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RELIABILITY STUDY OF BELARUS TRACTOR IN BANGLADESH

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ABSTRACT

The reliability engineering concept and its application to farm machinery were reviewed. A method of estimating the reliability parameter to agricultural tractor (Belarus) were discussed. The method used field data for estimation of parameters value for the reliability function. The Weibull distribution model with a shape parameter of 1.13 and scale parameter of 163.53 and location parameter of zero adequately represented the reliability function of Belarus tractors being used in Panchagarh Sugar Mills, Panchagarh. Reliability of an agricultural machine, such as tractor, is of help to farmers in purchasing and to manufacturers in producing more reliable machines.

INTRODUCTION

Bangladesh is an agricultural country. About 31 million acres of land is under agriculture and 77 percent of the people of Bangladesh are engaged in agriculture. More than 5000 of tractors are working directly or indirectly for the agricultural operations. Tractor plays an important role for successful agriculture.Agricultural machinery input in field operation is becoming a major component of investment in present day agricultural practices in Bangladesh. Selection of quality machines and use of proper management technique could reduce the cost. Timeliness in farm operations is an important factor for successful agriculture. Tractor equipment failures, especially during the busiest part of the season, causes delay resulting a great loss to farmers. The economic penalties for missing the optimum operational opportunity due to machine breakdown can be very serious. To make allowance for the time losses due to breakdown in planning, one needs to know the probability of machine failure. The failure could be taken care of in a short time if service facility is available nearby. Unfortunately, the service facility for agricultural machinery is very limited and unsatisfactory in Bangladesh. Furthermore, significant amount of money, time and effort are needed to provide service facility to farmers. Therefore, reliable farm machine can be more useful to the farmers in Bangladesh.

Reliability is usually defined as the probability that the machine will complete a specific task under specified conditions for a stated period of time or distance or revolutions. Reliability is thus a numerical value indicating the likelihood of satisfactory operation. A machine is a system consisting of group of components, working together to accomplish a specific task. The reliability of a machine is the product of its individual components reliability. The reliabilities of individual components, which therefore be very high if satisfactory operational reliability is to be achieved. A failure may be defined as any condition which prevents operation of a machine or which causes or results in level of performance below a specified limit. For example, in a tractor, failure could be a broken chasssis, broken hydraulic arm or it could be a failure of nozzle resulting in a degradation of performance. Machine failure can be categorized into three basic types (Amstardter, 1971); early life failures, random failures, and wear out. Out-of-tolerance failure are usually classified as wear out failures. Early failures occur because of

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some defect in a part or assembly resulting from a deficiency in design manufacture, or inspection. During the random failure period the failures occur because of the random occurrence of environmental stress levels sufficiently severe to cause component failures. The period in the life of component is also known as "useful life period". The wear out period is characterized by an increase in failure rate due to parts degradation with age.

Reliability of any equipment is of increasing concern and importance to all segments of society. In Bangladesh, the use of tractors and power tillers are increasing day by day. The tractor breakdown., lost time and repair cost etc. have a significant effect on agricultural production. This study has been conducted with the following main objectives;

1. To review reliability theory and its application to farm machines,
2. to collect machine failure information on agricultural tractors, and
3. to develop a reliability model for Belarus tractors.

METHODOLOGY

The Reliability Model

There are many kinds of probability (or failure) distributions in use. The choice of a distribution to use depends on the characteristic failure rate. Literature search reveals that in most of the reliability studies on machinery failure fairly follow the Weibull distribution. In this study, the Weibull distribution was used because it is a three parameter distribution, and increasing, constant, and decreasing failure rate patterns can be described by varying the parameter values. It has been used in many applications such as fatigue failures (Weibull, 1951), and failure in vechile structural components (Lemense, 1969). An attempt has also been used to use this distribution for farm equipment (Archer, 1962; Von Bargen, 1970; Chaudhury and Ahmed, 1988).

The agricultural tractor failure data were gathered from nine Belarus tractors operating in Panchagarh Sugar Mills Ltd., Panchagarh. The time of failure of different components was recorded under operating conditions and hence the time between failure was calculated. A computer programme was developed in BASIC for estimation of the Weibull parameters.

The Weibull failure probability function (pdf) is given as :

$$f(t) = \frac{\beta(t-\tau)^{\beta-1}}{\alpha} e^{-[(t-\tau)]/\alpha}; \quad \text{when } t > t$$

$$= 0; \qquad \text{otherwise}$$

where,

α = scale parameter

β = shape parameter or Weibull slope

τ = location parameter or lower bound of life

Integrating the above function gives the Weibull cumulative density function (cdf).

$$F(t) = 1 - e^{-[(t-\tau)]/\alpha}$$

The three parameters (α, β, τ) provide considerable flexibility in describing failure distributions.

In the case of farm machinery, the first failure can be expected as soon as the machine is placed in service, hence the lower bound is zero. Thus $t = 0$ and the Weibull density function becomes:

$$f(t) = \frac{\beta t^{\beta-1}}{\alpha} e^{-(t)/\alpha}$$

and cdf becomes

$$F(t) = 1 - e^{-(t)/\alpha} \qquad \text{.....(1)}$$

The reliability function,

$$R(t) = 1 - F(t)$$

For Weibull failure destribution

$$F(t) = e^{-(t^{\beta})/t} \quad \text{..... (2)}$$

Estimation Of Weibull Parameters

A least square method was used to estimate the Weibull parameters. This method is based on the fact that the reliability function of the Weibull distribution can be transformed into a linear function of Ln(t) by means of a double logarithmic transformation. Taking the natural logarithm twice of both sides of equation (1) gives;

$$\text{LnLn}\frac{1}{1 - F(t)} = \beta \text{Ln}(t) - \text{Ln}(\alpha)$$

This is of the form, $Y = mx + c$

Therefore, a plot of LnLn 1/[1 - F(t)] as the ordinate and Ln(t) as the abscissa will yield a straight line provided the it fits the Weibull distribution with t=0. The values for a and ß can then be estimated using simple regression analysis.

Kumar (1977) used the Monte Carlo method for predicting the machine future reliability. Details of this method has been given by Myers (1963). The Monte Carlo method selects the value of desired variable by choosing a random number from its distribution. In other words, the time between failures can be generated by solving for t in the espression.

$$y = \int_0^t f(n)\, dn$$

where,

Y = random number between 0 and 1 selected from a uniform distribution

f(n) = probability density function

t = time between failure

For Weibull distribution,

$$Y(t) = \int_0^t \frac{\beta\, x^{\beta-1}}{\alpha}$$

or, $Y = 1 - e^{-(t^{\beta})/\alpha}$

Solving for t, $t = \alpha[-\text{Ln}(1-y)]^{1/\beta}$

RESULTS AND DISCUSSIONS

The machine failure data on nine Belarus tractors in Panchagrh Sugar Mills Ltd. were collected from respective vehicle job card and logbooks. The tractors were in operation for last ten years. Fig 1 represents the histogram of failure observation as a function of time between failures. Considering the whole machine as a unit, the time between failures was the time between any two failures, irrespective of component type. The algorithm for optimation of Weibull parameters is shown in Fig. 2. The program calculates the Weibull parameters using least square method. The values of a and ß were 163.53 and 1.13, respectively. Thus the Weibull distribution which predicts the time between failures and reliability for the tractors were;

$$R(t) = F(t) = 1 - e^{-t\text{-}13\ /163.53}$$

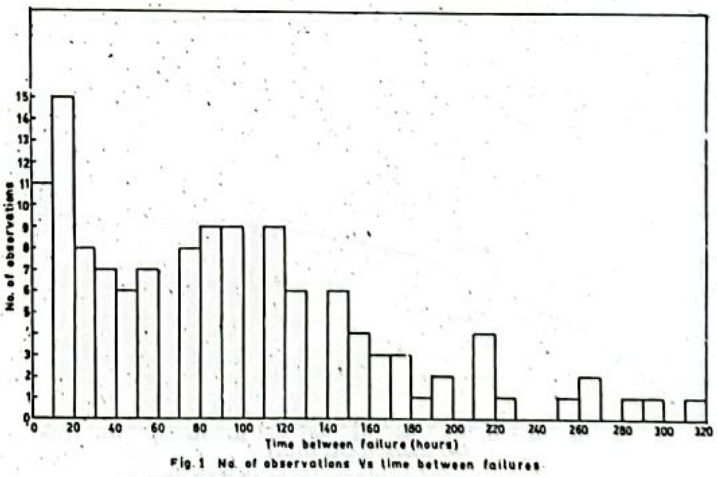

Fig. 1 No. of observations Vs time between failures

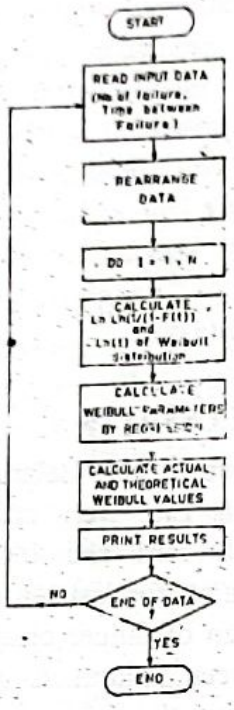

Fig - Flow chart for estimation of Weibull para

Fig. 3 shows the actual data points used to estimate the Weibull parameters and the theoretical cumulative distribution function of tractors. The Koimogorov and the Smirnov tests for goodness of fit indicated that there was insufficient evidence at 95% confidence level to reject the foregoing distribution as representative of true distribution.

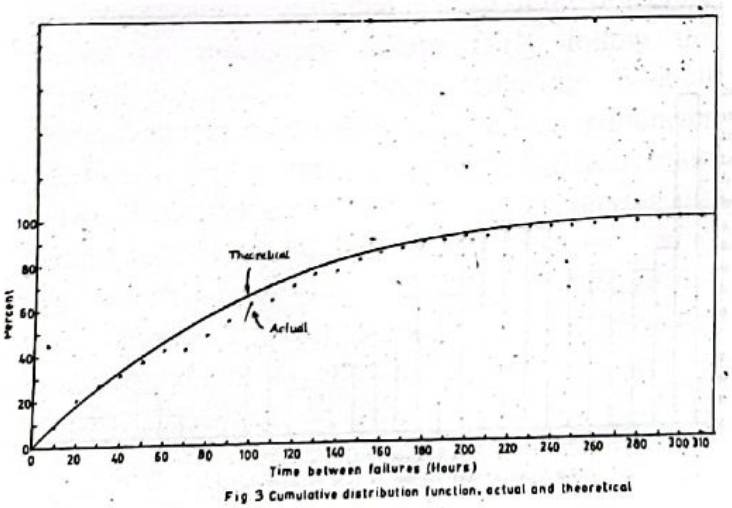

Fig 3 Cumulative distribution function, actual and theoretical

Table 1 represents the results of reliability model of the agricultural tractors. The first column of the table gives the failure ranks and second column gives mean time between failure i.e. 295.21 means that the first failure should be expected after about 295.21 hours of operation. Next 120.68 means that the second failure should be recognized at about 120.68 hours after the first failure had occurred.

Table 1 Predicted values of time between failure of Belarus tractor.

Rank	Probability	Time between failure (hr)
1	0.81	295.21
2	0.67	120.68
3	0.79	251.54
4	0.91	231.16
5	0.59	178.21
6	0.61	107.98
7	0.39	123.81
8	0.46	98.92
9	0.31	102.21
10	0.55	79.29

The reliable model has been developed with the assumption that the tractor itself was considered as a single unit. In other words the reliability of each component was not considered independently because of limition of time and availability of reliable data.

CONCLUSSION

The Weibull distribution model with a shape parameter of 1.13, scale parameter of 163.53 and location parameter of zero adequately represented the reliability function for Belarus tractor. The method may be applicable to other farm machineries such as power tillers, harvester, deep tubewell, rice mill etc.

Prior information on machine reliability may reduce the opportunity time and cost of repair work. Furthermore, sufficient spare parts may be stocked to minimize time lost during peak hours. Machine reliability helps in better planning of farming

operation. The research institutes should carry out field reliability study programme of machine manufactured by a particular firm. Therefore, guidance can be provided to the farmers, in purchasing more reliable machines; and manufacturer, in producing more reliable machine.

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