

Article

Design and Implementation of a Wire Rope Climbing Robot for Sluices

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Abstract: Regular maintenance of wire rope is considered the key to ensuring the safe operation of a sluice gate. Along these lines, in this work, a six-wheeled wire rope climbing robot was proposed, which can carry cleaning and maintenance tools for online cleaning and safety inspection of the sluice wire rope, without its disassembly. The developed climbing robot is composed of separable driving and driven trolleys. It adopts the spring clamping mechanism and the wheeled movement method. Thus, it can easily adapt to the narrow working environment and different diameter ranges of the sluice wire rope. In addition, the designed six-wheeled wire rope climbing robot not only possesses a simple structure, simple control, and stable climbing speed, which are typical characteristics of wheeled climbing robots, but also a large contact area with objects and small wheel deformation, which are typical characteristics of crawler climbing robots. Structural design and mechanical analysis were also carried out, with the fabrication of a prototype robot system called WRR-II. From the acquired experimental results of the prototype's climbing speed test, load capacity test, climbing adaptability test, and obstacle-negotiation ability test, the rationality and feasibility of the designed climbing robot scheme were verified.



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Keywords: climbing robot; mechanical analysis; spring clamping; sluice gate; wire rope; wheeled movement

1. Introduction

In water conservancy engineering facilities, sluice gates are widely used in rural and coastal river channels as the main water retaining and discharge structures. As the main load-bearing component of the hoisting sluice, the wire rope plays a vital role in the safe operation of the sluice. Due to the long-term exposure of the sluice wire rope to the outdoors, it is affected by irregular bearing, wind, rain, and sun, which will lead to various problems, such as grease hardening, local corrosion, wear, and breakage. Therefore, regular maintenance is essential for the proper operation of the wire rope. Currently, most of the daily maintenance of the sluice wire rope is done manually, leading to problems, such as high labor cost and intensity, low work efficiency, and high-risk factor. With the application of the scientific and technological developments in the field of robotics to the daily maintenance process of the wire rope, the above-mentioned problems can be easily solved. Therefore, the research and development of a wire rope climbing and maintenance robot in the water conservancy industry are anticipated to significantly improve work efficiency in this field, successfully addressing the labor issue in enterprises.

As an important branch of the mobile robot family, climbing robots have received widespread attention from the scientific community in the past two decades. As a result, a wide variety of prototype systems have been developed for specific applications, such as steel bridge climbing robots [1–4], cable-climbing robots [5–8], pole-climbing robots [9–13], tree-climbing robots [14–17], pipe-climbing robots [18,19], wall-climbing robots [20–24], among others.