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Reliability for weibull distribution using MS-Excel

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Abstract
The weibull distribution is mostly used in reliability analysis life data analysis due to its versatility. Depending on the values of the parameters, the weibull distribution can be used to model a variety of life behaviors. The three parameter weibull distribution can estimate the probability of null wind speed and gives greater weight to low wind speeds. We also discuss least square method of estimation problems and hypothesis testing issues, with the emphasis on graphical methods and some weibull analysis software are also provided. The analysis is also applicable in the design stage and in-service time as well and it is not only limited to the production stage. Now, the techniques to perform the Weibull analysis process are done by statistical software programs.

Keywords: Weibull distribution, Weibull failure rate function, Mean time to failure rate, Median life, Unreliability values

Introduction

- The used in reliability engineering, medical research, quality control, finance and climatology.
- Time –to-failure, such as the probability that a part fails after one, two (or) more years.
- Described by Three parameters
- Shape (β)
- Scale (η)
- Threshold parameters (or) location (y)
- The three- parameter weibull distribution expression

The probability density function is

$$F(T) = \frac{\beta}{\eta}(T-\gamma|\eta)\beta - 1e - (\frac{T-\gamma}{\eta})\beta$$

$F(T) \geq 0, T \geq 0, \gamma, \beta > 0, \eta > 0, -\infty < \gamma < \infty$

Weibull reliability metrics

The probability distribution function can be used to derive reliability metrics such as the reliability function, failure rate, mean and median.

Weibull Reliability function

$$R(T) = e - (\frac{T-\gamma}{\eta})\beta$$

$$R(T) = e - (\frac{t}{\eta})\beta$$

When threshold is zero

R (T) decreases for $0 < \beta < 1$

For β = 1, R(T) decreases monotonically but less sharply than for $0 < \beta < 1$
For β > 1 R (T) decreases as increases

Weibull Failurate Function

$$X(T) = \frac{f(T)}{R(T)} = \frac{\beta}{\eta}\left(\frac{T-\gamma}{\eta}\right)\beta - 1$$

- Population with β < 1exhibit a failure rate that decreases with time.
- Population with β=1 have a constant failure rate.
- Population with β > 1 has a failure rate that increases with time.

Weibull mean life (or) mean time to failure MTTF

$\bar{T} = \gamma + \eta, \Gamma\,(\frac{1}{\beta} + 1)$
Γ is a function
γ is a parameter

Where
Γ is the gamma function

$\Gamma(n) = \int e^{-x} x^{n-1} d\,x$

Median life (or) β_{50}Life

$\check{T} = \gamma + \eta\,(ln\ 2)\,\frac{1}{\beta}$

In these case of the 2- parameter weibull, the c d f (also the unreliability Q (t)) is given by

$F(t) = Q(t) = 1 - e - (\frac{t}{\eta})\beta$
This can be linearised by $Q(t) = 1 - e - (\frac{t}{\eta})\beta$
$ln\ Q(t) = ln\ (1 - (e - (\frac{t}{\eta})^{\beta}$
$ln\ (1 - Q(t)) = ln\ e - (\frac{t}{\eta})\beta$
$ln\ (1 - Q(t)) = -(\frac{t}{\eta})\beta$
$ln\ (-ln\ (1 - Q(t))) = \beta\ (\log\left(\frac{t}{\eta}\right))$
$ln\ (ln\ (1/(1 - Q(t))) = \beta\ ln\ t - \beta\ ln\ (\eta)$

This forms Y = M x + b
$Y = ln\ (ln\ (1/(1 - Q(t)))\ \&\ x = ln\ t$

$Y = \beta\ x - \beta\ ln\ (\eta)$
Where M =β (Slope (or) Sharpe parameter)
And intercept is equal to $b = -\beta\ ln\ (\eta)$

Determining the appropriate y plotting positions or the unreliability values

- We must first determine a value indicating the corresponding unreliability for that failure.
- The most widely used method is the method of obtaining the median rank for each failure.
- The median rank is the value that the true probability of failure, Q (t).

Should have at the j^{th} failure out of a sample of n units at the 50% confidence level.
Median ranks are calculated using the following equation also known as Benard's approximation.

$F(t) = \frac{j-0.3}{n+0.4}$
j is the failure order
n is the sample size

Illustration solve by using Ms-Excel
We have to find out the dependability or reliability, median ranks and unreliability function to the following data. The desired reliability at 400 cycles is 0.90 I e90% of the value to survive at least 400 cycles.

Design A cycle	19	41	39	18	8	29	11	59	40	48	53	49	21

Procedure

- First consider the design A type the data in Excel sheet then rank them 1 to 13 as given table.
- Using the linearizing the unreliability function.
- Now, estimate of the proportion of the population that will fail by the number of cycles listed.

This can be done by determining the median rank

$F(t) = \frac{j-0.3}{n+0.4}$ j is the failure cycle & n = 13.

Steps to calculated Median ranks values in MS-Excel
Step1: Enter the formula = ((B2-0.3/(10+0.4))
Step 2: Then determine 1 / (1-Median ranks)
Step 3: Followed by *ln* (*ln* (1/(1- Median ranks)))
Step 4: Determine in (design of A cycles)

Table 1: Median Ranks

Design A cycle	Ranks	Median ranks	1/(1-Median ranks)	*ln* (*ln* (1/(1-Median ranks)))	*ln* (design of A cycle)
59	1	0.052238806	1.05511811	-2.925223234	4.077537444
53	2	0.126865672	1.145299145	-1.99756029	3.970291914
49	3	0.201492537	1.252336449	-1.491606142	3.891820298
48	4	0.276119403	1.381443299	-1.129704207	3.871201011
41	5	0.350746269	1.540229885	-0.839487848	3.713572067
40	6	0.425373134	1.74025974	-0.5905284	3.688879454
39	7	0.5	2	-0.366512921	3.663561646
29	8	0.537424816	2.161810739	-0.260136719	3.36729583
21	9	0.649253731	2.85106383	0.046589839	3.044522438
19	10	0.723880597	3.621621622	0.252253233	2.944438979
18	11	0.798507463	4.962962963	0.47125468	2.890371758
11	12	0.873134328	7.882352941	0.724949317	2.397895273
8	13	0.947761194	19.14285714	1.082459075	2.079441542

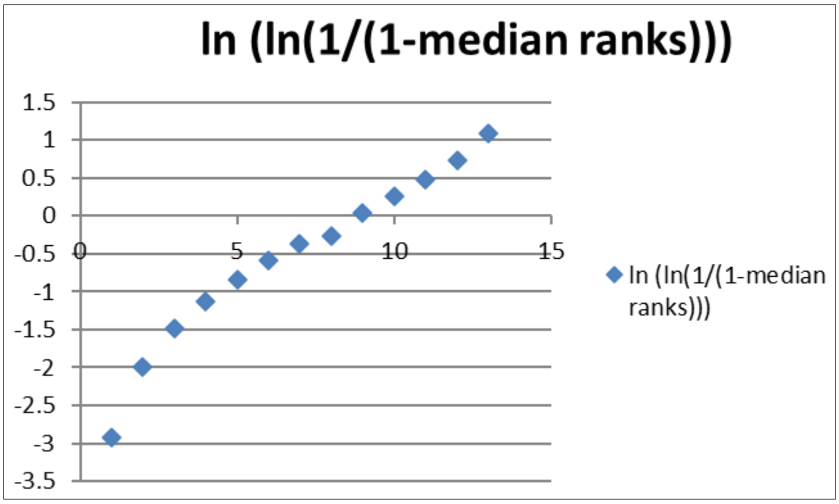

Fig 1: Median Ranks

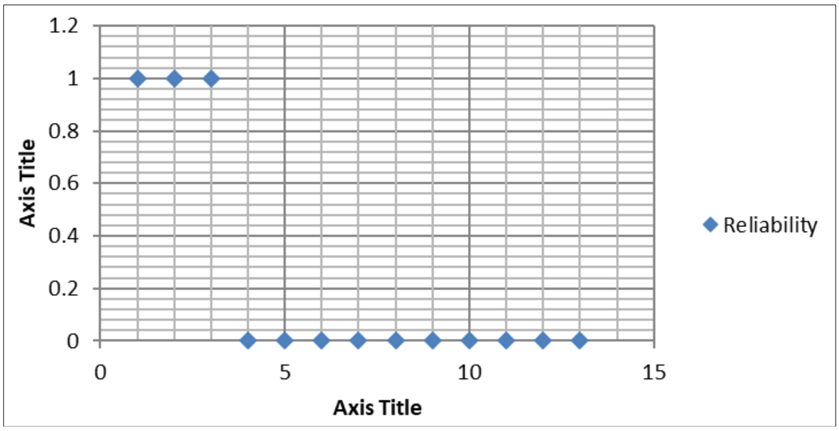

Fig 2: Reliability

When we perform the linear regression the estimate for the weibull parameter comes directly from the slope of the line.
Considering the straight line Y = M x + C
M = β (Slope (or) shape parameter)
ɳ = Characteristics life = (Parameter is (- ratio of intercept to slope)) (- C / β)

∴ $\beta = 3.104$; b = - β *ln* (ɳ) = ɳ = 30.399

Table 2: Reliability

Survival probability		Reliability	
Shape = 3.104	10	0	1
	20	0	1
Median life ɳ= 30.399	30	1.20176	0.999998798
	40	1	0
	50	1	0
	60	1	0
	70	1	0
	80	1	0
	90	1	0
	100	1	0
	110	1	0
	120	1	0
	130	1	0

Conclusions

Reliability analysis is determined by based on the above Table (1), Table (2) Fig (1) and Fig (2). This research has outlined the status of the extruder studied in terms of functions and typical graphical representations of reliability analysis. Thus it is possible to state that the objective was successfully achieved. Since all the median ranks, linear regression the estimate for the weibull parameters and reliability representations in MS- Excel sheet of interest were defined based on time to failure. It has been observed that the above calculations, Reliability starts with 1 end with 0. Total failure density is one.

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