DEVELOPMENT OF CABLE CLIMBING ROBOTIC SYSTEM FOR INSPECTION OF SUSPENSION BRIDGE

Ho Moon Kim[1], Kyeong Ho Cho[2], Fengyi Liu[3] and HyoukRyeol Choi[4]*

Department of Mechanical Engineering, Sungkyunkwan University, Suwon, Korea
** Corresponding author (hrchoi@me.skku.ac.kr)*

ABSTRACT: In this paper, we propose a wheel-based cable climbing robotic system which can climb up and down the vertical cylindrical cables in the suspension bridges. Firstly, we develop climbing mechanism which includes wheels driven by motors and adhesion system.In addition,we propose a special design of adhesion mechanism which can maintain adhesion force even when the power is lost.Finally, an additional mechanism is developed for guaranteeing the safety of the robot during operations on cables.

Keywords: *Suspension Bridge, Cable Climbing, Climbing Robot*

1. INTRODUCTION

Cablesare one of the most important components of the suspension bridges. Because enormous damages might occur by even just some mistakes, periodic maintenance is necessary to ensure the bridge safety. However, most of such inspection works are dangerous for human workers.Therefore, automatic inspection robot systemsarean alternative maintenance solution which provides low cost and saferperformances. Climbing robots are one of the most effective robots in inspection systems. These robotsare useful for accessing to difficult environments such as bridge cables, high buildings, nuclear power plants, gas pipelines, etc.

Cable climbing robots can be classified into four types according to the adhesion methods: magnetic, pneumatic, electric, and springy [1][2]. For solving themaintenanceproblem of adhesion force whenthe power is lost, electric method appears to be a good way.In addition,the advantages of the electric methodare thatit is very easy to control the robots and generate constant adhesion forces.

The proposed cable climbing robot use electric method to generate adhesion force.The robot mechanism provides the solution to maintain the adhesion force even when the power is off. In addition, safe-landing mechanism is proposed in order to prevent the climbing robot from falling down.

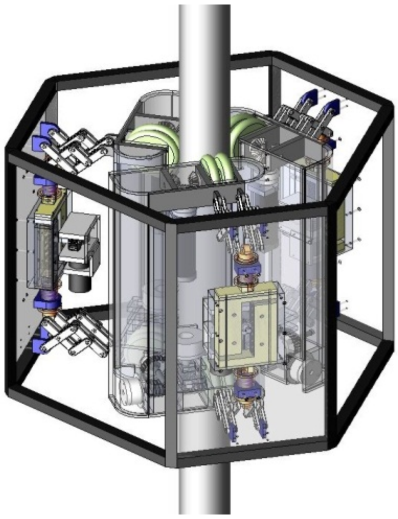


Fig. 1 Cable climbing robot modeling

2. ADHESION MECHANISM

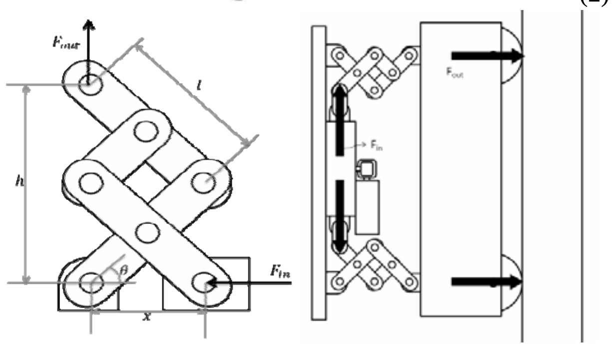
Adhesion force between the robot and the cable is an important factor of a climbing robot because it affectsrobot operation and mightdamage the cable jacket. Cable Climbing robots should adapt to the changes of the *cable diameter* because the diameter of the suspension hanger is diverged. Thus, the proposed robot is developed to be applied in variety of cable diameters using pantograph mechanism.

According to the pantograph mechanism, the output power is always transmitted perpendicularly so that it can reduce loss of adhesion forces.As shown in Fig.2(a), the initial position of the slider is x , the length of the link is l , and the initial angle is θ . Depending on the position of the slider, the height of pantograph is calculated as follows.

$$h = 2x \tan\theta = \sqrt{l^2 + x^2}, \quad (1)$$

and the calculation of the power transmission of pantograph is

$$F_{out} = \frac{1}{2} F_{in} \tan\theta. \quad (2)$$



(a) (b)

Fig. 2 Pantograph system.

3. SELF LOCKING MECHANISM

Cable climbing robot systems should be equipped with some preventing mechanism to prevent falling because suspension bridge cables areusually located at high vertical positions from the ground. Self-locking mechanism is designed using simple gear system which is composed of worm gear, worm wheel, pinion gear, and lack considering adhesion force becomes lost when the power is off.Fig.3 shows self-locking system designed to prevent the reverse force on the motor and to retain adhesion force when electric power is off.

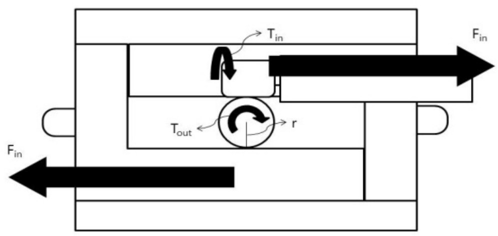
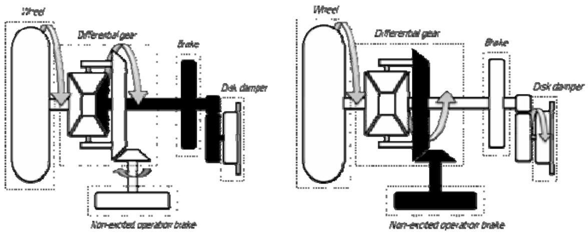


Fig. 3 Self locking mechanism

4. SAFE LANDING SYSTEM

Proposed cable climbing robot will slide down when the power is lost. Therefore, it is necessary to reduce the falling acceleration of the robot so that the robot can safely move down.

This system reduces the fallingforceof the robot system using differential gears and disk dampers. Differentialgears transfer the fallingforce from wheels to disk dampers optionally when electric power lost or normal operating condition.Disk damperscan reduce the force using siliconoil inside.When the robot system receives electric power, the safety landing system cut the power transfer to disk dampers as shown in Fig.4(a).In contrast, non-excited operation brake is operated. Then the force is transferred to the disk dampers from the wheels as in Fig.4(b).



(a) (b)

Fig. 4Safe landing mechanism

5. CONCLUSION AND FUTURE WORKS

This paper describes the development of a cable climbing robotic system. First, adhesion mechanism using pantograph, self locking mechanism, safe landing mechanismwasproposed.The robot design factors will be chosen based on the mechanical analysis from which the robot will be manufactured respectively.In addition, the inspectioninstruments will be integrated.

ACKNOWLEDGMENT

This work is a part of a research project supported by Korea Ministry of Land, Transportation Maritime Affairs(MLTM) through Core Research Project4 of Super Long Span Bridge R&D Center(08 CTIP-E01). The authors wish to express their gratitude for the financial support.

REFERENCES

[1] F. Xu, X. Wang, “Design and Experiments on a New Wheel-Based Cable Climbing Robot”, *Advanced Intelligent Mechatronics (AIM),* pp. 418-423, 2008.

[2] J. Yuan, X. Wu, Y. Kang, A. Ben, “Research on Reconfigurable Robot Technologyfor Cable Maintenance of Cable-stayed BridgesIn-service”,*Mechanic Automation and Control Engineering (MACE)*, pp. 1019-1022,2010.