Chapter 36
Design of a Mobile Robot to Clean the External Walls of Oil Tanks

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ABSTRACT

This chapter describes a Mechatronics Design methodology applied to the design of a mobile robot to climb vertical surfaces. The first part of this chapter reviews different ways to adhere to vertical surfaces and shows some examples developed by different research groups. The second part presents the stages of Mechatronics design methodology used in the design, including mechanical design, electronics design, and control design. These stages describe the most important topics for optimally successful design. The final part provides results that were obtained in the design process and construction of the robot. Finally, the conclusions of this research work are presented.

INTRODUCTION

Robotic systems have been applied to tasks where work by humans has drawbacks like the possibility of making mistakes during repetitive tasks, low levels of precision in tasks calling for rapidity, risks of exposure to hazardous settings, or the completion of work that calls for the application of force.

One specific application of robots is the maintenance of tanks in the industry of oil and oil derivatives. These tanks:

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- Avoid shortages of products necessary in the refining process.
- Ensure the continuous flow of products in the refining process.
- Measure the barrels of product processed per day.
- Allow the sedimentation of water, sludge, and other elements that come with oil that are to be removed during the refining process.

Because of the harsh sun, water, wind, and salt conditions these tanks are exposed to, damage to paint often results, thus reducing usable life. Consequently, these tanks constantly require both internal and external cleaning, wall inspection, and repairs.

This chapter presents the design of a mobile robot for externally cleaning tanks of hydrocarbons and hydrocarbon derivatives by removing paint and corrosion from external tank walls by means of high pressure techniques like sandblasting, hydroblasting and hydrosandblasting.

The vortex method, one existing vacuum generation technique, allows mobile robots to maintain a solid grip by means of a constant air-flow that creates a suction that in turn produces negative pressure in this closed area, resulting in the necessary force of attraction between the robots and the wall.

Traction in the four wheels enable this umbilical-cable powered mobile robot to climb walls from the ground, controlled through wireless systems like Xbee.

STATE OF THE ART

Adhesion Techniques

Literature contains many examples of adherence techniques, divided into 5 principal groups (Marques, et al., 2008; Longo & Muscato, 2008):

1. **Magnetic Adhesion:** Magnetic force exists between two electrically charged moving particles. Magnetic adhesion can use either coils or permanent magnets, where the latter is likely to be an easier way to obtain adhesion. Ferromagnetic materials will yield the best results. Some applications use this technique in mobile robot that climb walls on magnetic wheels that are designed for inspecting interior surfaces of gas tanks made out of thin metal sheets (Fischer, et al., 2008). Other works developed analyze permanent magnetic systems for wall-climbing robots with permanent magnetic tracks, used for rust removal in vessels (Wang, et al., 2009) (see Figure 1).
2. **Chemical Adhesion:** Chemical adhesion occurs because of a chemical reaction. Generally, chemical substances are used that generate adhesive forces between the robot and the surface. In some cases these, chemical forces originate at the molecular level. Some robots employ adhesive tape to gain grip (Daltorio, et al., 2006), while others use elastomer adhesives (Unver, et al., 2006) (see Figure 2).
3. **Electrostatic Adhesion:** Electrostatic force is generated by conductive materials, which allow electrons to form a difference in electrical charge between the robot and the surface. Some robots use electro-adhesion, a force controlled by inducing electrostatic charges on a wall substrate using a power supply connected to compliant pads placed on the moving robot (Prahlad, et al., 2008). Other robots developed use several design principles adapted from the gecko with a control of tangential contact forces to achieve control of adhesion (see Figure 3).
4. **Pneumatic Adhesion:** This adhesion force is generated from a pressure difference between two points. Pneumatic adhesion is obtained through techniques like vortex adhesion, vacuum adhesion and the Bernoulli Effect.

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