UNIVERSITI PUTRA MALAYSIA

DESIGN AND DEVELOPMENT OF A SELF-PROPELLED HYDRAULIC FLOOR CRANE

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BY

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Chairman: Professor Shamsuddin Sulaiman, PhD

Faculty: Faculty of Engineering

Crane is a device utilized for loading, unloading and transporting the loads. There are many types of cranes for various applications. Although cranes are profitable devices, they have a lot of problems. One of the most important problems of cranes is that they frequently generate hazards and accidents. Other problems relate to their performance and imperfection of systems. The purpose of this research is to design of a self-propelled hydraulic floor crane to prevent the hazards which are normally associated with the crane application in workshops and factories. The main focus was aimed at the remote controlling of the crane operations to reduce the hazards and improving the performance features such as rapidity, flexibility and maneuverability.

The methodology employed in this thesis consists of design of crane's framework, design of systems, modeling of the crane by use of computer-aided design, and several investigations for development of the crane regarding payload sway, crane stability, field application and application of composite materials in the crane structure. Stability analysis of the crane was performed in static and dynamic

situations. Equations of stability were derived and a crane was designed for field application. The results indicated that stability is based on the weight and center of gravity of crane and payload. Dynamics of payload sway was studied in a system with seven-degrees-of–freedom and equations of motion were derived by use of Lagrange's equation. Based on these equations, effect of hook and boom parameters on sway angles was studied and an anti-sway controller was designed.

Results denoted that by increasing the mass and length of hook, sway of payload was diminished. Computer-aided finite element analysis was performed to compare three composite materials, carbon epoxy, graphite epoxy and glass epoxy with steel from the weight and strength point of view and glass epoxy was known as an appropriate substitute for steel in crane structure. The general research resulted in several findings and contributions such as: an advanced self-propelled hydraulic floor crane holding specifications in tables 5.8 and 5.9 for application in factories, workshops, fields and some of the hazardous environments, articulated hook, steer-by-switch system, sway brake system which is an autonomous system, and determination of the most appropriate composite material for crane frame-work. The hydraulic floor crane, articulated hook, steer-by-switch system and sway brake system are all new designs. For validating the research work, a scale-model prototype of the alternating current crane was built and tested. The entire crane operations could be controlled properly from afar via a control box located in the operator’s hands. The estimated fabrication cost of a full-scale crane is 16000 RM. Finally, it was concluded that use of the wire remote control system reduced the hazards by keeping operator far from the crane. Use of platform and sway brake system eliminated payload sway. Use of

two electromotors, a three-piece boom, a compacted size, steering and drive systems, increased rapidity, flexibility and manueverability of the crane.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

REKABENTUK DAN PEMBANGUNAN KREN LANTAI HYDRAULIK BERGERAK SENDIRI

Oleh

DARYOUSH SAFARZADEH

Disember 2011

Pengerusi: Profesor Shamsuddin Sulaiman, PhD

Fakulti: Fakulti Kejuruteraan

Kren adalah alatan yang digunakan untuk memunggah, mengeluarkan dan menghantar bebanan. Terdapat beberapa jenis kren dengan pelbagai penggunaan. Walaupun ia alatan yang menguntungkan, ia juga menghadapi berbagai masalah. Satu daripada masalah penting ialah kerapkali mengalami kemalangan dan bencana. Masalah lain adalah berkaitan prestasi dan sistem yang tidak sempurna. Oleh itu tujuan penyelidikan ini adalah untuk merekabentuk kren lantai bergerak sendiri secara hydraulik untuk menghalang dari bencana di mana biasanya di gunakan di bengkel dan kilang-kilang. Fokus utama adalah operasi kren kawalan jauh untuk mengurangkan bencana dan menambahbaik ciri prestasi seperti kepantasan, kelugsan dan cara menggerakkan. Kaedah yang digunakan dalam tesis termasuk rekabentuk kerangka kren, rekabentuk sistem, pemodelan kren secara Rekabentuk Bebantu Komputer dan beberapa kajian untuk pembangunan kren berkaitan beban tergantung, kestabilan kren, penggunaan di lapangan dan penggunaan bahan komposit pada struktur kren. Analisa kestabilan kren dilakukan dalam situasi statik dan dinamik. Persamaan kestabilan telah dibentuk dan kren direkebentuk untuk

penggunaan lapangan. Keputusan menunjukkan kestabilan adalah berdasarkan berat dan pusat graviti kren dan beban tergantung. Beban tergantung secara dinamik juga telah diselidiki dengan sistem tujuk-sudut pergerakan bebas dan persamaan gerakan diperolehi menggunakan persamaan Lagrange. Berdasarkan persamaan ini, kesan penyangkuk dan parameter boom pada sudut tergantung telah ditentukan dan kawalan anti-gantungan telah direkabentuk. Keputusan menunjukkan dengan menambah berat dan panjang penyangkuk, beban tergantung dapat dikurangkan.

Komputer Terbantu Unsur Terhingga telah dilaksanakan untuk melihat perbandingan tiga bahan komposit iaitu epoksi karbon, epoksi grafit dan epoksi kaca dengan keluli pada sudut berat dan kekuatan. Hasilnya epoksi kaca diketahui sebagai pengganti yang sesuai untuk struktur keluli kren. Keputusan dan penemuan serta sumbangan penyelidikan ini secara amnya ialah: kren hidraulik lantai bergerak sendiri termaju untuk penggunaan di kilang, bengkel, lapangan dan persekitaran bahaya, penyangkuk memunggah bebanan, sistem mengemudi-oleh-suis, sistem gantungan brek autonomi, penentuan bahan komposit untuk kerangka kren.

Kren lantai hidraulik, penyangkuk memunggah bebanan, system mengemudi-oleh-suis dan system gantungan brek adalah hasil rekabentuk baru. Untuk pengesahan kerja penyelidikan, kren prototaip model berskel dengan arus ulang-alik telah dibina dan diuji. Operasi keseluruhan kren dikawal dengan baik secara kawalan kotak di tangan pengendali. Kos pemasangan untuk skel penuh dianggarkan sebanyak RM 16000. Akhirnya, dapat disimpulkan bahawa kren system kawalan berwayar dapat mengurangkan bencana dan dikendalikan secara jauh. Penggunaan platform dan system brek tergantung menghapuskan ayunan beban tergantung. Kren dengan

menggunakan dua elektromotor, tiga-batang teras, saiz terpadat, system pemanduan dan pepandu dapat menambah kepantasan, keluesan dan cara pergerakkan.

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I certify that a Thesis Examination Committee has met on 16 December 2011 to conduct the final examination of Daryoush Safarzadeh on his thesis entitled "Design and Development of a Self-Propelled Hydraulic Floor Crane" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

DARYOUSH SAFARZADEH

Date: 16 December 2011

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