Journal of Agricultural Machinery
Vol. 5, No. 2, Fall - Winter 2015, p. 446-455

نشریه ماشین‌های کشاورزی
جلد ۵، شماره ۲، نیمسال دوم ۱۳۹۴، ص ۴۵۵-۴۴۶

Reliability evaluation and analysis of sugarcane 7000 series harvesters in sugarcane harvesting

P. Najafi[1]- M. A. Asoodar[2]- A. Marzban[3*]- M. A. Hormozi[4]

Received: 21-11-2013
Accepted: 03-02-2014

Introduction: The performance of agricultural machines depends on the reliability of the equipment used, the maintenance efficiency, the operation process, the technical expertise of workers, etc. As the size and complexity of agricultural equipment continue to increase, the implications of equipment failure become even more critical. Machine failure probability is (1-R) and R is machine reliability, and that 0<R<1 (Vafaei *et al.,* 2010). Moreover, system reliability is the probability that an item will perform a required function without failure under stated conditions for a stated period of time (Billinton and Allan, 1992). Therefore, we must be able to create an appropriate compromise between maintenance methods and acceptable reliability levels. Precision failure data gathering in a farm is a worthwhile work, because these can represent a good estimate of machine reliability combining the effects of machine loading, surrounding effects and incorrect repair and maintenance. Each machine based on its work conditions, parts combinationand manufacturing process follows a failures distribution function depending on the environment where the machine work and the machine's specifications (Meeker and Escobar, 1998). General failures distributions for contiguous data are normal, log-normal, exponential and Weibull (Shirmohamadi, 2002). Each machine can represent proportionate behavior with these functions in short or long time.

Materials and methods: The study area was the Hakim Farabi agro-industry Company located 35 kilometers south of Ahvaz in Iran. Arable lands of this company are located in 31 to 31°10 N latitude and 45 to 48°36 E longitudes. The region has dry and warm climate. A total of 24 Austoft 7000 sugarcane chopper harvester are being used in the company. Cane harvesters were divided into 3 group consisting of old, middle aged and new. From each group, one machine was chosen. Data from maintenance reports of harvesters which have been recorded within 400 hours were used. Usually, two methods are usedfor machine reliability modeling. The first is Pareto analysis and the second is statistical modeling of failure distributions (Barabadi and Kumar, 2007). For failures distribution modeling data need to be found, that are independent and identically (iid) distributed or not. For this, trend test and serial correlation tests are used. If the data has a trend, those are not iid and its parameters are computed from the power law process. For the data that does not havea trend, serial correlation testare performed. If the correlation coefficient is less than 0.05 the data is not iid. Therefore, its parameters reach via branching poison process or other similar methods; if the correlation coefficient is more than 0.05, the data are iid. Therefore, the classical statistical methods will be used for reliability modeling. Trend test results are compared with statistical parameter 𝕌 (Eqn 1).

$$\mathbb{U} = 2\sum_{i=1}^{n-1} \ln(Tn/Ti) \qquad (1)$$

where *n* is total number of failures, *Tn* is time of the nth failure and *Ti* time of the *ith* failure.
A test for serial correlation was also done by plotting the *ith* TBF against the *(i-1)th* TBF, i ¼ 1; 2; . . . ; n: If the plotted points are randomly scattered without any pattern, it can be interpreted that there is no correlation in general among the TBFs data and the data is independent. To continue, one must choose as the best fit distribution for TBF data. Few tests can be used for best fit distribution that include chi squared test and Kolmogorov–Smirnov (K-S) test. Chi squared test is not valid when the data are less than 50. Therefore, when the TBF data are less than 50, K-S test must be used. Hence, the K-S test can be used for each TBF data numbers. When the failure distribution has been determined, the reliability model may be computed by equation (2).

$$R = \int_0^{\infty} f(t)\,dt \qquad (2)$$

where *R* is reliability, *f* is failures distribution and *t* is operation time.

Results and discussion: Results of trend analysis for TBF data of sugarcane harvester machines showed that the calculated statistics U for all machines was more than chi squared value that was extracted fromthe chi square table with

1- Former Agricultural Mechanization MSc student of Ramin Agriculture and Natural Resources University of Khuzestan and PhD student of Agricultural Mechanization, University of Tabriz
2, 3 & 4- Professor, Assistant professor and Lecturer respectively, Department of Agricultural Machinery and Mechanization, Ramin Agriculture and Natural Resources University of Khouzestan, Mollasani, Iran
(*- Corresponding Author Email: afshinmarzban@hotmail.com)

2 (n-1) degrees of freedom and 5 percent level of significance. Hence, it is possible that all of the machines' TBF data will have identically and independent distributions. For validating this hypothesis, correlation testwas performed on TBF data that verified prior results. Then, Kolmogorov- Simonov test was done on TBF data. Results showed that all three machines followed Weibull 3 parameters function, but the shape parameter was different for them. The analysis showed the shape parameter for old, middle aged and new cane harvesters was 1.5, 1.42 and 1.35, respectively.
Conclusions: In order to control and reduce failures and to plan and schedule the harvester operations in optimum time, machine reliability must be known. In this paper, three sugarcane harvesters were studied individually. From the trend analysis and serial correlation, it is seen thatthe assumption of identically and being independently distributed was valid for all machines' TBF data of sugarcane chopper harvesters.

Keywords: Correlation test, Shape parameter, Sugarcane harvester, Trend test, Weibull function