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Reliability Analysis of Various Automobile Parts of Ford 1250 Il Tractor under Preventive Maintenance using Weibull Distribution

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Abstract—In today's world of advanced technology and global competitiveness where less emphasis is laid on traditional maintenance practices, it is important to analyze various maintenance issues and risk associated with it. Preventive maintenance practices assist in improving the reliability of automobile parts and thus preventing its premature failure. The study was made on an automobile park composed of the same model of automobile for one individual part.The reliability research work focuses on shock absorbers, brake lining, clutch plate, differential, air filter and turbocharger. Reliabilities of these parts are compared while carrying periodic maintenance to the one not undergone maintenance.Weibull Distribution is used for statistical calculus, with the result being presented in charts. Computation is made by the Minitab software. Finally, some recommendations and conclusions based on the reliability and maintenance of studied parts are presented.In this research work the various parts of an automobile were studied and the data regarding the failure of various parts was collected. The cumulative failure analysis was done afterwards and the results were tabulated. The tabulated results were further used to generate Weibull 2 parameter probability distribution curve and the shape and scale factors were obtained for each part under study. The reliability without preventive maintenance was calculated separately

Keywords—Reliability; preventive maintenance; weibull distribution; shock absorber; brake lining; clutch plate; differential; air filter; turbocharger.

I. INTRODUCTION

Reliability describes the ability of a system or component to function under stated conditions for a specified period of time. Reliability may also describe the ability to function at a specified moment or interval of time. Reliability is theoretically defined as the probability of success (Reliability=1-Probability of Failure), as the frequency of failures; or in terms of availability, as a probability derived from reliability, testability and maintainability.

Design in and continuous improvement to:

1. Reduce risks and losses;
2. Manage assets based on lifecycle (total cost);
3. Partner with operations, engineering and maintenance to enable practicable problem solving

PREVENTIVE MAINTENANCE

Preventative maintenance (or preventive maintenance) is maintenance that is regularly performed on a piece of equipment to lessen the likelihood of it failing. Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.

Preventative maintenance is planned so that any required resources are available.

The maintenance is scheduled based on a time or usage trigger. A typical example of an asset with a time based preventative maintenance schedule is an air-conditioner which is serviced every year, before summer.

Preventative maintenance is more complex to coordinate than run-to-failure maintenance because the maintenance schedule must be planned. Preventative maintenance is less complex to coordinate than predictive maintenance because

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monitoring strategies do not have to be planned nor the results interpreted.

WEIBULL DISTRIBUTION

The Weibull distribution is a versatile distribution that can be used to model a wide range of applications in engineering, medical research, quality control, finance, and climatology. For example, the distribution is frequently used with reliability analyses to

LITERATURE REVIEW

Ofqual as part of the reliability programme stated: "Reliability" in the technical context means how consistent the results of qualifications and assessments would be if the assessment procedure was replicated[1]. Meadows and Billington (2005)[2] and Baird et al. (2012)[3] both present detailed descriptions of the different levels at which reliability can be measured and the statistical methods that can be used, and discuss their pros and cons in an operational setting.As stated above this review builds on the work produced in 2005 by Meadows and Billington.Meadows and Billington (2005) concluded that a measure of the reliability of a test should be published alongside the results in order for the results to be fully understood. Sunil Dutta, Dinesh Kumar and Pradeep Kumar in 2010 stated that substantial increase in the reliability can be obtained by regular preventive maintenance[4].Bramley and Dhawan, 2010 stated that qualification level reliability can be difficult to calculate especially in modular examinations and those with many options or shared units.[5]Aurelian Constantin SÎRBU1, Andrei Dragoş Mircea SÎRBU2 in 2011 researched on the reliability of shock absorber from a car pool of identical specifications using Weibull Distribution.[6]

METHODOLOGY

In this research work the various parts of an automobile were studied and the data regarding the failure of various parts was collected. The cumulative failure analysis was done afterwards and the results were tabulated. The tabulated results were further used to generate Weibull 2 parameter probability distribution curve and the shape and scale factors were obtained for each part under study. The reliability without preventive maintenance was calculated by using the formula

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

The reliability with preventive maintenance was calculated using the formula

$$Rpm(t) = e^{\wedge}[-n(T/\eta)^{\wedge}(\beta)] \times e^{\wedge}[-((t-nT)/\eta)^{\wedge}\beta]$$

Where T be the interval between preventive maintenance, n is the number of maintenance interval and t is the number of hours/kilometres for whch the reliability is to be evaluated. To show the efeect of preventive maintenance policies, the reliability of various automobile parts are calculated for a mission of 30000, 70000 and 120000 km (these values are selected randomly).

WEIBULL DISTRIBUTION PARAMETERS

The Weibull distribution most frequently provides the best fit of life data. Beta (β) & Scale (η) are the two crucial parameters of Weibull line. The slope of the line, β is principally significant and may provide a trace to the physics of failure. The characteristic life η is the typical time to failure in Weibull analysis .The slope β also indicates which class of failures is present.

- $\beta < 1.0$ indicates infant mortality
- $\beta = 1.0$ means random failures (independent of age)
- $\beta > 1.0$ indicates wear out failures

The Weibull plot shows the beginning of failures. The characteristic life η is defined as the age at which 63.2%) of the units will have failed. For $\beta = 1$ the mean time to failure and η are equal. The parameter β is a pure number, i.e. it is dimensionless.

CASE STUDY

The failure data is collected for 40 identical specifications vehicles having the following specifications:-

Engine	**F Series 8 FTI2K Turbocharged Intercooled with inline FIP**
Engine Cylinders	**4**
Displacement (cc)	**5600**
Max Power	**180bhp @ 3400rpm**
Max Torque	**500Nm @ 1000 to 1700rpm**
Transmission	**Manual**
Clutch	**300 mm dia. Single Plate dry type axial s PR ing clutch**
Gearbox	**5-Speed**
Fuel Tank (Litres)	**200**
Gradeability (%)	**36**
Max Speed (km/h)	**90**
Axle Configuration	**4x4**

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Front Tyre	**10 x 20 - 15 PR**
Rear Tyre	**10 x 20-15 PR**
Wheelbase (mm)	**6300**
GVW / GCW (Kgs)	**15200**
Payload (Kgs)	**16200**

1) COMFORT FEATURES

Steering	A/C
Cruise Control	Navigation System
Driver Information Display	Telematics
Adjustable Driver Seat	Tilt able Steering
Arm-rest	Seat type

2) SAFETY FEATURES

Brakes	**Air Brakes**
Front Suspensio	**Semi-elliptical multi-leaf s PR ings suspension**
Rear Axle	**Single-speed hypoid gear Axle**
Rear Suspensio	**Semi-elliptical multi-leaf s PR ings suspension**

The data is sorted and subdivided under various subheads. The failure data is plotted with the help of graph .Under a constant failure rate preventive maintenance has no effect.

Therefore Weibull distribution has been chosen for the analysis purpose. Weibull parameters β & η are first calculated for individual sub assembly using least square method and subsequently for each automobile part.

Once we obtain the parameters, reliability with and without preventive maintenance are calculated using the formula given below:

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

In the case of non-preventive maintenance the 2 factors are used for 3 values of 't' i.e. 40000km, 70000 km and 120000 km.

(Without preventive maintenance)

$$R_{pm}(t) = e^{[-n(T/\eta)^{\wedge}(\beta)]} Xe^{[-((t-nT)/\eta)^{\wedge}\beta]}$$

(With preventive maintenance)

In case of preventive maintenance T be the interval between preventive maintenance, n is the number of maintenance interval and t is the number of hours/kilometres for which the reliability is to be evaluated

CLUTCH PLATES	BRAKE LINING	DIFFERENTIAL	AIR FILTER	TURBOCHARGER
TIME FAILURE (in kms)	TIME FAILURE (in kms)	TIME FAILURE (in kms)	TIME FAILURE (in kms)	TIME FAILURE (in kms)
123533	46883	110593	48414	247890
145800	47585	115860	43660	226785
86453	35478	89563	79818	137869
53966	43785	97225	53219	136212
28970	65251	115869	45670	143680
18082	54811	127815	45898	532577
26668	52378	89250	43625	321451
97446	61222	95631	56234	211430
85329	35874	120036	65237	203257
67050	45420	85369	45212	212568
58894	33785	99256	45895	168562
135459	24757	105266	87413	187865

CONCLUSION

With the available failure data for various automobile parts parameter β & η are computed subsequently reliabilities with and the without preventive maintenance are calculated. Substantial increase in reliability has been observed with PM policy for 40000, 70000 and 120000 kilometres run of the vehicle respectively. The analysis will be helpful to the maintenance engineer to develop sound maintenance/replacements frequencies, appropriate provision for spare parts and provision of standby units. The study shows that five parts namely Clutch Plate, Air Filter, Brake Lining and Differential are more prone to wear and needs repair/replacement in due time.The Air filter needs regular replacement and must be replaced after each service in order to ensure smooth vehicle operation. The reliability of the various other parts has increased substantially after Preventive Maintenance.

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