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Self-Balancing Tower Crane

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Abstract: Tower Cranes are extensively used for lifting materials in construction sites. Most construction sites are very confined and close to public due to which Tower crane accidents are not only hazard to workers at the site but also to pedestrians and residents residing in vicinity of the Tower Crane. The counter weight of the existing tower cranes are manually loaded and unloaded using calculations done on site by the engineers and then operated by the crane operator. This leads to numerous human errors and technical faults. Our project aims to minimize all the safety hazards of human and technical errors by implementation of automization and minimal human intervention. The idea is to modify the rear arm of the existing tower crane with a fixed counter weight in such a way that, when it detects load on the primary arm, it slides to and fro from the centre of gravity of the structure to keep the whole system in dynamic equilibrium.

Keywords: Self, Balancing, Crane, tower

I. INTRODUCTION

Overall a Crane is a mechanical system designed to hoist and move loads through a hook suspended from a cable. In the period of around 12th century, Harbor cranes were introduced to load and unload ships. This concept was later introduced in the field of Construction as Steel or Tower cranes which were adopted with the inception of Industrial Revolution. The first known construction cranes were invented by the Ancient Greeks and were powered by men or beasts of burden (such as Donkeys, Bullocks, Elephants, etc). For many centuries power was supplied by physical exertion of men or animals. The first mechanical power was provided by Steam Engines and around 1854 the first hydraulic crane was by William Armstrong. Modern cranes usually use internal combustion engines or electric motors and hydraulic systems to provide a much greater lifting capability than that of the previously possible. There are three major considerations in the design of cranes. First, the crane must be able to lift the load; second, the crane must not topple; third, the crane must not rupture. As per these considerations Modern Steel cranes are manufactured. The primary feature of the tower crane is its elevated boom or jib. There are many design variations, depending upon the manufacturer and the intended use. The tower crane can be erected on a minimum of ground area or within a building; for example, within the elevator shaft or other floor opening. To increase their range and versatility, some tower cranes are mounted on under-carriages running on rails, rather than on a fixed base; there also is a truck-mounted type A turntable, which permits swinging (slewing) the jib, is mounted near the top of the tower. The operator's cab also may be on the turntable. Swinging, hoisting, trolleying and travelling motions are powered by electrical hydraulic or diesel machinery placed at a convenient location on the crane. The impact of these tower cranes on the construction industry is being felt by all organizations concerned with the safe installation and use of this equipment. Like every devices invented Tower cranes also has some limitations and impact on its purpose. If the Operators are not being fully cognizant of the limitations or operating characteristics of tower cranes or there is any Tampering with limit switches or other safety devices, the crane may topple or rupture thus causing damage to life and property. By this concept of "Self-Balancing" crane, the human errors are intercepted which further safeguards the life of workers on the site and the nearby pedestrians and residents.

II. METHODOLOGY

Fixed movable counter-weight mounted on the modified rear arm

- To eliminate manual loading and unloading procedures, the counter-weight is now a fixed weight mounted on a rail (attached t the modified rear arm, refer 3.1.1.2) to allow it transverse movement, towards and away from the CG of the structure..
- At no load condition, the counter-weight shall be nearest to the pivot point and the whole system should be in equilibrium.

Rear arm modification

- To make this mechanism possible, the rear arm is now extended by a length calculated based on the principle of moment
- Principle of moment states that When an object is balanced (in equilibrium) the sum of the clockwise moments is equal to the sum of the anticlockwise moments.

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Force 1 x distance 1 from pivot = Force 2 x distance 2 from pivot
F1xd1 = F2xd (Refer fig.)
Load sensor mounted on the front end of the primary arm

- A load sensor (or load cell) is mounted in "S" configuration on the foremost end from where the load is to be picked up and collects raw data about the pay load.
- This data is then fed into the micro controller for further processing.

Arduino Uno (Atmega 328) in mounted inside the housing replacing the crane operator

- A customized code is written in embedded C to convert raw
- data into readable weights in milligrams o This value is then used to calculate the moment to be produced on the rear arm to balance out the moment on the primary arm

Counter-weight moves to appropriate position

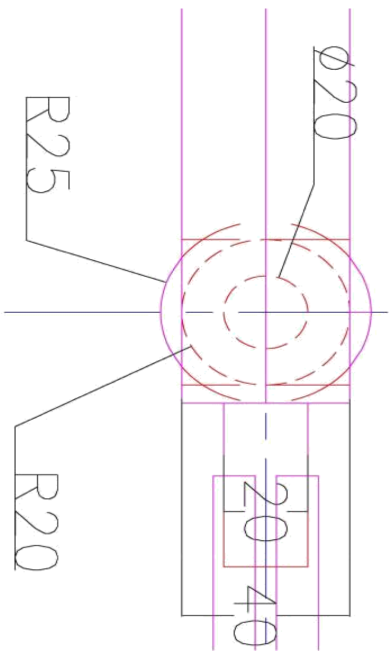
- Once the calculation is complete the microcontroller commands the aft most DC motor to turn a specific number of rotations to place the counter-weight at the required position
- This function is executed by the use of a lead screw mechanism
- One end of the screw is attached with the motor's axel and the other end is fixed in a cavity which allows free rotation
- The lead screw passes through a threaded sleeve in the counter weight which helps the weight to move to and fro when the screw rotates, thus rotational motion is converted to translational motion
- This process takes care of the toppling effect by the pay load and the system is in now static equilibrium

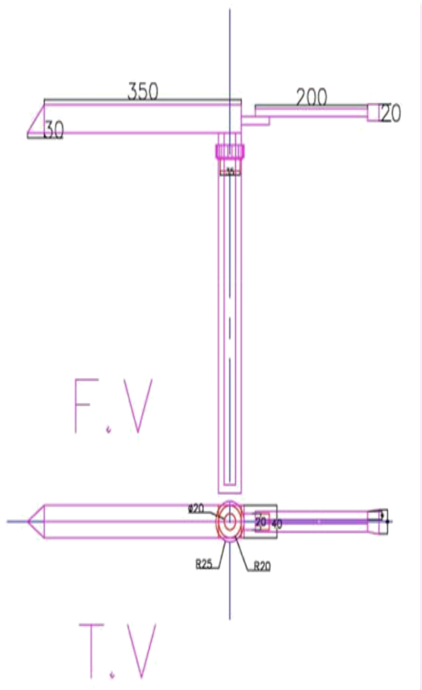
General operation of the crane

- Since the whole system is in equilibrium the general functions
- of the crane now be carried out
- These functions shall be same as the traditional crane functions i.e. before the modification to aid the crane operator in carrying out the functions with ease

Fail-safe mechanism

- If the pay load weight exceeds the maximum carrying capacity of the structure the microcontroller does not allow the servo motor to operate under any condition
- If during the operation unexpected change in weight occurs





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III. NECESSITY

On an average 130 crane accidents take place annually. These accidents cause huge loss of life and property. Maximum accidents are due to human errors in estimation of load that causes the crane to topple. To minimize the factor of human error we came up with the concept of self-balancing crane. This modification of the crane does not completely replace the traditional design; it is rather developed as a modular design to be installed on directly on the crane. As a one time installation process, it is economical to modify the structure rather than load carrying capacity by taking into account recommendations of IIW (International Institute of Welding Technology, published the guideline "Recommendations for the HFMI Treatment" in October 2016).replacing it completely. The modification not only guarantees safety but also efficiently increases.

IV. FURTHER APPLICATION

Dams

The construction of the large dams requires high performance pouring equipment to place both roller compacted concrete (RCC) or conventional concrete in a short time

Bridges

Potain developed the largest tower crane ever built, the MD 3600, for the construction of one of the world's largest stay cable bridges in steel elements in China.

Shipyards and Power Plants

The Sports city tower in Doha was constructed for the 15th annual Asian games held in Qatar on December 06 as Doha's newest tower. The MR 225 for this tower has a lifting capacity of 14 t and was braced by 11 anchorages on this project.

V. CONCLUSION

The dynamic model used and described in Ec. 7 consists of three quotations, where each one corresponding to each degree of freedom of the crane. This means that if $\tau\ \theta 1 = 0$, there is no control over the angle $\theta 1$, then only have control over two degrees of freedom, r1 and r2, and as a consequence is free oscillation in the load. If $\tau\ \theta 1$ is a control law, then we have a third articulation that will compensate the oscilation of the load (m1), which corresponds to the displacement of the trolley that moves the load along the mast. Therefore the dynamic model is very representative of the proposed tower crane on different forms of control, which was checked with the simulation. In the simulation of each control law and with different values of the parameters, it is found that the dynamic model is correct and covers the most important features of a mechanical crane to ensure when it is built it could be made a good control, in addition it can be ensure that with a modern control law it may be controlled much better. The path has been followed for the development of the crane self-balancing, it has been in the first place modelling and then its simulation, considering that from these steps it can be defined with great accuracy factors that determine a good behaviour of the system to design and build.

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