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16.90 Project #3

Impact of Variability on Turbine Blade Temperature

1. Estimation of Probability of Failure

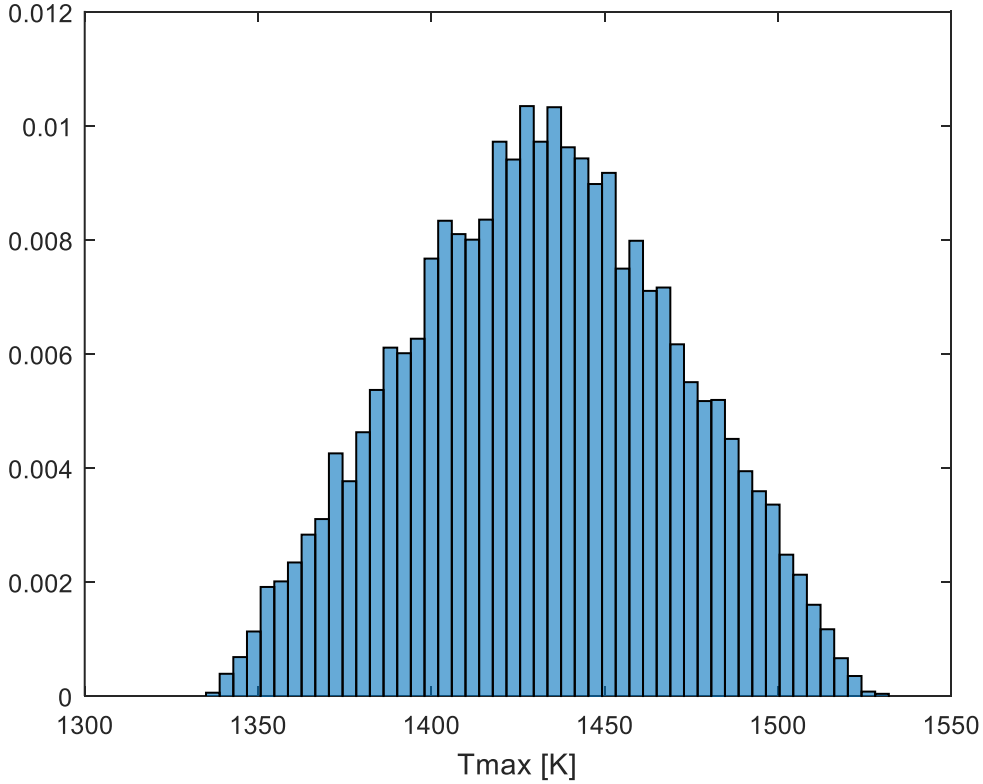
The estimated probability of failure is .1855. A sample size of 13000 was used to achieve this accuracy. The estimate of the probability of failure is normally distributed around the true P(Failure) with a standard error of [P(F)(1-P(F))/N]^1/2. This is an unbiased estimate of the true probability of failure. For 99% confidence within +-.01, we need to ensure that a distance .01 away from the mean was at least three standard deviations away in other words:

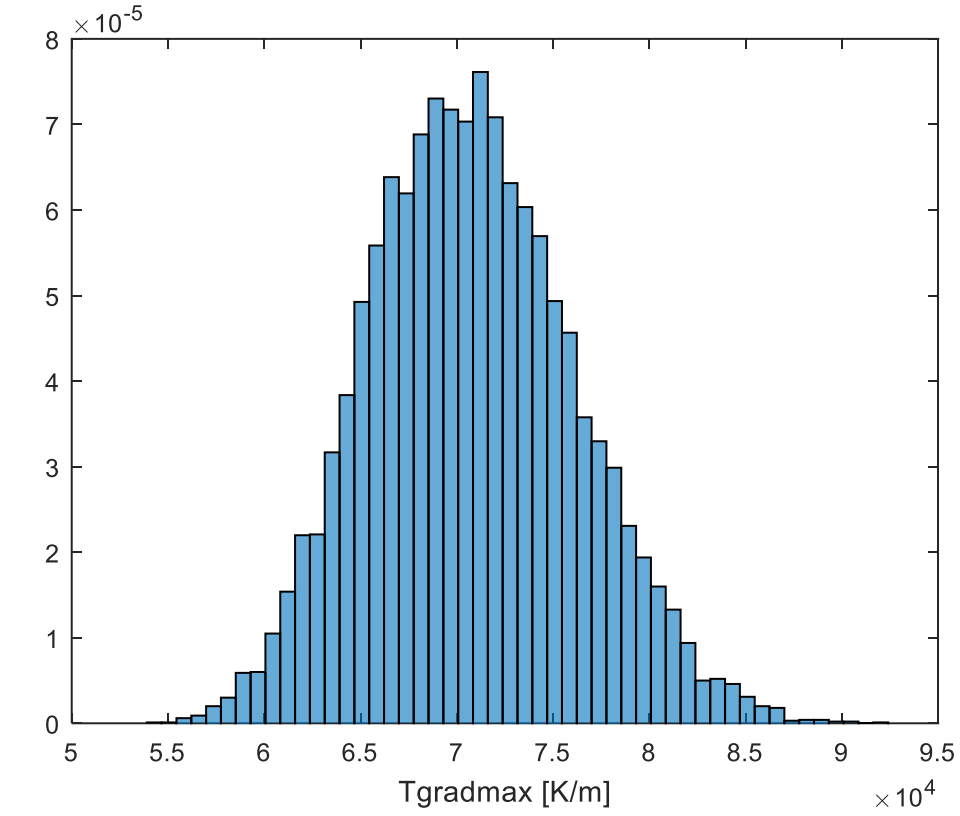
$$\frac{.01}{\sqrt{\frac{P(F)(1-P(F))}{N}}} \geq 3$$

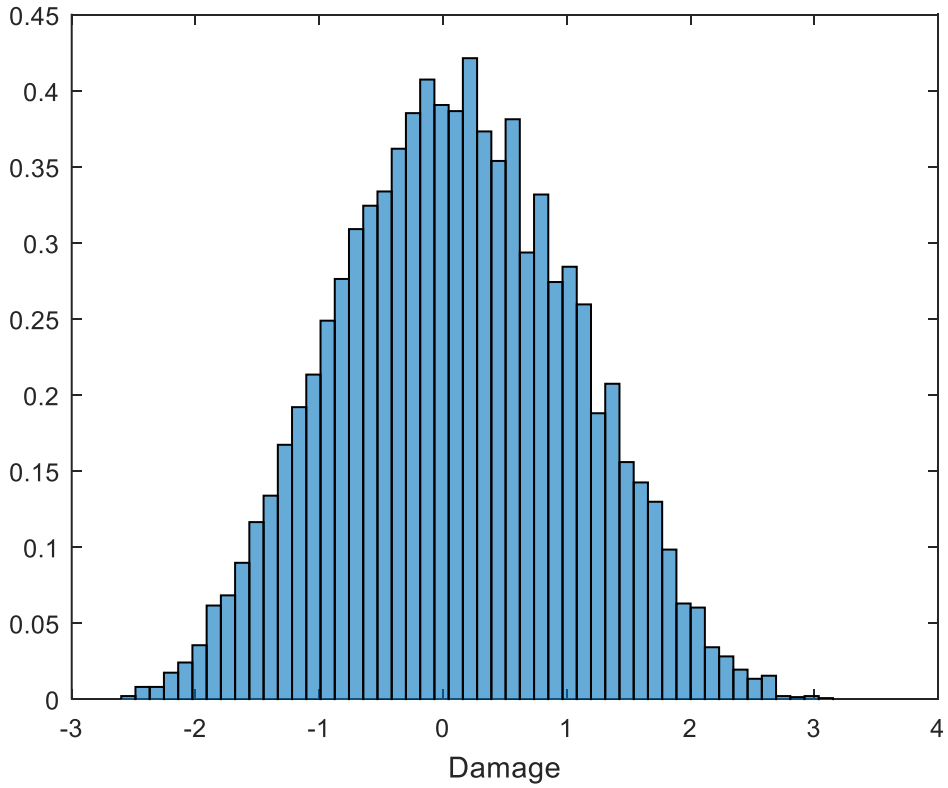
Using an unbiased estimate that P(F) = .17, a required N of 12699 was calculated. To over match the requirement, an N of 13000 was used.

The estimated probability that $T_{max} > T_{limit}$ is .0346. The 99% confidence interval that $T_{max} > T_{limit}$ is [.0298, .0394]. The estimated probability that $gradT_{max} > gradT_{limit}$ is .0490. The 99% confidence interval that $gradT_{max} > gradT_{limit}$ is [.0433, .0547]. The 99% confidence intervals were calculated using the fact that the estimated probability is approximately normal with mean of true probability and standard error, $\sqrt{\frac{P(E)(1-P(E))}{N}}$. The bound for the confidence interval are then P(E) +- 3*standard error.

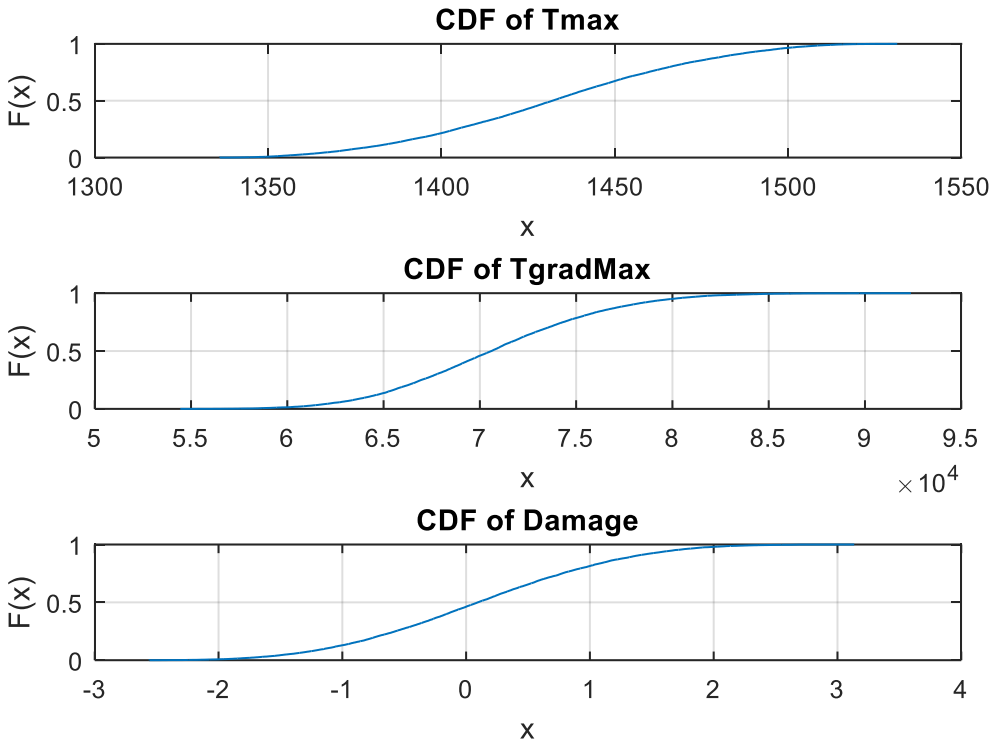
Histograms:




×10^-5
8
7
6
5
4
3
2
1
0
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Tgradmax [K/m]
×10^4


0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-3
-2
-1
0
1
2
3
4
Damage

CDF plots:



2. Screening for Important Factors

I used the Spearman correlation coefficient to quantify the strength of coupling between variables in my sample. I calculated the coefficient between the damage and each of the six input parameters.

Spearman Correlation Coefficients between rank of damage and inputs

Input	Correlation Coefficient
hcool	.0157
hgasLE	.0152
hgasTE	.0149
Kblade	.01
Tgas	.0039
Tcool	8.92 x 10^-4

From the table above, we see that the inputs with the highest correlation to damage are the heat transfer coefficients. Specifically, the highest correlation is returned between damage and the heat transfer coefficient for the cooling passage.

3. Impact of Important Factors on Probability of Failure

The input variable with the largest correlation with damage was the heat transfer coefficient for the cooling passage. After reducing the variability of the heat transfer coefficient in the cooling passage the probability of failure within +-.01 at 99% confidence is .1473 and required a sample size of 11308 to achieve.