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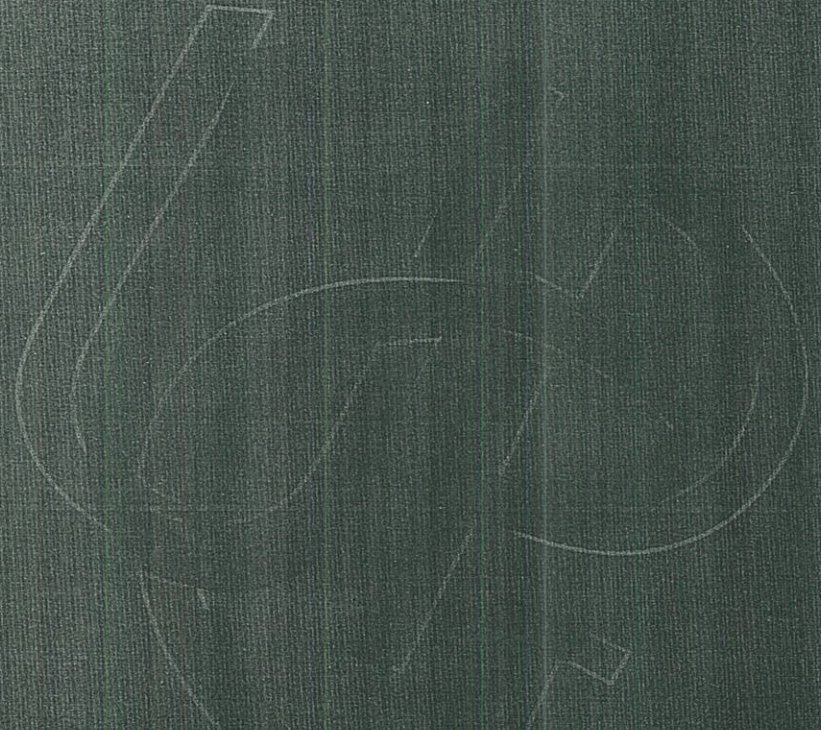

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Optimizarea robotilor industriali cu ajutorul unui algoritm hibrid genetic

Rezumat

In cadrul acestui articol se prezinta unele probleme de optimizare ale robotilor industriali folosind un algoritm hibrid genetic. Criteriile principale de optimizare sunt durata ciclului de lucru, ocolirea pozitiilor singulare, evitarea obstacolelor, cat si domeniul de lucru ale articulatiilor robotului. Problema de optimizare este rezolvata cu ajutorul unei metode hibride care combina un algoritm genetic, un algoritm quasi-Newton si o metoda de manuire a constrangerilor, folosind o functie multi-obiectiva si diverse constrangeri. Validitatea algoritmului propus este verificata in trei aplicatii ale robotilor privind proiectarea sau utilizarea lor intr-o celula de fabricatie.

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Proportional Hazards Method: Location and Procedures

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Abstract

In spite of reliability methods have come to be applied in an ever broader way in recent years, providing results in the maintenance policy of a wide range of equipment, quite of confusion is remaining concerning the different types of models and their applications.

Reliability is also highly connected to the quality of the production. Reliability is an extension of quality along time and it is as much necessary that quality so that the users can be satisfied. So it is very important to relate both quality and reliability equipment parameters simultaneously.

In this paper the authors intend to present a proposal of a general classification of reliability models in order to locate an important statistical reliability method, the proportional hazards method (PHM). As a matter of fact PHM allows the simultaneous evaluation of different equipment parameters, for instance condition and quality parameters. The authors illustrate PHM applications with an example and also provide a general procedure in order to decide the use of PHM and its application.

The example shows the capability of PHM for the evaluation of any kind of parameters, quality and condition parameters for instance, since the predicted and the real values for the machines reliability concerning the main failure mode are quite approximated.

Key words: *reliability models, proportional hazards method, statistical models, semi parametric models, quality and reliability parameters, time dependent covariates.*

Introduction

PHM was first presented by Dr. Cox (1972), and almost all its applications were related to the biomedical area. Some years ago PHM began to be used by reliability engineers in the industrial area.

PHM and its mathematical evaluation and types of parameters (covariates) are presented before the example's presentation.

To apply this method there previous knowledge is required about a set of failure points and the time to failure corresponding to each point, as well as the covariates related to the process either fixed or time dependent as one can see in Ferreira *et al* (1996), Kalbfleish and Prentice (1980) and Pereira (1996).

The paper also provides some information about the type of cases generally suitable for PHM treatment. The maintenance policy and relations between different kinds of covariates (also defined from the industrial point of view) are also referred to.

After results have been obtained conclusions may be drawn so that maintenance initiatives can be promoted and the conduction process can be improved.

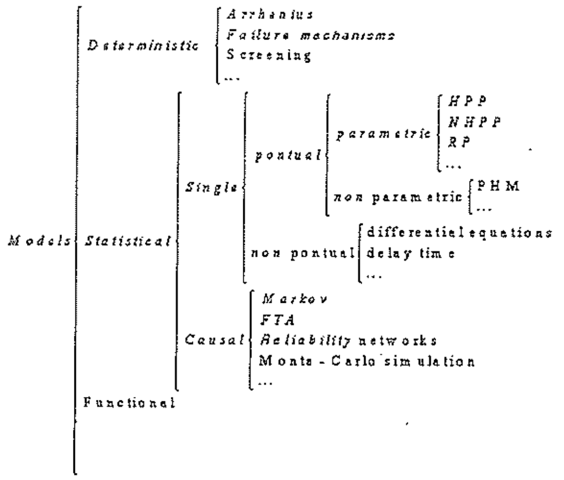
PHM results show good agreement with real cases in terms of the rectifiers survival and general conclusions are drawn related to this fact and to the general conditions that must be provided by specific equipment care to make PHM implementation possible.

Locating PHM

PHM as it is used in this paper is a statistical non parametric method. To distinguish between parametric and non-parametric methods, please see Kalbfleish and Prentice (1980) and Pereira (1996). For now the authors would like to present an approach of a schematic location of non parametric PHM. That's what one can see below.

As one can find in AFNOR (1988) reliability is an extension of quality along time and it is as much necessary that quality so that the users can be satisfied. So it is very important to relate both quality and reliability equipment parameters simultaneously. PHM allows us to get this aim.

However it is important to realize that the application of PHM in a parametric way is also possible.



A causal model is one concerning the relationships between component and system's reliability or the relationships concerning different moments and different states (up and down for instance). For further information about this kind of models, please see Andrews and Moss (1993) and Ascher and Feingold (1984).

Functional models are not based on events. They are concerned with the overall process working conditions. For a general view about it please see Pereira (1996).

For further information on deterministic models see Klaasen and Van Peppen (1989). Ascher and Feingold (1984) may provide information about single statistical models and Cox (1972), Kalbfleish and Prentice (1980) and Pereira (1996) have a large lot of information about PHM.

The PHM method

PHM is a non parametric technique based on a log-linear hazard function. Statistical models are called non parametric if they do not impose at the beginning any kind of distribution to relate the events.

The model is a way to analyze the data concerning the survival times or the failure times, depending on each situation. A set of conditions is assumed first and then the covariate's effects on the system's reliability are estimated. So it is a regression model and one can express it as

$$h(t;Z)=h_0(t).e^{(Z\beta)} \tag{1}$$

being

- $h_0(t)$ - base hazard function
- β - column vector of the k regression parameters
- Z - row vector of the k used covariates
- t - failure time

The reliability function or survivor function R(t;Z) can be derived from (1):

$$R(t;Z)=\exp\left[-\int_0^t h_0(u).e^{(Z\beta)}du\right] \tag{2}$$

It is a conditional survivor function for t given Z and it represents the potential effect on the base survivor function. The last one differs from (2) in so far as it does not contain the exponential factor.

PHM can use time dependent covariates. Suppose, for instance, we have m fixed covariates and n time dependent covariates. In that case one could write (2) as

$$R(t;Z)=\exp\left[-\int_0^t h_0(u).e^{[Z_1\beta_1+\ldots+Z_m\beta_m+Z_1(t)\beta_{11}+Z_n(t)\beta_{m}]}du\right] \tag{3}$$

PHM models the base hazard function so that for a given set of items it can be formed by two factors. The first factor is the base hazard function itself and it belongs to every set element. The second one is an exponential term including the specific effects of the different covariates on each element.

The presence or not of a given factor (place, maintenance policy, etc) is expressed by means of a discrete covariate. Measured values related to the working systems are represented by a continuum Z. So PHM evaluates simultaneously the effects of different parameters on system reliability.

Evaluating a working case by means of PHM

From now on we are going to present an example, details described in Ferreira et al (1996). A general procedure in order to decide the use of PHM and their application is also provided. Two other examples can be found in Pereira (1996).

The case we are going to present concerns two machine tools - rectifiers. PHM provides the survivor functions values to the rectifiers for all the given points of failure whatever the specific patterns of the covariates may be. The vibration level and the surface roughness are treated in a particular way since there were no direct measures of the first parameter as a covariate and the second one depends on the first and on the survival time. Vibration level was measured making use of equipment which is duly described.

The aim of this study was to predict the reliability of two rectifiers based on previous knowledge about the roughness of the rectified surfaces (quality parameter) and vibration level (reliability parameter). The rectifiers are installed in the factory of Cacia (Aveiro - Portugal) of Renault. The relationship between roughness and vibration level was to be established. Five statistical data sets, one for each failure mode, were built based on time failures, machines and vibration levels according to the steps below:

1) Failure modes were defined as indicated

mode 1 - lubrication
2 - cooling oil
3 - washing water
4 - tools (hydraulic pressure, quality loss, replacement, adjusting operations)
5 - doors

2) Vibration level and roughness were measured after each failure

3) Failure times were distributed according to the failure modes or they were censored

4) A relationship was built between roughness and vibration level by means of a statistical linear regression, vibration level being the independent covariate. A similar process was used to evaluate the relationship between roughness and failure time since roughness was the time dependent covariate.

According to the steps above five data sets were built differing from each other only by the reject column, a discrete variable taking 0 for a censored observed case and 1 if not. There were 86 observed cases by data set and variables and covariates were:

- survival - failure time - continuum
- reject - censoring mechanism - 0/1 - 1 if failure was owing to that specific failure mode
- dum - machine - 0/1
- rug - vibration level - continuum

The rectifiers are very simple machines, basically a support shaft connected to an electric motor. The surfaces to rectify belong to the engine valve balancers disposed on a grinding table just below the grinding wheels mounted on the shaft. The working process is much more complex owing to the working cycles being numerically aided. The lubrication system, the washing system, the cooling system, the grinding table longitudinal displacements (x), the grinding wheels displacements (horizontal, y and vertical, z) and the so called grinding wheels diamonding have their own electric motors.

The study proceedings

The covariates defining vibration level and roughness are intended to represent two types of problems, the problems arising from the machine condition (vibration) and the problems arising from the production quality (roughness). It is important that maintenance supervisors can have reliability predictions about their machines based either on quality covariates or condition covariates. However the evaluation of a relationship between vibration and roughness was not easy in this case since vibration level is very different from one moment of the working cycle to another and it also differs from one vibration frequency to another. There was a need to identify at what moment inside the working cycle we could take the vibration value and which of the vibration frequencies were significant ones.

Since the working cycle has three principal types of jobs, rough-hewing, finishing and diamonding, and since we intended to compare between vibration level and roughness it was easy to decide about diamonding. Diamonding is a washing grinding wheel operation by which metallic particles are removed from the grinding wheel surface. Meanwhile there is no contact between the wheel and the balancer surface, so no roughness is produced and it makes no sense comparing between vibration level and roughness during diamonding operation.

The final roughness is produced after the rapid finishing process, which is the last stage of the production process. It was therefore decided to take measured vibration values over the last 8 seconds (i.e. the time for rapid finishing) of the 140 second working cycle.

Vibration measurements were specifically taken during this study for a period of 3 years long because Renault hadn't experienced it. For that purpose a piezoelectric accelerometer as described in Wowk (1991) was used in connection to a signal amplifier described in Bruel & Kjaer (1989). Signal treatment and acquisition were made by means of specific software. The description and the types of applications for the software can be found in CSI (1989, 1991a, 1991b and 1992). For further information about vibration measurements please see Pereira (1996) and Wowk (1991).

The decision concerning the relevant frequencies was much more difficult. Observing figure 1 we can see a large range of frequencies but also some perfectly defined peaks. We must know why each peak is there and if that is not possible, at least, to check some of them concerning the roughness spectrum we have when a balancer passes through the rough meter.

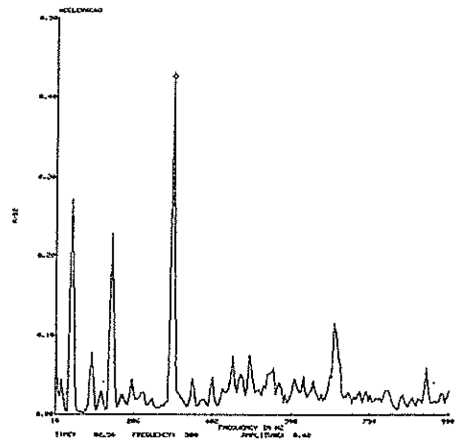


Fig. 1 Frequency spectrum (quick finishing moment)

To begin with we must know the rotating velocity of each electric motor. It was around 1500 rpm/25 Hz for all of them but 3, table displacement motor (167 Hz), cooling pump motor (25 Hz) and, of course, the grinding wheels motor which has a variable speed motor (but typically 1700 rpm). We checked also the frequencies associated to the different roller bearings just like Wowk (1991) prescribes supporting the different shafts - about 12.5, 150, 350 and 420 Hz. However the roller bearing's frequencies are not important for our study as they change along the calendar/survivor time due to wear.

It was now the moment to compare the frequency spectrum to the roughness spectrum -more detailed information can be found in Pereira (1996). 4 frequencies were identified along the roughness spectrum by means of FFT analysis, 12.5, 25, 50 and 150 Hz. For this we choused 25 and 50 Hz. They are related to the motors but in the case of the 50Hz frequency perhaps also to the electric current frequency.

So we tried to get the predictions using separately two different covariates to define vibration level, one related to 25 Hz (vib25) and another related to 50 Hz (vib50).

Regarding the roughness values they were provided by Renault since they are constantly checked by quality control services and they are currently used to verify the product quality even imposing production interruptions according to the measured values so that tool adjustment or repairs can be carried out.

After the regressions between roughness and end roughness and vibration we build two covariates rug, one for each case:

$$rug = 52.9\ vib25(-.05surv+1.66) \quad (4)$$

$$rug = 26\ vib50(-.05surv+1.66) \quad (5)$$

We tried also an exponential regression for failure time but the results were not so good as the results we got using linear regression.

The data sets are defined in Ferreira et al (1996) and Pereira (1996).

To get the results (β) BMDP PC-90 2L routine described in BMDP (1992) was used. Hazard function was then evaluated by specific software since time dependent covariates were used.

Only failure mode 4 had results showing a good agreement between predictions and real cases. As that is the most important failure mode since all the others had only a few no rejected cases, we will only show the results for failure mode 4 using a linear regression for roughness vs. failure time.

Table 1 Results (failure mode 4)

	β (25 Hz)	β (50 Hz)
dum	1.2922	1.2346
vib	1.1853	2.0392
rug	.4628	.2516

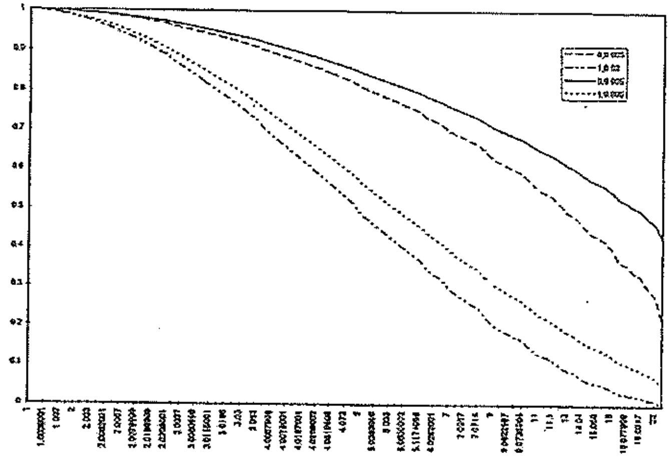


Fig. 2 Reliability predictions (50 Hz)

After these results had been obtained a test was made so that the results could be validated. We checked the absolute statistical frequencies for each class of failure time according to both situations,

predicted and real ones, using then the qui-square test. Results showed good agreement as one can see in figure 3.

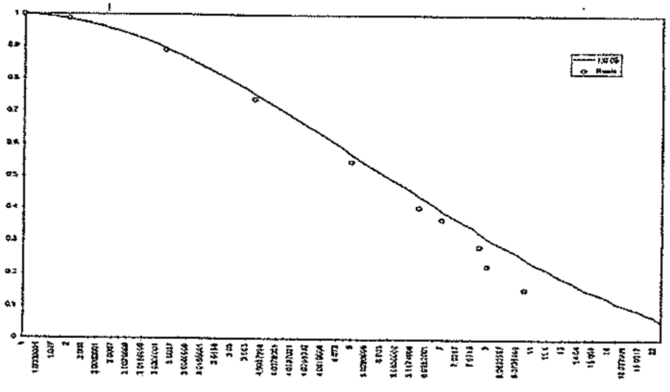


Fig. 3 Predicted values vs. real values (50 Hz)

Conclusions and general procedures

Analyzing the results we must begin by saying that the vibration level appears to have a significant negative effect on the machine reliability. On the other hand machine coded 0 has better performances than the other one (we can conclude this as they present β's > 0). As to roughness we see a negative effect but less than vibration and machine. This work showed it was possible to use a relationship between condition and quality covariates with positive results. This relationship, if possible, is of capital importance to control the equipments working conditions allowing the operators and the Maintenance services the prediction of those working conditions one or another of the covariates being known. It also allows the prediction of the time evolution of one of those covariates if we know the other.

Very reliable results were obtained from the utilization of time dependent covariates which are perfectly applicable under these conditions and with condition and quality covariates. However, some problems occurred and since vibration level is one of the most common variables to check equipment condition, a much easier and cheaper process is important to define vibration level significant values.

A failure mode's analysis is important as they must be as few as possible. The time between failures must be short to get more and more failure cases but if we want to use time dependent covariates longer times produce better results. That means that we must be prepared to have a longer observation time when using these kinds of covariates.

Failure times should be longer enough to allow the vibration level being treated as a time dependent covariate. Of course this condition means more and more convergence problems but also more reliable results. We can say also that in this case we must use a linear regression rug(t) and covariates machine, vibration and roughness must be considered.

PHM is indicated if we need to evaluate as to their influence on reliability different parameters simultaneously and if we are unable to fit a parametric model to our system. The first situation is associated to complex production processes and the second is related to incomplete knowledge about working conditions, equipment parts or interactions between them.

We can define step by step a general procedure to use PHM after the decision concerning that use has been taken:

a) - Select covariates

b) - Identification of failure situations and failure modes

c) - Construction of data set(s)

d) - Results and posterior analyzing

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Metoda riscurilor proporţionale: Cazuri şi proceduri de aplicare

Rezumat

În ciuda faptului că metodele de fiabilitate au ajuns să fie aplicate într-un mod mai larg, în ultimii ani, oferind rezultate bune în politica de întreţinere a unei game largi de echipamente, este destul de confuză utilizarea lor cu privire la diferite tipuri de modele si aplicatiile lor. Fiabilitatea este, de asemenea, foarte legată de calitatea producţiei.

În această lucrare autorii intenţionează să prezinte o propunere de clasificare generală a modelelor de fiabilitate, pentru a localiza o importantă metodă statistică de fiabilitate, metoda riscurilor proporţionale (MRP). De fapt permite evaluarea simultană a diferiţilor parametri ai echipamentelor, de exemplu, ai parametrilor de stare şi de calitate. Autorii ilustrează aplicaţiile MRP cu un exemplu şi oferă, de asemenea, o procedura generală cu utilizarea metodei şi aplicaţiile sale. Este arătată capacitatea de evaluare a MRP a oricărui fel de parametri, de calitate şi de stare, de exemplu, de la valorile prezise până la cele reale pentru fiabilitatea maşinilor, în ceea ce priveşte principalele moduri de defectare, sunt destul de apropiate.

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Experimental Results for Local Buckling under External Pressure (Collapse) and Axial Tension of Perfectly Circular Tubes

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Abstract

The paper presents the results of an experimental study aimed to investigate the behaviour of perfectly circular tubes loaded by external pressure (collapse) and axial tension. The tests have been performed on small scale pipe specimens, based on the similitude law, and their results have been compared with collapse pressure values calculated with formulas usually used to assess pipe collapse under external pressure with axial tension.

Key words: *pipe, collapse, external pressure, axial tension.*

Introduction

An important loading which can decisively affect the resistance capacity of oil industry tubulars is the external hydrostatic pressure. Under the external pressure, often combined with tensile and/or bending loads, the local buckling phenomenon can occur leading to the ovalisation followed by flattening of tubulars. Such phenomenon is of crucial importance for casing and tubing (mostly in high pressure wells), and for submarine pipelines during the installation phase (when the pipeline is empty), especially in deep waters. The paper presents the experimental facility and the methodology applied in order to study the influence of the axial load on external collapse pressure for perfectly circular tubes by performing the tests on small scale models, based on the similitude law.

Analysis of previous results concerning collapse of ideal circular tubes

Various researchers proposed a series of calculation formulas, based on theoretical models and/or test results, to evaluate the critical external collapse pressure, p_c, for perfectly circular (nominally round) pipes. The main problem emerging from those studies is that the collapse mechanism differs essentially with the value of the ratio between the pipe outside diameter and its wall thickness, D/t [8].

For great values of D/t ratio ($D/t > 35$), collapse occurs by means of an elastic flattening, before the pipe material reaches its yield strength. However, for small values of the D/t ratio (under 15...20), typical for instance for deep water submarine pipelines, collapse will take place in the plastic field. As a consequence, in such case, an adequate modelling of the non-linear behaviour of pipe material becomes necessary. For $D/t = 20...35$, the pipe failure mechanism is much more complex – an elastic-plastic collapse will take place.