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The design process of a self-propelled floor crane

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Abstract

In order to prevent the hazards associated with the crane application in workshops and factories, a self-propelled hydraulic floor crane with wire remote control was designed. The main focus was directed on remote control of the crane operations such as rotation of booms, rear and forward movements, changing travel speed, steering, braking and hook rotation. This configuration prevents the hazards and damages which may be created due to the proximity of operator to crane and provides the feasibility of utilizing the crane in crowded manufacturing areas, fields and hazardous environments. Research into the stability of crane on a slope route was also performed to obtain the equations of stability in static and dynamic conditions and recognition of the ways to enhance the stability. To validate the research work, a scale-model prototype was built to test the manner of controlling the crane operations from afar.

Keywords: Crane; Hazards; Hydraulic; Remote control; Self-propelled

1. Introduction

Cranes are devices utilized for loading, unloading and transmitting the loads. They are profitable devices but hazardous in nature. Aneziris et al. [7] knew the crane activities responsible for 4% of the reported accidents and according to OSHA regulations, about 15.2% of crane events are occurred in manufacturing environments. Many researches have been performed regarding the causes of injuries and death from cranes, for instance Hakkinen [6]; Neitzel et al. [10]; Suruda et al. [1]; Yow et al. [9]. Crane accidents have been grouped in the following categories according to NIOSH (National Institute of Occupational Safety and Health) report, including: swinging loads, overturning of cranes, falling loads, crushing between moving parts of cranes, falls of people from cranes, power line contact, overloading, contact the hook assembly with boom tip, obstruction of vision, assembly and disassembly of boom. Crane hazards are normally related to design and crane use. From a safety point of view, one of the most important issues in design of a crane is determination of stability. Stability of cranes has been studied by some researchers such as Sochacki [11]; Towarek [12]; Klosinski and Janusz [4]. Weak segments, stress, strain, displacement, critical points and strength of parts under definite loads are determined by computer aided finite element analyses. Strength of the components versus the applied loads is determined based on FOS

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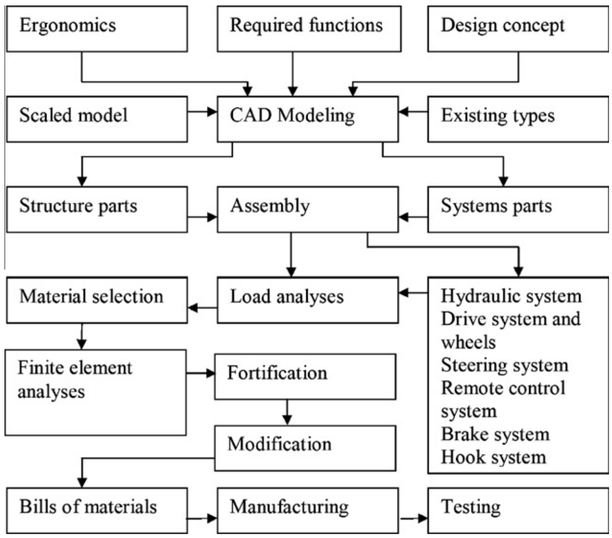

Fig. 1. Design flow diagram.

Table 1
Crane specifications.

Description		Specification
1	Total mass (kg)	840
2	Rated capacity (kN)	13
3	Max. grade ability laden (%)	9.7 – field configuration
4	Max. grade ability unladen (%)	33
5	Max. travel speed (km/h)	2.88
6	Electromotor output (drive system)	$24v \times 4000w \times 1400$ rpm
7	Electromotor output (hydraulic system)	$24v \times 4000w \times 1400$ rpm
8	Batteries	2 pcs × 12 V × 200 AH
9	Speed reduction ratio of drive system	45.79
10	Capacity of hydraulic reservoir (l)	35
11	Rear wheel size ($W \times D$) (mm)	150 × 500
12	Front wheel size ($W \times D$) (mm)	100 × 400
13	Angle of static longitudinal stability	Laden 40°, Unladen 15°
14	Angle of static lateral stability	Laden 48°, Unladen 40°
15	Material	Steel AISI 1045
16	Overall dimensions ($L \times W \times H$) (mm)	1940 × 1516 × 2391

(factor of safety). For a safe performance, FOS is typically considered more than 1. Hydraulic floor crane is a kind of crane which has been used in workshops and factories from olden times. Basically, it is composed of a base, a column, a boom and a hydraulic cylinder for hoisting the boom. Nowadays, its application has been limited because of innumerable defects. The major research contribution of this paper is the use of CAD to design and develop a wire remote control hydraulic floor crane for the aims of decreasing the hazards, improving the performance and efficiency compared to the existing types and application in various locations such as hazardous environments and fields. Hence the main focus was directed on hazards reduction. Furthermore, the design has been also accomplished based on the required functions to perform the corresponding operations and employing peculiarities of the existing types considering their defects including hand-operated actuation, lacking of motor supplies, low safety, slow response and low speed as Fig. 1 shows. Table 1 denotes the specifications of the crane.

2. Modeling of the crane

Solid Works and Cosmos were used for CAD modeling of the crane and finite element analyses to determine the strength of components respectively. Fig. 2 represents two computer models of the crane.

Finite element analyses were performed based on the static and dynamic forces applied to the components in various situations of the booms. A lot of analyses were performed on the components using the maximum forces. The allowable stress method based on ISO 8686 standard 1989 was used to assess the strength of the components. The weak locations were fortified in several stages to enhance the factor of safety up to the optimum values. Table 2 represents the results of analyses after finial fortification of the components.

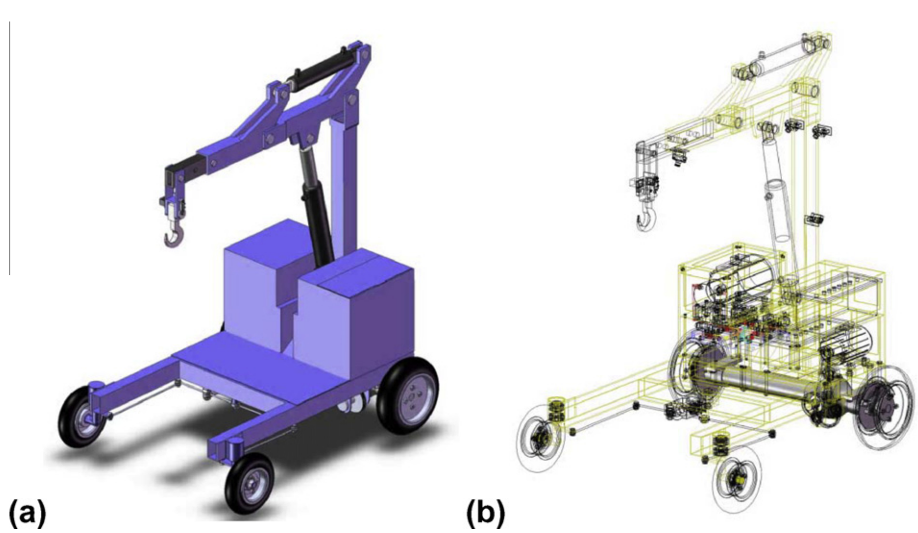

Fig. 2. Computer models of the crane: (a) solid 3 D and (b) wire frame.