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Detection of equipment aging and determination of the efficiency of a corrective measure

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Abstract

When too many failures occur on a given piece of equipment, the dependability engineer needs to decide whether these failures are attributable to poor initial design or if they are due to a phenomenon of aging. If aging is confirmed, the problem is then to determine the moment at which the process began and what corrective measure (generally, a modification in the design or in the preventive maintenance program) is the best suited to delay the occurrence of the failure. This measure will thus make it possible to extend the lifetime of the equipment.

The method is based on the simple hypothesis of a model of step aging and on Bayesian techniques.

The principal benefit of this method is the determination of the time at which aging begins (and the related uncertainties), the evolution in the failure rate of the component in its initial state and once modified, and the probability of success of the corrective measure. The IBTV software was developed to implement this methodology.

Keywords: Aging; Bayesian techniques; Corrective measures; Weibull law; Aging step model; RCM; Lifetime; Aging start up

1. Introduction

One practical problem frequently encountered by dependability engineers in cases where an excessive number of equipment failures have been observed is determining whether the failures are in fact due to a phenomenon of early aging of the equipment. If aging is confirmed, the problem is then to determine the moment in time when the process began and what corrective measures (preventive maintenance operation or a modification in the design or actual replacement) will best help to delay the occurrence of a failure. Finally, once new feedback has been collected, one must determine the efficiency of the corrective measure chosen.

The first part of this paper presents the overall context of this study; the Bayesian methodology used is then described, as are the objectives of specific software developed for this purpose (IBTV: 'Inférence Bayésienne pour le Traitement du Vieillissement'—Bayesian inference for treatment of aging); the last part of the paper presents some concrete applications and comparisons.

2. Context and approach

Operation feedback points up any weaknesses or illnesses in a component (the relationship between component/measurable effect obtained from a FMECA in the framework of Reliability Centered Maintenance) On the basis of feedback, it is possible to remedy the situation and thereby improve component reliability, ensuring that past anomalies will not be reproduced. One must then verify that the reliability of the modified component has indeed been improved.

In practice, there is a tendency to explain the symptom 'too frequent failures' automatically by 'phenomenon of aging', but this is not necessarily correct. It can happen that in service failures occur too frequently because the equipment, though its behavior is exponential, has a mean service life which is too short. Diagnosis must then attempt to verify if the failures are due to 'aging' or to 'weakness' in the population observed. The statistical tool used for

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the diagnosis must therefore be capable of identifying any phenomenon of aging.

Generally speaking, the information provided by feedback data is sufficient to point up the existence of an aging process. It is not, however, sufficient for choosing the most appropriate model to represent the phenomenon of aging, or determining whether the phenomenon is serious for periods of time more or less equal to the time during which demands will be made on the component. The more sharply the failure rate increases, the more serious is the phenomenon of aging during the period of demand.

In any sample, we may find an accumulation of failures for one of two reasons:

- The accumulation may be totally 'accidental', in which case a similar accumulation may be found in exponential lifetime samples;
- Or it may be due to the fact that equipment in service is equipment subject to aging, and the age of the 'survivors' is approaching the mean lifetime of the population.

These two situations may be found in samples of components which age and break down in accordance with a probability law (such as the Weibull law) whose shape parameter is higher than 2. These laws are characterized by a failure rate curve which increases sharply:

- Initially, we find behavior very similar to that typical of the exponential law (accidental accumulation);
- Later, after the curve has risen sharply, we find the 'final accumulation' of failures, which will terminate with the extinction of the population.

One way of modeling the behavior of a piece of equipment subject to aging is to use a piecewise constant failure rate model, with the step corresponding to the instant at which aging begins. Such a model is well suited to confirming a phenomenon of aging when a component is in service.

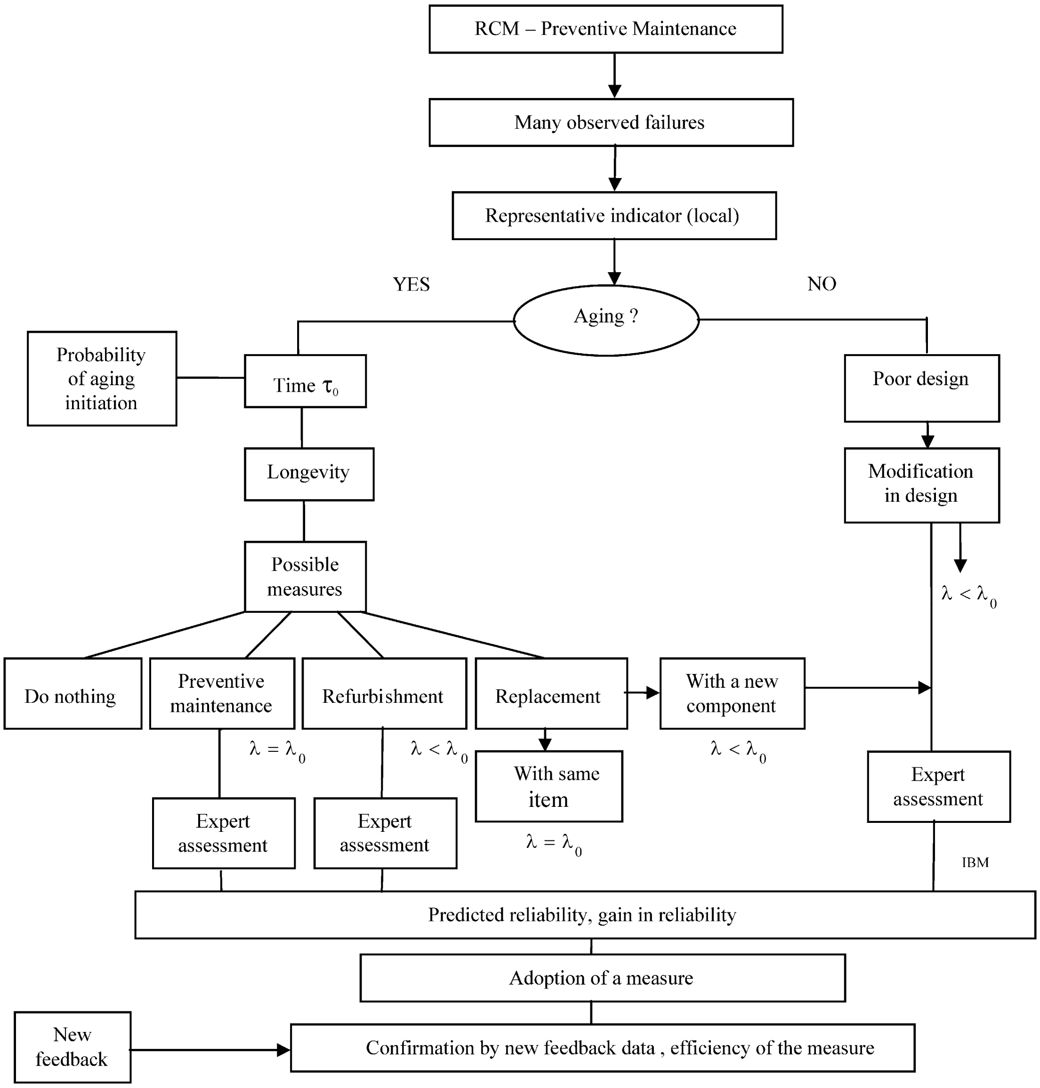

Fig. 1. Framework and method of analyzing longevity.