IOP Conference Series: Materials Science and Engineering

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To cite this article: Zhu Han *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **362** 012028

IOP Conf. Series: Materials Science and Engineering **362** (2018) 012028 doi:10.1088/1757-899X/362/1/012028

Reliability Modeling of Double Beam Bridge Crane

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Abstract. This paper briefly described the structure of double beam bridge crane and the basic parameters of double beam bridge crane are defined. According to the structure and system division of double beam bridge crane, the reliability architecture of double beam bridge crane system is proposed, and the reliability mathematical model is constructed.

1. Introduction

Bridge crane is a large lifting equipment and widely used in business workshop, which can effectively reduce the labor intensity and improve work efficiency [1]. However, most of the bridge cranes currently used in our country are produced before the 1980s. Considering the cost of production, only a small amount of bridge crane was scrapped. Most of the bridge cranes entering the aging state are still in service. The aging problem is increasingly prominent and bringing greater risks. The key to solving the above problems lies in establishment of a set of effective fault detection and diagnosis system and reasonable risks assessment. The reliability analysis of bridge cranes is an important means to ensure safe and reliable operation of cranes and is also an important step to establish the fault detection and diagnosis system. In this paper, a double beam bridge crane is taken as the research object, whose reliability model is established and reliability parameters are determined.

2. Double beam bridge crane system structure

The double beam bridge crane (shown in Figure 1.) is composed of three parts: metal structure, mechanical transmission and electrical equipment.

Figure 1. Double beam bridge crane.

(1) Metal structure includes bridge, trolley frame and control room. The bridge is a removable metal structure consisting of main beam, end beam, trolley rails and guardrail. The trolley frame is welded by a steel plate with lifting mechanism and car movement organization. Control room is suspended under the bridge and equipped with electrical control equipment for the operator to use.

(2) In order to realize the different requirements of crane, the mechanical transmission is divided into lifting mechanism, trolley traveling mechanism and cart traveling mechanism. The lifting mechanism used to realize the lifting of the goods and installed on the upper of the trolley frame, is composed of motor, brake, reducer, coupling, reel and pulley. The trolley traveling mechanism drives the load for lateral movement, which is composed of motor, brake, coupling, reducer, wheel and drive shaft and other components. The cart traveling mechanism drives cart wheels running along the track and the trolley and goods for longitudinal movement, composed of wheel, angle shaft, reducer, coupling, drive shaft, brake and motor and other components.

(3) The electrical part consists of electrical circuit and electrical equipment.

3. The main parameters of double beam bridge crane

The following are the main parameters of the double beam bridge crane:

(1) Lifting capacity:	5T	10T	16/3.2T
	20/5T	32/5T	50/10T

(2) Span:	10.5M	13.5M	16.5M	19.5M
	22.5M	25.5M	28.5M	31.5M

(3) Working conditions:

A5 (Used for less frequent jobs such as general machining and assembly workshops).

A6 (Used for more frequent jobs, such as auxiliary lifting in metallurgy and foundry shops).

A7 (For busy use and hot metal lifting).

When the weight is expressed as a fraction, the numerator indicates the main lifting weight, and the denominator indicates the secondary lifting weight.

A crane with a weight of 5 or 10 tons is a single hook crane with only one set of lifting mechanism. 16/3.2-50/10 tons of cranes have two hooks, so there are two independent lifting mechanisms. The main hook is used to lift heavy objects. In addition to lifting lighter objects, the auxiliary hook can also be used in conjunction with the main hook to turn or reverse the object in its rated load range. But it must be noted that two hooks are not allowed to simultaneously ascend two objects. When two hooks work together, the weight of the object must not exceed the weight of the main hook.

4. Selection of reliability parameters of double beam bridge crane

In engineering, the following three reliability parameters are commonly used.

1) Reliability

Reliability refers to the probability of the product completing the set function under the specified conditions and within the specified time.

2) Failure rate [2]

Failure rate refers to the probability that a product has not been malfunction at a certain time and the failure occurs within the unit time after this time.

3) Mean time between failures (MTBF) [3]

MTBF is an important reliability parameter for repairable products. The repairable product occurs N_0 failures in use, after each repair to continue to use, the continuous working time (i.e. the time between failures) is $t_1, t_2, \cdots, t_i, \cdots, t_{N_0}$, and the observed value of MTBF is

$$MTBF = \frac{1}{N_0}\sum_{i=1}^{N_0} t_i = \frac{T}{N_0} \tag{1}$$

where, T is the total working time of the product.

Among them, the application scope of MTBF is extensive, and it is also a measure of the basic reliability of the repairable product, which reflects the related requirements of the product on maintenance resources [4]. For a repairable large mechanical equipment of double beam bridge crane, because the reliability of its parts and components have big difference, MTBF is selected as its reliability design and evaluation of reliability parameters.

5. Establishment of reliability model for double beam bridge crane system

When establishing the reliability model, we need to collate and analyze the failure information of the crane, and judge the source of the fault, so as to find the mechanism of the failure and deal with the fault in time. Combined with the structure of double beam bridge crane, mechanical transmission is the most important part of crane and the most prone to failure [5]. Therefore, the double beam bridge crane are divided into three important subsystems.

1) Lifting mechanism system

The lifting mechanism includes motor, brake, reducer, coupling, reel and pulley group etc.

2) Trolley traveling mechanism system

The trolley traveling includes motor, coupling, reducer, brake, drive shaft and wheel etc.

3) Cart traveling mechanism system

The cart traveling mechanism includes motor, angle shaft, reducer, coupling, drive shaft, brake and wheel etc.

It can be seen that the double beam bridge crane consists of three subsystems, and its reliability system can be made up of a simplified series model. The reliability diagram of the double girder bridge crane subsystem is shown in Figure 2.

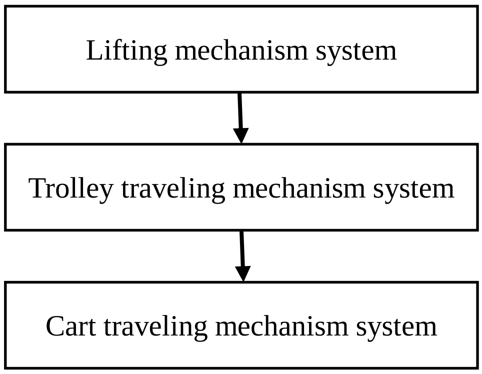

Figure 2. Reliability architecture of the subsystem of double beam bridge crane.

According to the above analysis, the reliability model of double beam bridge crane system is as follows:

$$R(t)=R_L(t)\times R_T(t)\times R_C(t) \tag{2}$$

where, $R(t)$ is reliability of double beam bridge crane system, $R_L(t)$ is reliability of lifting mechanism system, $R_T(t)$ is reliability of trolley traveling mechanism system, $R_C(t)$ is reliability of cart traveling mechanism system.

The reliability block diagram of the double beam bridge crane obtained by connecting the parts of each subsystem is shown in figure 3.

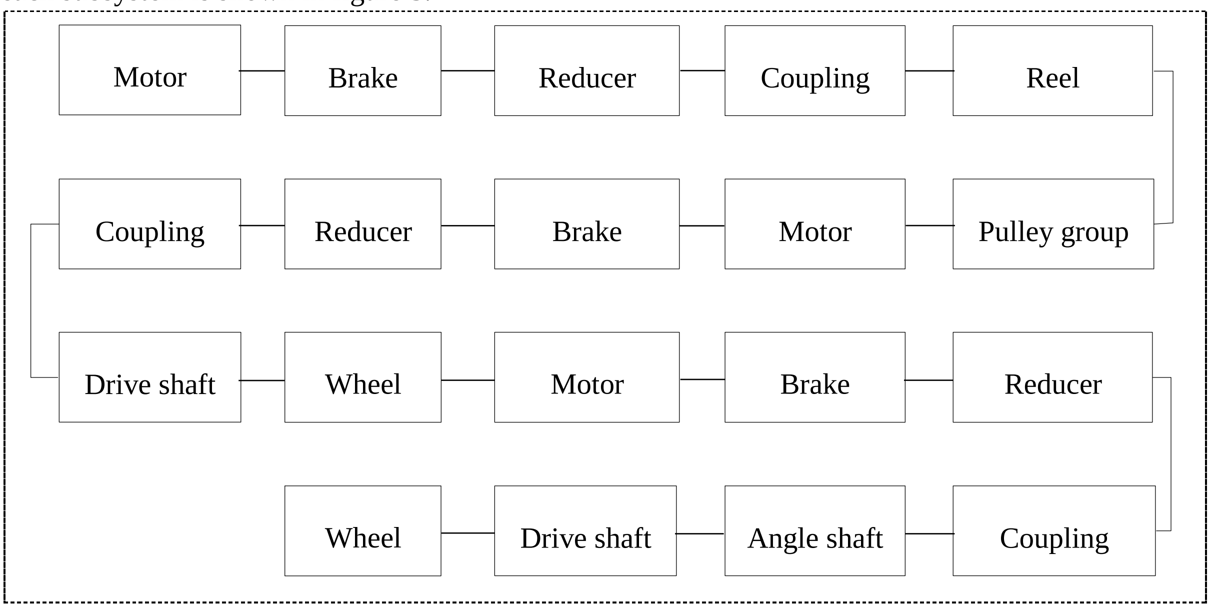

Figure 3. Reliability architecture of double beam bridge crane system.

For double beam bridge crane, the subsystem is also composed of various component. The reliability model of the subsystem is as follows:

$$R_S(t)=R_1(t)\times R_2(t)\times\cdots\times R_n(t) \tag{3}$$

where, $R_S(t)$ is reliability of the crane subsystem, $R_i(t)$ (i =1,2,⋯,n) is reliability of part i .

6. Conclusion

According to the characteristics of double beam bridge crane, the system is divided into three subsystems. The reliability architecture is proposed as well as its reliability model.

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Acknowledgments

This work was financially supported by the Program of Science Foundation of General Administration of Quality Supervision and Inspection of Jiangsu Province (KJ175940). The supports are gratefully acknowledged.