بسم الله الرحمن الرحيم

DEVELOPMENT AND APPLICATION OF MATHEMATICAL MODEL FOR SUGARCANE HARVESTERSFAILURE PREDICTION

تطوير وتطبيق
نموذج رياضي للتنبؤ بأعطال حاصدات قصب السكر

BY

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Dedication

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

Thanks for everything.

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A viations

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.

PSM Planned Scheduled MaintenanceMaintenance.

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.

δ Common Failure Rate (Combined Failure State).

ε Common Failure Rate (Combined Failure State).

λ Failure transition rate before partial and complete States.

ρ Repair Rate (Combined Failure State).

ψ Repair Rate (Combined Failure State).

μ Repair transition Rate before partial and complete States.

ABSTRACT

The general objective of this study is developing and improving the performance of sugarcane harvester by management of maintenance, for the purpose of increasing availability and reliability of harvester and decreasing cost of maintenance and repair, by developing mathematical and an analytical, user-friendly model for sugarcane harvester failures analysis and management, using Gamma distribution for failures.

The developed algorithm of Gamma distributions for failures analysis looks on the sequence of events (failures), 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 sugarcane harvester with time-dependent transition rates using analytical distributions 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.

To verify model accuracy, its basic functional relations of model (Gamma distributions matrix) are compared with Amri and McLanghim model (2004), and results showed no mathematical difference between two models.

The failures analysis model is run using failure data of two sugarcane Harvesters collected from two study sites (Guneid factory and New Halfa factory workshops), the purpose is to investigate and evaluate performance of the studied sugarcane harvester, with respect to the stander of maintenance in these two workshops using three proxy indicators (maximum time before failure, dependability and availability).

The result showed that, the dependability as function of the sugarcane Harvester, makes is of significant impact on maximum time before failure for all Harvester while the sugarcane harvester of Guneid is the most reliable with a 50 % Availability of 19 hours of time before failures and sugarcane Harvester of Sinnar showed at 50 % Availability a value of 15 hours of time before failures.

ملخص الدراسة

الهدف العام لهذه الدراسة هو تطوير وتحسين اداء حاصدة قصب السكر من خلال ادارة الصيانة بغرض زيادة الاناحية والموثقية للحاصدة وخفض تكاليف الصيانة والاصلاح وذلك ببناء نموذج رياضي تفصيلي وسهل التعامل لادارة وتحليل اعطال حاصدات قصب السكر بأستخدام خورازمية توزيع قاما للاعطال.

تنظر تطوير خوارزمية توزيعات قاما لتحليل الاعطال، الى تتابع الاحداث (الاعطال) التى تعرف كحالة انتقالية بين المراحل والى حساب الاحتمالية النسبية التى تتضمنها هذه الاحداث في المدي القريب (عطل جزئ) والمتوسط (عطل مركب) والبعيد (عطل كامل). وعليه تم استخدام الخورازمية لتقييم اعتمادية واتاحة حاصدة فصب السكر حسب معدل الانتقال الزمني باستخدام طريقة توزيع المصفوفة التحليلية.

تم بناء الخوارزمية باستخدام لغة وبيئة تشغيل النظام الحاسوبي (Excel) الذي يتيح لمستخدم البرمجية القدرة على ترتيب وتحليل البيانات مباشرة باستخدام القوائم المنسدلة والقيام بعمليات مختلفة بالنقر على الفارة.

لاجل تحقيق صحة النموذج تم مقارنة علاقات البنية والصيغ الرياضية الاساسية (الخاصة بمصفوفة توزيع قاما) في النموذج مع تلك المستخدمة في نموذج امري وماك لانقهيم (2004) وقد اوضخت نتائج المقارنة عدم وجود فرق رياضي بين النموذجين.

تم تشغيل نموذج تحليل الاعطال باستخدام بيانات اعطال لحاصدتين قصب سكر تم تجميعها من موقعي الدراسة (ورشة مصنعي سكر الجنيد وحلفا الجديدة) كوسيلة لاجراء تجارب استكشافية وتقييم اداء الحاصدات تحت الدراسة بالاعتماد على معايير الصيانة في الورشتين وذلك بالتقدير الكمي لثلاث مؤشرات استكشاف (اقصي زمن تشغيل قبل حدوث العطل، الاعتمادية والاتاحية).

اوضحت النتائج ان مؤشر الاعتمادية يحدث اثر معنوي اذا تم استخدامه كدالة لاقصي زمن تشغيل قبل حدوث العطل لحاصدات قصب السكر حيث كانت الحاصدات المستخدمة في مصع سكر الجنيد اكثر اعتمادية بنسبة اتاحة 50% لتسعة عشر ساعة قبل

حدوت العطل واظهرت حاصدات قصب السكر المستخدمة في مصع سكر سنار اعتمادية بنسبة اتاحة 50% لخمسة عشر ساعة قبل حدوث العطل.