible]i[illegible]j[illegible]SN[illegible]$m1$[illegible]$m2$[illegible]D_{al}[illegible]1.0[illegible]SN[illegible]

[illegible]S-N[illegible]

[illegible] (Utilization Ratio)

[illegible] $$ UR = \frac{{\Delta {\sigma _{eq}}}}{{\Delta {\sigma _{R2}}}} $$ [illegible]S-N[illegible]

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