A New Energy Saving Device of the Tyre type Container Gantry Crane

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Abstract. This paper introduces a new type of energy saving device for tyre type container gantry crane (RTG for short), the main principle of reducing the energy consumption of the lifting process is for equipping the counterweight device and the wire rope winding device on cranes’ steel structure. The main components of the energy saving device are introduced in detail in this paper, and the stress analysis and theoretical mechanics calculation are carried out. The calculation results imply no significant stress influence on the steel structure of the equipment for the reasonable design of the steel wire rope winding device and the rationally distribution. The crane’s energy consumption decreased by 15% at the chosen port test after the installation of energy-saving devices, which has significant social and economic value.

1. Introduction
RTG is a necessary and widely used mechanical equipment in ports and wharfs for ocean shipping and inland cargo transportation. It is mainly responsible for loading and stacking containers. With the rapid growth of China's economy and the popularization of RTG in recent years, how to efficiently use RTG has become the focus of attention of various research institutes and design. Many advanced theories have been applied to the research and development of the crane [1].

The traditional RTG is mainly driven by a diesel generator set. The general fuel consumption is about 25 liters (according to the installed capacity, the type of diesel engine and the consumption situation of each wharf, the data here is an approximate average). It was systematically studied about the energy saving technology of RTG[2-7]. The energy saving and consumption reduction technology of traditional RTG is mainly divided into two research directions of energy saving RTG and electric RTG [8]. The energy saving RTG mainly adopts the technical measures to improve the energy efficiency of diesel generating set and store and reuse the regeneration energy generated by the braking of RTG under the heavy load and operation mechanism, so as to achieve energy saving and consumption reduction by improving the energy utilization ratio of the whole machine. A practical engineering application example is SIEMENS's ECO energy saving technology as a representative of the engine speed regulation mode, and the energy storage and feedback mode represented by super capacitor and flywheel energy storage system. The electric RTG is the operation of "oil to electricity". That means the power needed by RTG is no longer used by diesel generating set, but from cheap power supplied by wharf yard, and the energy efficiency of the whole machine is high. On the premise of energy saving and consumption reduction, the energy saving type RTG fully preserves the advantages of RTG's flexibility. The electric RTG is more focused on energy saving and consumption reduction, low operating cost and good environmental protection effect, on the other hand. Also with the disadvantage that the transfer is inconvenient and it is necessary to increase the power
infrastructure investment of the wharf.

It is mainly introduced and studied a new tyre type container gantry crane of new energy saving device in this paper. The energy saving effect of the device is tested through a port energy test. The effect of the installation on the RTG steel structure is verified through the field stress test, at last.

2. The Energy-saving Device of RTG

2.1 Structure and principle
The energy-saving device of the crane is mainly composed of the counterweight device of lifting hoist and the wire rope winding device. The gravity of the counterweight is used to counteract part of the gravity of the container lock to achieve energy saving. The energy saving device includes at least two sets of parallel consists of lifting device and counterweight unit group, and each group of lifting device counterweight unit comprises two sets of parallel and counterweight steel wire ropes counterbalanced and anti rolling units which are mutually arranged. The weight of the wire rope at one end of the weight reducing unit of each set of sling is connected with the counterweight, and the other end is fixed after the pulley is passed. Through two sets of sling units which are intersected with each other, the horizontal direction of the lock can be simultaneously forced when the lock is hoisting the container. The horizontal component is equal due to intersection of symmetry, which could greatly reduce the energy consumption during container lifting. The structure is illustrated in Figure 1.

![Figure 1 Structure of Energy Saving Device](image)

2.2 Stability Test
In order to further verify the influence of the energy saving device on RTG, stress test should be carried out on key parts of RTG installed. The new wireless stress tester is chosen to measure the stress during the whole operation of the equipment including dynamic load and impact load. RTG for the test simulates the normal operating condition. Four key points of structure are selected for stress test, and
the two signal receiving devices are used for the stress wireless data transmission. Collating the data in the work cycle of the equipment, and eliminating the invalid data and the low stress level monitoring data. The strain diagram of the key point in the equipment operation cycle is shown in Figure 2.
According to the results of the stress test, it is found that the strain range of the key points is basically the same as that of the routine inspection reports of previous equipment. It is shown that the use of new energy saving devices will not affect the normal operation of RTG.

3. Energy Consumption Test
Energy consumption test is a necessary test to verify the energy saving effect of energy-saving devices[9]. In order to further verify the actual energy saving effect of the new type of energy-saving devices, the actual RTG equipment should be installed in the port, and the actual energy consumption test will be carried out. The device runs as shown in Figure 3.
According to the average weight of the annual operating container, three test cases with weight of 21t are selected. The total load is 300 kN, including the weight of the lifting gear 9t. The fuel consumption of single case operation is tested separately. According to experience, RTG took about 40 liters to complete the fuel consumption test. In order to simulate the actual working conditions, the test condition could be decomposed into three movements: container getting, container sending and big-trailer traveling. The process is as follows:

1. At the beginning of test, RTG is moved to the test container location, and small-trailer is above the trailer path getting ready for container getting.
2. The whole test process is carried out in a container getting-container sending order, 1 container getting or 1 container sending is counted as 1 container operation.
3. The whole test process lasts 2 hours, and a RTG needs to complete 30 container operations each test, which is similar to the actual operation speed.
4. After completing 1 container getting and 1 container sending, 1 big-trailer traveling is carried out. During the whole test process, the big-trailer traveling operation needs 15 times.
5. 15 container operations must be completed within 2 hours, otherwise, the test needs to be redone.
6. The fuel consumption is recorded after the test.

The test results before and after loading energy saving device are shown in Table 1. It could be obviously seen that the energy saving effect of RTG after loading the new energy-saving device is excellent, which could save 15.8% of diesel. The RTGs of the port could complete about 8,000 to 12,000 standard containers per month. If the energy saving device is installed, at least 1760L of diesel will be saved, and the emission of CO2 will be reduced by 4.63 tons [10], which could result in significant economic and environmental benefits.

| Energy Saving | Total Fuel Consumption /L | Total test time /h | Fuel Consumption / h | Total Amount of Operation (TEU) | Fuel Consumption / TEU |
|---------------|---------------------------|-------------------|----------------------|-------------------------------|----------------------|
| Original      | 170                       | 8                 | 21                   | 120                           | 1.41                 |
| installed     | 143                       | 8                 | 18                   | 120                           | 1.19                 |

4. Conclusion
It is introduced a new type of energy saving device for RTG. The main conclusions are as follows:

1. The new energy-saving device for RTG is based on the steel structure of RTG adding the
balance weight device for lifting hoisting equipment and the wire rope winding device, which could greatly reduce the consumption of container crane.

(2) It is resulted that the new energy-saving device will not affect the normal operation of RTG. The strain range of key position points for RTG structure changes little, and RTG is running smoothly.

(3) It could be obviously seen that the energy saving effect of RTG after loading the new energy-saving device is excellent, which could result in significant economic and environmental benefits.

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