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Research on unattended hoisting in solid waste disposal

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ABSTRACT

Collection, transfer and storage of solid waste cannot do without hoisting work. Hoisting operators are usually exposed to bad working circumstances. Studying the precise on-ground locating of solid waste carriers and auto offset correcting gripper design with no need of precise locating are the key to accomplishing unattended operation. This paper proposes a combination of slidable flat washer and four-jaw auto-centering chuck to meet the clamping requirement and provide millimeter-grade carrier locating precision; realization of auto offset correction by use of the clamping jaws of a quasi-planetary gear structure is a guarantee of hoisting work on the carrier in the condition of gripper swinging. The feasibility of the fruit of the paper has been verified by hoisting work in the disposal of nuclear waste and hazardous waste.

Introduction

In CHINA, solid wastes are divided into ordinary industrial solid waste, hazardous waste and municipal household refuse. Among industrial solid wastes, harmful residues are toxic, flammable, corrosive, disease communicating and chemically reactive solid wastes or other harmful solid wastes discharged in industrial production. Hazardous wastes have one or more hazardous features, such as corrosivity, toxicity, flammability, reactivity and infectivity. The amount of municipal solid wastes produced in CHINA increases year by year; municipal household refuse picked up and conveyed countrywide amounted to 0.164 billion tons in 2011 [1]. Municipal solid wastes are normally characteristic of high organic content and high moisture content and may produce a lot of foul gas in their treatment and disposal processes, such as collection, transfer, storage, biochemical treatment and landfill [2,3]. Collection, transfer and storage, as necessary in solid waste treatment and disposal processes, can't do without hoisting work.

In a nuclear environment, remote control of a bridge crane outside the storehouse is adopted due to the hazard of radioactivity in the working environment [4]. Conventional way of nuclear-grade crane control requires high-precision locating design; hence the impossibility to widely transplant the unattended system of nuclear-grade cranes to conventional solid waste disposal process. To prevent hoisting operators from working in a toxic, infectious, radiation or foul environment, this paper describes researches on a key technique for unattended carrier locating and auto offset correcting gripper design for solid waste hoisting work, so as to provide the possibility of remote control by operators.

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Problems and limitations in connection with locating precision in a solid waste disposal hoisting process

In an actual hoisting process, a crane is allowed to play 40 mm or more laterally, instead of operating along a straight line parallel with the track, during operation or braking. Adjusting deviation wheel may avoid or reduce lateral reciprocating traverse, as shown in Fig. 1. Bridge cranes main girder camber is described in Ref. [5] in the following way: when the unloaded trolley stays at the limit position, the highest point on the arch of the main girder after a static load test should lie in the range of S/10 in the middle of the span and its value should be no less than O.7S/1000. Dynamic change of cart/trolley track parallelism and levelness error and main girder camber during work inevitably results in the failure of crane wheels to travel along the center of the track.

During crane conveyance, the effect of external resistance (wind force, friction, etc.) and variation in drive motor speed may cause problems like imprecise trolley locating and great amplitude of load swing [6,7]. The anti-swing control limits swing continuously by altering the speed command signal sent to the converter, as shown in Fig. 2. There is little or nearly no swing when the object reaches the set speed or stops. The anti-swing control is unable to eliminate gripper swing fundamentally and the automated system really costs.

Existing precise locating systems and anti-swing control systems for hoisting work cannot be widely generalized to solid waste disposal. There are two key parts when it comes to solid waste hoisting process: solid waste carrier on-ground locating and gripper-carrier alignment design. This paper is to deliberate relevant easy-to-generalize designs respectively.

Fig. 1 – Cart with horizontal offset-adjusting wheels.

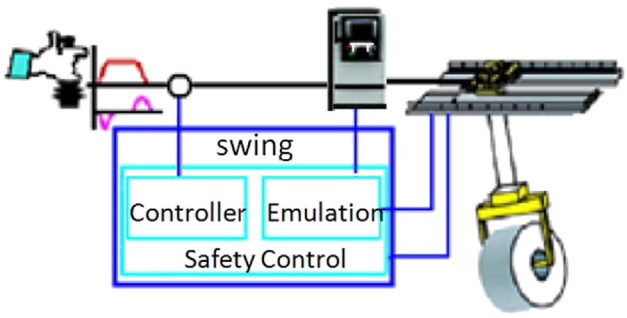

Fig. 2 – Anti-swing control card system.

A new-type precise locating technique for solid waste carriers

On-ground precise locating of solid waste carriers is prerequisite to hoisting work automation. Since gripper swing is impossible to eliminate, increase in solid waste carrier locating precision as far as possible can reduce the requirement on gripper locating precision.

With auto-centering function, a four-jaw chuck meets the clamping requirement and provides millimeter-grade locating precision. If it exerts a force directly on the carrier, sliding friction between the carrier and ground will possibly result in carrier tilting or tumbling. This paper proposes to add a transitional piece between ground and the carrier, or a plane retainer package with steel balls and a flat washer, which form a flat washer assembly. When the four-jaw chuck contacts the carrier, it will give a thrust in the horizontal direction to the carrier; since friction between the carrier and the flat washer assembly is greater than that between the balls and ground, there is no relative motion between the carrier and the assembly, and original sliding friction between the carrier and ground is changed to rolling friction between the balls and ground.

The diameters of the four-jaw chuck, the carrier and the flat washer form the following relation: $d_1 + L_2 = L_3$, $L_1 + L_2 + L_3 = L_4$. It can be then guaranteed that there is no need to do any relative motion between the carrier and the washer in any cases, as shown in Figs. 3 and 4. L_1, L_2 and d_1 in the equation are determined by the designer and L_3 and L_4 can be then determined.

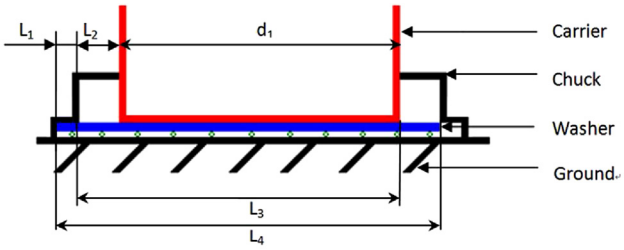

Fig. 3 – Schematic of precise solid waste carrier locating.

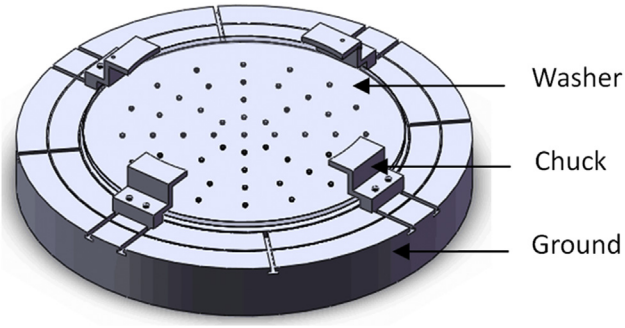

Fig. 4 – Model of precise waste solid carrier locating.