بسم الله الرحمن الرحيم

DEVELOPMENT AND APPLICATION OF PREDICTIVE MARKOV-CHAIN CONDITION-BASED TRACTOR MAINTENANCE MANAGEMENT MODEL

تطوير وتطبيق
نموذج حاسوبي للتنبؤ بأدارة صيانة الجرار بأستخدام متسلسلة ماركوف

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ATHESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
.AGRICULTURAL ENGINEERING

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DECEMBER 2009

Dedication

This thesis is dedicated to my father, who taught me that the best kind of knowledge is that which is learnt for its own sake,

It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time,

It is also dedicated to my brothers and sisters

.Thanks for everything

Acknowledgements

First of all, praise is due to almighty ALLAH on whom ultimately we depend for sustenance and guidance. Second, my sincere appreciation goes to my supervisor Dr. Elngomi Omer, whose guidance, careful reading and .constructive comments was valuable

I am also deeply indebted to my co- supervisor Dr. Hassan Ibrahim Mohammed for his invaluable advice and supervision at the initial stages of this study. He also encouraged me in my interest in this topic and provided me with many helpful and technical discussions during model development, especially in structural equation modeling, also he friendly helped and co-operated with all analyses of model output. He showed a great deal of interest in reading, discussing and giving feedback on all .aspects of my thesis. Hearty thanks for my supervisors

I also wish to thank the administration and staff of Sennar and Gunied Sugar Factories workshops, who made data record completion possible; also, I am very grateful to Eng/Shawgi and Mr. Mohammed for their great .help, especially at the initial stages of this work

Finally I want to thank all the staff of Agricultural Engineering Department at College of Agricultural studies who were directly or indirectly involved in .this study

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Abbreviations

.AMS Agricultural Mechanization Strategy

.BD Break Down Maintenance

.CBM Condition-Based Maintenance

.CCF Common Cause Failures

.CM Corrective Maintenance for tractor

.FF Failure Frequency

.FIT Failures in Time

.HSMM Hidden Semi-Markov Model

.MT Maintenance Time

.MTBF Maximum Time Before failure

.MTTF Mean Time to Failure

.MTTR Mean Time to Repair

.NDT Nondestructive Testing

.OTCM Operating Time Between Corrective Maintenance

.OTPM Operating Time Between Preventive Maintenance

$.P^{A}$ Probability of failure when tractor on working State

$.P_{a1, e1}$ Probability of failure when tractor on partial failure state

$.P_{a1e2, a1e2, a2e1}$ Probability of failure when tractor on combined failure state

$P_{a2, e2, b2, c2, d2, f2}$ Probability of failure when tractor on complete failure state.

.PDF Probability Denasality Function

$.P_{i}^{A}$ Probability of transition before states

.PM Preventive Maintenance for tractor

. Maintenance PSM Planned Scheduled Maintenance

.RCM Reliability Centered Maintenance

.RNG Random Number Generator

.RUL Remaining Useful Life

$.S_{a2}$ S_{e2} Combined Failure States

.S_{a2} S_{e2} Partial Failure States

.S_{b2}, S_{c2}, S_{d2}, S_{f2} Complete Failure Sates

.SSC Sudanese Sugar Company

.SWOT Strengths, Weaknesses, Opportunities, and Threats Analysis

.t Operating time

.TBF Time Between Failures

.TBI Time Between Interruptions

.TD Tractor Dependability

.TPM Transition Probability Matrix

.TV Tractor Availability

.(Common Failure Rate (Combined Failure State δ

.(Common Failure Rate (Combined Failure State ε

.Failure transition rate before partial and complete States λ

.(Repair Rate (Combined Failure State ρ

.(Repair Rate (Combined Failure State ψ

.μ Repair transition Rate before partial and complete States

ABSTRACT

A repairable system (tractor) is subject to deterioration or repeated failure. At each inspection of failure status (partial, Combined and complete) a general repair (minor replacement of parts by preventive maintenance) or complete overhaul (major replacement of parts by corrective maintenance) is performed to restore the system to "as good as new ."state

Considerable research has been conducted on the issue of periodic replacement times of failing systems. No doubt this is a reflection, at least in part, of the high capital cost, of many farming systems and on the importance of minimizing unnecessary failure costs. Despite relatively the large body of literature on this topic, analysis of dynamic maintenance schedule and their effect on performance of the system remains as an open problem. In response to these challenges this study is directed to develop a computerized recursive Markov-chain closed form analytical solution for prediction of tractor failure, analysis, control, scheduling of .maintenance activities and determining of tractor availability

The developed algorithm of Markov chain for failure analysis looks at a sequence of events, defined as transition between states, and calculates the relative probability of encountering these events in short-run(partial),medium (combined) and long-run (complete). Hence, the algorithm is used to evaluate reliability and availability of tractor with .time-dependent transition rates using analytical matrix –based methods

The developed procedure is written in Microsoft Excel (Spread sheet) operating environment. With the software the user will have the ability to manipulate and analyze the data directly using customized menus and .point and click mouse operation

Typically, the failures time distribution are determined and applied, using three years tractor failure data collected from two different workshops at Sudanese Sugar Company(Sennar and Gunied) for three medium (72-120 .hp) tractors models

To verify model accuracy, its basic functional relations (decision state matrix) are compared with Amri and McLanghim model (2004) and with .(WINQSB software using (t- test

For purpose of model validation real data from the field is compared with that predicted by the model and results showed no significant difference .(between them (P =.05

Sensitivity analysis is used to utilize the model as experimental tool to explore the structure of various improvement scenarios using a two-step procedure and analysis of variance. Consequently, performance of the tractors with respect to six evaluation parameters and their ranks for the .various workshops is quantified

ملخص الدراسة

تتعـرض النظـم الـتى تصـان (الجـرار) الـى التـدهور أو العطـل المتكـرر عنـد كـل تفـتيش لحالـة العطل(جزئي , مشترك, كلي) تجري صـيانة عامـة (اسـتبدال للاجـزاء بالصـيانة الوقائيـة) أو صـيانة كاملة (صيانة تصحيحية اساسية) حتى يمكن اعادة النظام لحالة (جودة كالجديد).

تم اجراء العديد من البحوث فـي مجـال زمـن الاسـتبدال الـدوري للاجـزاء المتعطلـة. ولاشـك هـذا يعكس ولو جزئيا التكاليف المالية في كثير من النظم المزرعية واهمية تقليـل التكلفـة العاليـة غيـر الضرورية للاعطال . وعلى الرغم مـن ادبيـات البحـث الكـثيرة فـي هـذا الموضـوع, يشـكل تحليـل ديناميكية جدولة الصيانة واثرها على اداء النظام مشكلة مفتوحة قيد البحث. استجابة لهذا التحدي , قامت هذه الدراسة بتطوير حـل تفصـيلي مقفـل وحاسـوبي لمتسلسـلة مـاركوف للتنبـوء باعطـال الجرار والتحكم و الجدولة لنشاطات الصيانة وتحديد اتاحية الجرار.

تنظر تطوير خوارزمية متسلسلة ماركوف لتحليل الاعطال، الى تتـابع الاحـداث الـتى تعـرف كحالـة انتقالية بين المراحـل والـى حسـاب الاحتماليـة النسـبية الـتى تتضـمنها هـذه الاحـداث فـي المـدي القريـب(عطـل جـزئ) والمتوسـط (عطـل مشـترك) والبعيـد(عطـل كامـل). وعليـه تـم اسـتخدام الخورازميـة لتقييـم اعتماديـة واتاحـة النظـام حسـب معـدل الانتقـال الزمنـي باسـتخدام طريقـة المصفوفة التحليلية.

تم بناء الخوارزمية باستخدام لغة وبيئة تشـغيل النظـام الحاسـوبي(Excel) الـذي يتيـح لمسـتخدم البرمجية القدرة على ترتيب وتحليل البيانات مباشرة باستخدام القوائم المنسدلة والقيـام بعمليـات مختلفة بالنقر على الفارة.

وبالضبط، تم تقدير توزيع زمن الاعطال وتطبيقه باستخدام بيانات اعطال ثلاث جرارات متوسـطة (72 - 120 حصان) لثلاث سنوات، تم تجميعها من نوعين مختلفين مـن الـورش فـي مـوقعين مـن مواقع شركة السكر السودانية (الجنيد وسنار).

لاجل تحقيق صحة النموذج تم مقارنة علاقات البنية والصيغ الرياضية الاساسية (الخاصـة بمصـفوفة اتخاذ القرار) في البرنامج مع تلك المستخدمة في نموذج امري وماك لانقهيـم (2004) وبرمجيـة (Win QSB) باستخدام اختبار (t - test).

لاغراض تحقيق قدرة النموذج على التعبير عن الحالة التى تم دراستها تم مقارنة بيانـات حقليـة مـع تلك التى تم استنباطها بواسطة النموذج وتبين في المقارنة عدم وجود فروق معنوية بين الاثنين (P = 0.05%).

تم استخدام تحليل حساسية النمـوذج للتغييـر فـي المـدخلات كوسـيلة لاجـراء تجـارب استكشـافية بغـرض خيـارات تحسـين حـالات متعـددة باسـتخدام طريقـة تعتمـد علـى خطـوتين وعلـى تحليـل

المتغيرات الاحصائية. وتبعا لذلك تم التقدير الكمي لست معاملات تقييم لانواع موديلات الجـرارات المختلفة في كل ورشة.