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A study on analysis of reliability distributions

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Abstract

When we buy a mobile, laptop, scooter, car, or even a small item like bulb or battery, we can expect function satisfactory for a specific period of time. For this purpose one life testing experiments are wanted. These experiments are designed to find average life of an item or to ensure the questions like is the probability. The item will fail in time interval (t_0, t_0+t) such thing we will estimate reliability of the item through some continuous probability distributions.

Keywords: Descriptive statistics, continuous probability distributions, reliability distributions, statistical inference, failure distributions

1. Introduction

The reliability distributions are used to model random events for which the outcome is uncertain such as one time of failure for a component Artin E 1964 ^[1]. Before placing a demand on that component, the aim it will fail is unknown. The distribution of the probability of failure at different times is modelled by reliability distributions Dekking FM *et al* 2007 ^[2]. The reliability Distributions Analysis allows us to describe one time to failure (TTF) as a statistical distribution which is usually characterised by a specific pattern. Four different “A” types are supported: Weibull, Normal, Long Normal, and Exponential Hastings NAJ *et al*. 2000 ^[3].

2. Measures of reliability

The most commonly used methods to measure the reliability are.

- Failure rate
- Probability of survival
- Mean Time Between Failure
- Mean Time To Failure.

3. Failure rate

The failure rate is defined as where in (iii) the ratio of number of failures during a particular unit interval to average population in that interval Meeker WQ *et al*. 1998 ^[4].

$$\text{It is given by } z(i) = \frac{ni}{\frac{s(i-1) + (si)}{2}}$$

The failure rate is commonly expressed in terms of failures per hour or 100 hours (or) 1000hrs (or) percentage failures per 1000 hrs Meeker WQ *et al*. 1998 ^[5].

Sometimes the failure rate is represented by a Greek letter ‘ λ ’, and it is calculated as a simple ratio of total no. of failures during a specified test interval to total test hours. And it is given by

$$\lambda = \frac{f}{t} = \frac{\text{Total No. of failures}}{\text{total test hours}}$$

1. Probability of survival: It indicates the probability or expected no. of items that will operate for a required period of time. and

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2. Mean Time between Failures: It is applicable to repairable items and is expressed in hrs. It is a ratio of total survival time to no. of failures during that period and it is given by Modarres M *et al.* ^[6].

$$MTBF = \frac{T}{f} = \frac{\text{Total test hours}}{\text{No. of failures during that period}}$$

$$\text{Then } MTBF = \frac{T}{f} = \frac{1}{(f/T)} = \frac{1}{\lambda}$$

We can say that MTBF is a reciprocal of constant failure rate.

4. Mean time to failure

This measures is applicable to non – repair items. The MTTF is expressed as average time of item. That is expected to function before failure WQ *et al.* 1998 ^[7].

Table 1: Types of numbers survivals and failure

Time in hours	Number of Fails(f)	Number of Survivals (S)	No. of Failure (F)	Reliability of R(t)	Failure Rate F(t)	Failure Density F _d (t)	Hazard Function Z(t)
1	130	1184	0	1.00	0.00	0.11	0.04
2	83	1054	130	0.89	0.11	0.07	0.04
3	75	971	213	0.82	0.18	0.06	0.04
4	68	896	288	0.76	0.24	0.06	0.05
5	62	828	356	0.70	0.30	0.05	0.05
6	51	766	418	0.65	0.35	0.04	0.06
7	46	715	469	0.60	0.40	0.04	0.06
8	41	669	515	0.57	0.43	0.03	0.06
9	37	628	556	0.53	0.47	0.03	0.07
10	34	591	593	0.50	0.50	0.03	0.07
11	31	557	627	0.47	0.53	0.03	0.08
12	28	526	658	0.44	0.56	0.02	0.08
13	64	498	686	0.42	0.58	0.05	0.09
14	72	434	750	0.37	0.63	0.06	0.10
15	62	362	822	0.31	0.69	0.05	0.13
16	40	300	884	0.25	0.75	0.03	0.15
17	39	260	924	0.22	0.78	0.03	0.17
18	38	221	963	0.19	0.81	0.03	0.21
19	35	183	1001	0.15	0.85	0.03	0.25
20	30	148	1036	0.13	0.88	0.03	0.31
21	25	118	1066	0.10	0.90	0.02	0.39
22	27	93	1091	0.08	0.92	0.02	0.52
23	25	66	1118	0.06	0.94	0.02	0.78
24	21	41	1143	0.03	0.97	0.02	1.36
25	20	20	1164	0.02	0.98	0.02	4.15
	1184					1.00	

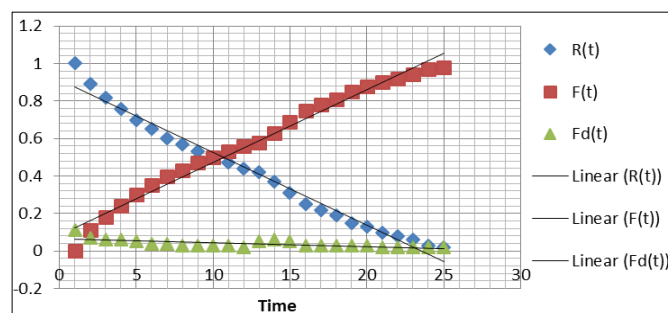


Fig 1: Shows the time linear

Table 2: Analysis of Descriptive statistics that the product will works Average 47 hrs, Minimum 20 hrs and Maximum 130 hrs

Mean	47.36
Standard Error	5.02
Median	39.00
Mode	62.00
SD	25.09
Sample Variance	629.57
Kurtosis	3.56
Skewness	1.64
Range	110.00
Minimum	20.00
Maximum	130.00
Sum	1184.00

5. Reliability Estimation through Distributions

1. Exponential distribution;
2. Weibull distribution;
3. Gamma distribution; and
4. Lognormal distribution.

We will calculate reliability for given to three different distributions. On the event, we want estimate the reliability of an item at a specific time. Whatever specific situation, you have the life distributions parameters Singpurwalla ND 2006^[8]. We just need to calculate reliability at a specific time. We can do that and let's try it with three distributions using their respective reliability functions: Exponential Distribution, Weibull Distribution, and lognormal Distributions Meeker Plaba AS^[9]

1. The Reliability Function for the Exponential Distribution (E.D) is

$$R(t) = e^{-t/\theta} = e^{-\lambda t}$$

2. The Reliability Function for the Weibull Distribution(W.D) is

$$R(t) = e^{-(t/\eta)^\beta}$$

Where β the shape parameter and η is the scale parameter.

Remark: If time equals to η it does not matter what the β value is? The Reliability Function for the Log N.D. is

$$R(t) = 1 - \Phi\left(\frac{\log(t) - \mu^1}{\sigma^1}\right)$$

The lognormal distribution is similar to the Weibull Distribution (W.D) yet parameters are the Mean and S.D. of the transformed data we have to consider natural log value of each data point Kolowrocki K 1994^[10]

3. The Reliability for Gamma Distribution

This distribution has been used as a model for industrial reliability problems. This distribution is characterized by two parameters γ and λ Roy B *et al.* 2008^[11] Its P.D.F. is given by

$$f(t) = \frac{\lambda^\gamma}{\Gamma(\gamma)} (\lambda t)^{\gamma-1} e^{-\lambda t}$$

$$= \frac{\lambda^\gamma}{\Gamma(\gamma)} t^{\gamma-1} e^{-\lambda t} \text{ for } t > 0, \gamma > 0, \lambda > 0$$

Here γ = shape of the parameter

λ = scale parameter; for $\gamma = 1$, it reduced as $f(t) = \lambda e^{-\lambda t}$ which is a p.d.f. of E.D.

Table 3: Shows the Number of Fails (f) and Number of Survivals (S)

Time	Number of Fails(f)	Number of Survivals (S)	$R(t)=e^{-\lambda t}$	$R(t)=\lambda e^{-\lambda t}$	$R(t)=1-\Phi((\log(t)-\mu)/\sigma)$
1	130	1184	2702.797	128004.46	0.6784
2	83	1054	730.511	34597.0009	0.532
3	75	971	197.442	9350.853	0.6784
4	68	896	53.3646	2527.347	0.6784
5	62	828	14.423	683.073	0.6784
6	51	766	3.898	184.609	
7	46	715	1.0534	49.8890	
8	41	669	2847.78	134870.861	
9	37	628	769.697	36452.8499	
10	34	591	208.033	9852.443	
11	31	557	56.2272	2662.92	
12	28	526	15.197	719.73	
13	64	498	4.1074	194.5264	
14	72	434	1.1101	52.5743	
15	62	362	3000.544	142105.76	
16	40	300	0	0	
17	39	260	0	0	
18	38	221	0	0	
19	35	183	0	0	
20	30	148	0	0	
21	25	118	0	0	
22	27	93	0	0	
23	25	66	0	0	
24	21	41	0	0	
25	20	20	0	0	
	1184				

6. Conclusions

Reliability analysis is determined by based on the above Tables (1) and (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

reliability representations of interest were defined based on time to failure. It has been observed that the above calculations, Reliability starts with 1 and ends with 0, total failure density is one.

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