FIELD APPLICATION OF A ROBOTIC SYSTEM ON CABLE STAYS OF INCHEON BRIDGE FOR SNOW REMOVAL

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ABSTRACT: Recently, an increase in the number of construction of long span bridges like a cable-stayed bridge has necessitated the development of technologies for long-term maintenance works and safety of vehicles using such bridges. A lot of researches on application of cutting-edge IT technologies and robotics in the civil engineering field have been conducted for better operation and maintenance of a bridge (Integrated Construction Technology). The cable stays supported by two inverse-Y type pylons of Incheon Bridge are located at the center of the bridge, which results in a potential risk of snow drifts and ice on the cables falling onto the road, threatening the safety of driving vehicles. Therefore, a Snow-Removing Robot (SRR) was developed and tested on the cables of Incheon Bridge to remove snowdrifts on the cables in a bid to secure the safety of vehicles using the bridge and to efficiently maintain the bridge structures.

Keywords*: Long Span Bridges, Long-term Maintenance, Safety of Vehicles, Snow, Snow-removal Robot (SRR)*

1. INTRODUCTION

In recent times, an increase in the number of construction of long span bridges like a cable-stayed bridge has necessitated the development of technologies for long-term maintenance works and safety of vehicles using such bridges. Many researches on application of cutting-edge IT technologies and robotics in the bridge maintenance have been being carried out. Such researches in the civil engineering field are for the development of various integrated construction technologies [1]-[5].

In particular, the structures maintenance and inspection area focuses on a smart sensor technology, an ubiquitous-sensor network-technology using a remote-control-communication-technology, a digital image processing technology, a robot for estimating dynamic properties of cable stays in various ways as well as an evaluation of damping ratios of cable stays using a robot mounted on the stays. The cable stays supported by two inverse-Y type pylons of Incheon Bridge are located at the center of the bridge, which has a potential risk of snow drifts and ice on the cables falling onto the road, affecting the safety of driving vehicles (Fig. 1). A Snow-Removal Robot (SRR) that climbs cables to remove snow is being tested on the Incheon Bridge to secure the safety of the vehicles using the bridge.

Fig. 1 Ice formation on a stay of Incheon Bridge

2. Design of SRR

The SRR was designed to facilitate snow removal using a robotic system, to prevent a traffic accident by removing snow/ice that may fall on the road, and to easily be ready for service by using commercial electricity. The main design features of the SRR are the robot automatically slides down in case of power failure, a damper support is installed for the automatically sliding robot at the lower part of a cable, and front·rear sensors installed on the robot make it avoid conflicts with the pre-installed sensors on the cables. In addition, the robot is designed to be compatible for installation of wireless camera, nondestructive equipment and etc. through further IT development. When a power supply ceased, a robot is sliding automatically. A robot in free fall is installed a damper support for the lower part of a cable. And the front and back robot installed sensors is to avoid conflicts a sensor on cable, which are a main design functions of a SRR. A SRR provided for IT technology development could install compatibility that is the front of robot such as the nondestructive equipment and the wireless camera. A specification for a SRR is present as shown in a Table 1.

Table 1 Specifications for SRR

Classification	Specifications
Weight	25kg
System Drive	DC motor
Size	300 × 300 × 300
System Components	Climbing part, Control part
Power Supply Method	AC 220V
Control Method	Wire Controller
Climbing Angle	50°
Climbing Speed	10m/min
Brush System Drive	DC motor

The diameter of the target cables (Fig. 2) ranges 108-153mm and the length 170-420mm. The blocks inside the robot were fabricated to change to each diameter. Also the target cables are at 50° or less because it is unlikely to have snow drifts for cables more than 50°.

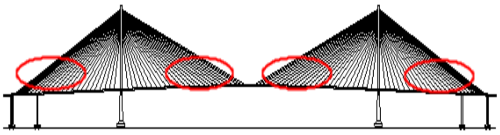

Fig. 2 Locations of target cables

The target cables are C10-C20, C33-C52, C53-C72 and C85-C104, which are about 76% of the total cables (160No. out of 208No.). Fig. 3 shows a 3D drawing of the SRR.

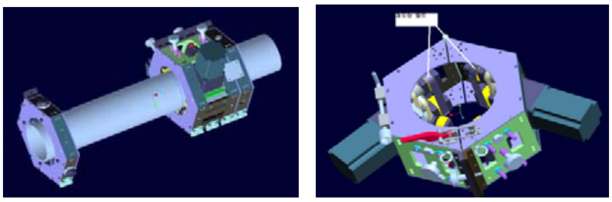

Fig. 3 3D drawing of SRR

3. Operation of SRR

A trial operation of the SRR was carried out on the cables of Incheon Bridge as shown in Fig 4. The trial operation of SRR on site resulted in good operation of removing snow drifts on cables when it is wet after snowing, enhanced operability due to using a small-sized generator, improved travel speed by using urethane rolls and track belts as expectedly designed in the first place. However, frequent errors in the controller, frequent adjustments of the tension of cables, cleaning-up power cables remain for further review so as to ameliorate the efficiency of SRR.

Fig. 4 Trial operation of SRR on Incheon Bridge cables

4. Conclusion

The following advantages were achieved by use of SRR: 1) snow removal was easily performed by the robot; 2) the small size facilitated the maintenance; and 3) the travel speed was ameliorated by using urethane rolls and track belts. Additional development requirements for more efficient snow removal are as follows: 1) frequent errors require more solid robot system; 2) clean-up of power cables is required for more efficient operation; and 3) work time increase due to frequent tension adjusting per cable diameter needs to be reviewed.

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