

DESIGN AND DEVELOPMENT OF ROPE CLIMBING DEVICE FOR MULTI STOREY BUILDINGS

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Abstract

Hoisting devices are a special category of devices used for working on tall buildings and in hazardous locations where it is difficult for human beings to operate. Rope climbing devices have been developed for various functions and wide ranging tasks for construction and material handling in not too tall buildings. The ease of operating rope climbing devices is high as compared to complicated and heavy hoisting systems normally used for tall buildings. Besides, such devices do not cost much. In this paper, the focus is on developing a low cost and reliable vertical climbing that is simple in operation and is useful for construction of buildings of about 5-6 stories. The drive is a simple roller squeeze mechanism based on sugarcane juicer machine concept. The device can be relocated quickly at desired location at the construction site, as opposed to fixed location type systems, and shall be able to carry tools and construction equipment up to 100kg weight using ropes of different diameters.

Keywords: Rope Climbing Device, Hoisting Mechanisms, Construction Equipment, Tall Structures.

I. INTRODUCTION

In recent years, hoisting devices are increasingly used for building construction work, especially tall buildings, to lift and deliver construction material at the place of use. Invariably, these devices are rigidly anchored in earth, have a fixed location and are heavy. They provide safety to operators and goods in particular in hazardous locations where it is difficult for human beings to operate. Wall climbing robots are a special category of devices used for working on tall buildings. However, they are, not considered suitable for construction activities due to unfriendly work environment and non-availability of smooth climbing surfaces. They are of great use, however, in cleaning glass panels and for undertaking repair works in existing tall building.

For buildings which are not too tall, say 5-6 stories, use of costly and rigid systems becomes much less desirable if reducing the overall construction costs is an issue of concern. Availability of a simple and remotely operated portable device would greatly ease material handling requirements at construction sites. This paper is aimed at understanding the earlier efforts at designing and selection of hoisting mechanisms, safety systems and related aspects considered in the wide range of hoisting devices being currently used in construction industry.

II. HOISTING MECHANISMS AND DRIVES

Arditi [1] examined and compared current practices used for the loading in/out of materials in construction of high rise

structures. The various hoisting mechanisms used include scaffold platform, rack and pinion drive, static platform, mast climber. Choice of the type of mechanism is based on the capacity in terms of maximum weight to be lifted at a time, first installation cost, operating difficulties, equipment utilization, repositioning needs, loading are and so on. Drives used in these systems are AC or DC motors.

Sung-Min Moon et al [2] has described the development of a building maintenance robot that makes use of built-in guide rails for climbing purpose. In some high rise building constructions, overhead robotic cranes with an automation system have been used so as to reduce risk factors in human operation, decrease the construction cost and shorten the construction period [3].

Urankar [4] has proposed a design based on a set of four bar mechanism in fabrication of robot worm and worm-wheel tool is located at the center of the whole mechanism. Because the mechanism is used at that location is a self-locking mechanism, it safeguards that when the motor has to be deactivated at the time, the link doesn't collapse back.

Ho Cho et al [5] used caterpillar mechanism to convert the torque into the dynamic force through by means of a single active timing pulley, two passive timing pulleys and a timing belt. The timing belt is capable to generate high frictional force because it is covered with the rubber thick with and by the thermo-welding.

Ibrahim Hussain et al [6] have to be proposed and established a robot proficient of rope climbing in the direction of both horizontal and vertical. The robot has the capability to achieve surveillance by using a camera mounted on top of the robot and makes use of two ropes for vertical or horizontal movement using DC Porsche motor. This motor has two chains attached, one for the parallel movement and other for upright movement.

Osswald [7] proposed using hot melt adhesive (HMA) to reach robotic mountaineering locomotion by means of this process. For this, motor is used as basic drive function. It performs three main operations, first is to supply HMA material amongst foot segment and environment to keep adhesive force in contradiction of gravitational force and another one is to regulate temperature of HMA material to assign and separate the foothold and the last one is to revolve its own body about pivoting foothold. Also there are six motors at the platform: two motors are employed for revolution movement about the feet and another couple of motors are located in between foot segments and the core body segment. Robot platform is able to lift at left and right foot segments with esteem to main body segment, which permits the robot to walk not in one direction on a flat ground but also on a variation of unstructured walls. For climbing purpose Peltier element is used and is capable of both heating completes a Peltier element and a servomotor.

Kooa et al [8] have proposed piston tool consisting of crank, connecting rod and end bar with DC motor powering a crank. Also for the achievement rate of robot climbing procedure two types of motors are provided i.e. DC motor and servo motor.

Ozgur Unver [9] developed flat dry elastomer adhesives as add-on materials for the purpose of climbing robots. In this climbing robot, a four bar mechanism which is to be used to reduce the weight of the actuators and the whole assembly. The other sections of climbing robot contain of kinematics, passive tail, passive peeling mechanism, footpad compliance and footpad-force transmission.

Yu Yoshida [10] presented a wall-climbing robot which is to be implements passive suction cups as attached constituents. This robot has to be transfers by crawler-driven mechanism. Several mechanisms have been used in this robot which include suction mechanism, attachment mechanism, detachment mechanism, guide rail-load on suction cups due to downward force, moment applied on robot, tail mechanism etc. The drive motor used in this robot is able not first to transfer it on the wall but also assign and separate suction cups to and from the wall. The other motor is to be initiative to the rear pulleys. Some suction cups have been mounted on the outer surface of the belt at equivalent recesses.

It is observed that the mechanisms suggested above generally presuppose application of the system for tall buildings in a generalized manner. The use of rope based low capacity devices that have complete flexibility for

relocating it anywhere along the construction site, seems to have received little attention.

III. SAFETY MECHANISMS

All hoisting systems have to have mandatorily safety systems built into them for safety of workers, material, and equipment itself and avoid any possibility of accident. Several different types of safety mechanisms have been suggested by earlier designers and researchers.

The use of self-locking gripper arrangement has been used for the Robo-Sloth system [11]. The locking system safeguards that the robot does not slip down at any plug of period. Additional mechanism over this stuff allows us to put large quantity of shipments on the robot. The more the load, stronger is the hold. There has force generated because of friction results in producing torque around the pin joint which is that bases the link to clamp the rope underneath the action of its individual weight. Therefore, each time the robot initiates to slip, the clamp grips it constricted, building the mechanism self-locking.

Roboclimber [12] is capable of walking deprived of ropes on surfaces up to 30 gradations slope. By means of ropes, it has to be climb walls which are in the upward direction. For safety purposes, it has been provided with four or more legs. Specially designed clamps were used to restrict the motion for developing a locking system while the linear movement is on negative slope and the robot is expected towards slide backward [13].

It is essential that inter locking systems are developed for climbing devices. The provision of safety should be in built in electrical systems in addition to development of reliable mechanical systems.

IV. SENSORS TECHNOLOGIES

A variety of sensor technologies have been recommended and used in developing hoisting and climbing devices. IR sensors have been used to intellect strips devoted at each floor for rope climbing robot [6]. As soon as the strips have to be sensed, a releasing mechanism is triggered in which a specific object is dropped to the targeted floor or location. The robots can effort in automatic mode or manual done by RF signals since an RF transmitter. In addition to that above, 4 relays has to regulate the vertical, horizontal movements. A drop box tool with universal asynchronous receiver transmitter (USART) has also been provided for serial port configuration. Kooa [8] used microcontroller to regulate LEDs, 3 servo motors and the hand-drill DC motor although getting signal from a limit switch. LEDs remained used as indicators to designate the status of robot. Relay was also determine to switch ON the hand-drill DC motor and to distinct the control circuit from high weight hand-drill DC motor as a guard from physical impairment to microcontroller. A two level architecture of the control system for legs-ropes co-ordination is presented in [12] for autonomous climbing or manual driving through a remote console.

A lot of room is seen to exist for designing reliable and effective remote sensing and control systems to make full proof and accident free climbers. Rope climbers in particular need such systems since there is no rigid or fixed structure to support mounting of sensing devices in a permanent manner.

V. LOADING CAPACITY

Conventional hoisting systems with platforms have been built to carry heavy loads, even in excess of 1000 Kg, because of the support structure anchored to ground and as the construction moves up. Rope climbing devices, on the other hand, face a serious limitation on this account. Other issues of concern include strength of the rope, wear and tear of rope and its life, degradation of rope properties with time and so on. Earlier rope climbing devices and robots, therefore, had a much less load carrying capacity. With new technologies available for producing high strength and reinforced ropes, as used for sailing, mountaineering, material handling in heavy engineering plants, shipping etc., it is now possible to use the same more meaningfully for construction applications too.

VI. PROPOSED DESIGN

The device proposed in this work is a simple portable system that climbs up or rolls down a rope using an AC motor together with a gear transmission and electronic control system. The maximum safe load for the device is 100kg. The proposed new product is remotely controllable as regards speed of hoisting and delivery location. The drive is a simple roller squeeze mechanism based on sugarcane juicer machine concept. It has two drum winding and rewinding connected to gear box and which is driven by AC motor system and is firmly held against the rope by tension of the whole assembly. It has been provided an anti-locking mechanism as safety arrangement. The design also provides for two parallel ropes to take care of the eventuality of a rope getting snapped accidentally. This is schematically shown below.

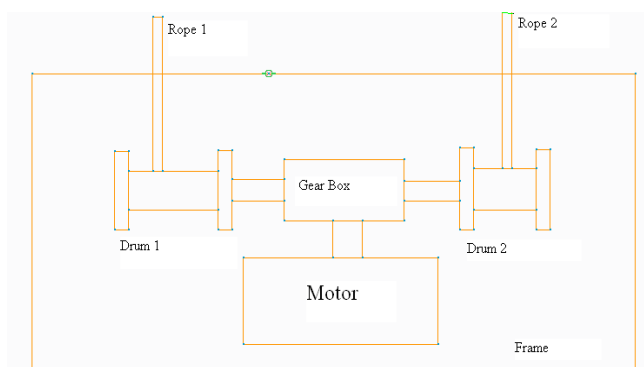


Figure 1. 2D CAD MODEL

Control and sensor systems have been proposed for operating the device remotely from multiple locations, including those on ground level, the top of the building and also by the operator who may, in emergent situation, may

require hoisting up. It having two drum arrangement system connected to central gear box and it is driven by a motor. For the safety and balancing of whole assembly, it having provided two rope connected to two drums. Also provided the platform for the purpose of human stand and equipment place. The handles are shown in the CAD model for the purpose of handling. Gear box is provided for reducing the speed of whole assembly and maintain it constant. Figures 2 – 3 show the perceived CAD images of the device.

Besides applications in construction of buildings the device can be used for

- Checking pipe leakages as the device can be used also as a pipe climber.
- Rescue operations using helicopters
- Cleaning of glass panes of multistory buildings.
- Delivering inspection gadgets, tools and materials for inspection and repairs at places inaccessible to humans.

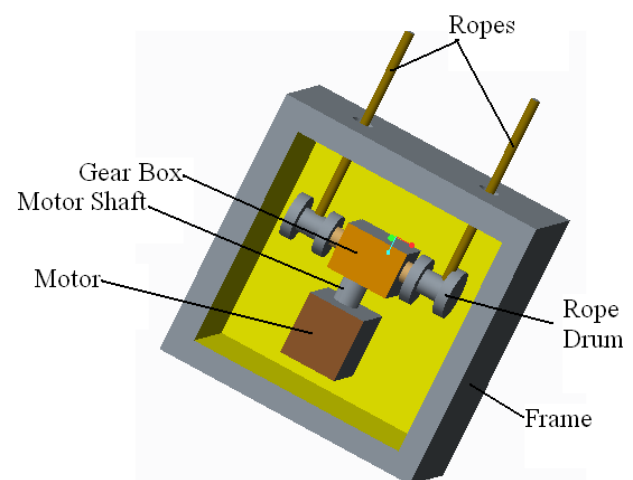


Figure 2. Rear view of the proposed model

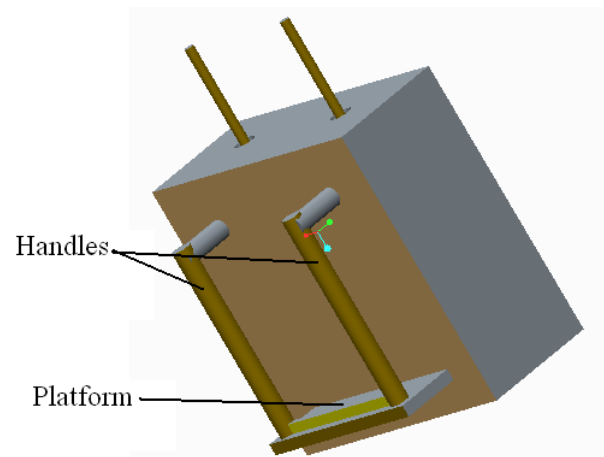


Figure 3. Front view of model with attached platform/basket for holding goods

VII. CONCLUSION

The proposed design and development of rope climbing device, capable of moving in vertical direction, is expected to be a handy and low cost facility available to users who

wish to handle or transport objects and tools weighing up to 100kg vertically from one floor to another. Analysis and optimization of components using CAD is proposed.

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