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Research Article

Mobile Crane without Counter weights

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Abstract

This paper will present a model, which will allow operation of mobile cranes without counterweights. The model is based on utilization of atmospheric pressure – one of the greatest forces of nature. The model accomplishes this by replacing the base plates of crane's outriggers with simple patented mechanism. Appropriate calculations will also be demonstrated.

Keywords: crane, atmosphere, pressure, counterweight, outrigger, plates.

Mobile cranes are extensively used at construction sites around the world. When crane lifts a cargo, the force of gravity acting on the cargo creates a force momentum that is acting to overturn the crane. Currently, all famous production mobile cranes (PNG, LIEBHERR, KATO, IVANOVETS, КС, etc.) are outfitted with counterweights to improve stability and prevent overturning. The counterweights are extremely heavy, in excess of several tens of tons, and they present extra weight that crane needs to carry. And, since the counterweights do not represent useful weight their maintenance costs, transportation, loading and unloading reduces overall efficiency of the crane. Additionally, the crane is required to have special area where the counterweights can be anchored which also contributes to excess maintenance costs. Counterweights are especially undesirable for cranes on cargo ships since they already have ballast.

This paper will present a model which will allow operation of mobile cranes without counterweights. The model is based on utilization of atmospheric pressure – one of the greatest forces of nature. We know that atmospheric pressure (P_{atm}) can be expressed as $P_{atm} = 10^5$Pa, or more simply there is 1kg of force per square centimeter.

All known mobile cranes are equipped with four outriggers. The outriggers help expand the surface area of the crane and provide stability. The outriggers also remove load weight off the springs and tires of the mobile crane during operation.

The solution to the problem of removal of mobile crane counterweights is as follows:

Crane outrigger base plates will be replaced with modules outfitted with vacuum pumps. Each module consists of an assembly housing (4) with a hollow cavity (a). The cavity is connected to a vacuum pump (8) and a manometer (9). Using the vacuum pump, the air is pumped out of the cavity of the module assembly creating a vacuum. Air tight seal is provided by the gasket (5) and a relatively thick and flexible cellular plastic (7). The pressure inside of the module assembly is controlled by attached manometer which insures safety of the crane during operation. Figure 1 shows a partial conceptual sketch of the new outrigger base module. Figure 2 shows the drawing of the proposed module.

When the outriggers are deployed to lift the crane, under the force of gravity, the cellular plastic (7) is pressed against the ground sealing the cavity (a). The gasket (5) is also used for sealing the cavity (a).

Once outriggers are deployed and crane is lifted, vacuum pump (8) is utilized to pump the air form the cavity (a) creating a vacuum within. Then, based on laws of physics, the atmospheric pressure will press the assembly housing (i.e. new outrigger supporting pillars) to the ground with a certain force F. And, this force will replace the counterweights. Even with an average vacuum (approximately 100 Pa) the force acting on the pillars will be significant. The necessary force can be achieved by providing an appropriate diameter of metal place (6), which is the same as the diameter of the module housing.

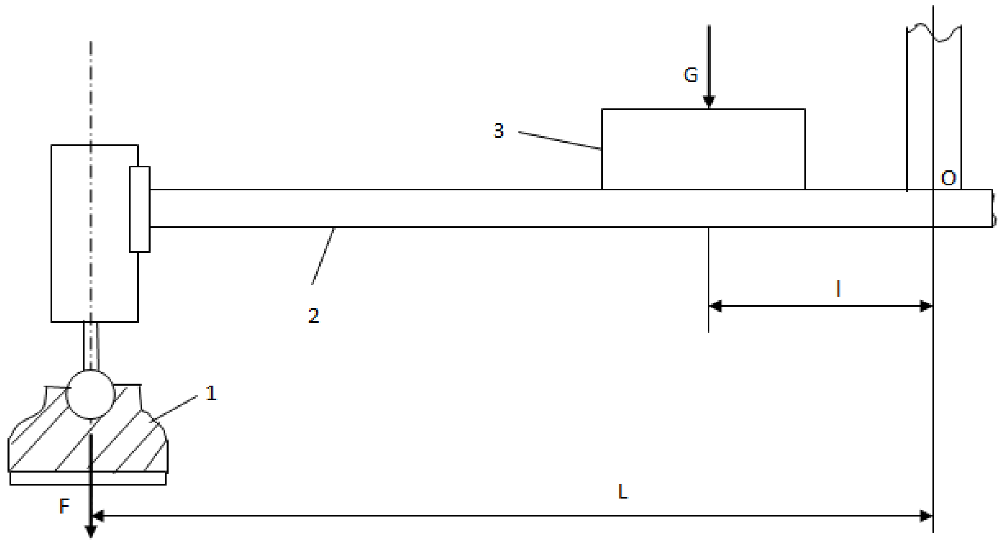

Figure 1. Conceptual drawing of the crane outrigger

1 – Outrigger base plate, 2 – outrigger main beam, 3 – counterweight

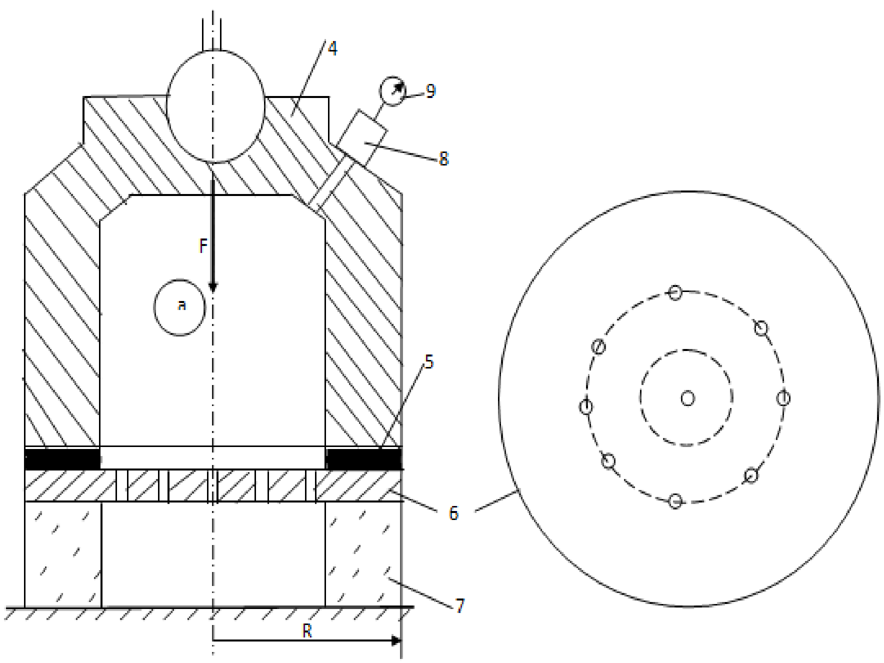

Figure 2. Assembly

4 – Assembly housing, 5 – gasket, 6 – steel plate with holes, 7 - thick and flexible cellular plastic, 8 – vacuum pump, 9 – manometer

Example:

Given R = 50 cm, where *R* is the radius of the metal plate (6), the acting force on one pillar will be more than 7.5 tons, and more than 30 tons on all four pillars together. However, by design, the counterweights are placed on the crane such that they are relatively near the tipping point (O), which makes force (F) of shoulder (L) several times higher than force of the counterweights for shoulder (l) as depicted in Figure 1. Consequently, the force (F) of the atmospheric pressure that holds the crane needs to be increased by that much. If, for example, L/l = 3 (although in reality it may be more), then the sum of all forces on the support pillars from the atmospheric pressure will be equivalent to 90 tons of counterweight.

If we increase the radius of the metal plate (6), which is the same as the radius of the module assembly, the atmospheric pressure force will also increase with quadratic order, and it is expressed by the following formula:

$F=\pi R^2(P_{atm} - P_{vacc})$

Where, P_{vacc} is the pressure (vacuum) in the cavity (a). The pressure is controlled from the same area where the manometer (9) is located, which also insures safe operation of the crane.

Using the method above and utilizing atmospheric pressure, we can apply more force to outriggers of the crane.

References

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