Institute of Solar Research

Precise Low Cost Chain Gears for Heliostats

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Chain Gear Systems

This work aims to reveal cost reduction potential for rim drive heliostats using chain gears. The wind loads on the drives are reduced and precise tracking is achieved by long lever arms of the rims [1]. Due to slow movements and reduced loads low wearing and long lifetime of the chain gears can be expected. A first prototype with rim chain gear has been mounted at the Solar Tower Jülich (Fig. 1). Simplified mounting and higher gear ratio are the main advantages compared to winch wheel drives of previous solutions.

Fig. 1: First rim drive prototype with 8 m² mirror surface mounted at Solar Tower Jülich, Germany

Two main gear stages are used: the rim combined with a sprocket (Fig. 3) and an intermediate spur gear between sprocket and motor with a gear ratio of 1:49. The intermediate gear is meant to be replaced by a cheaper chain gear combined with a stronger engine. Each rim is driven by equal drive units (Fig. 2).

Fig. 2: Mounting of the drives

The precision of chain gears is realized by applying a tensile force in longitudinal direction of the chain. This pretension allows of switching the rotating direction with nearly no backlash (Fig. 5).

Rim Gear Stage

A chain rim drive for a 8 m² heliostat is presented in Fig. 3. A "Z"-arrangement of the sprockets provides a high arc of contact around the sprocket. Each chain is fixed at the ends of the rims and set under pretension to reduce backlash. The rim gear stage has a gear ratio of 1:47.

Fig. 3: "Z"-arrangement of sprockets for 1st rim

First operation was successful. It also showed that the so called "polygon effect" has an impact on the movement of the focal spot (Fig. 4). The phase of the movement corresponds to the length of the single chain members and the amplitude to the calculated speed variation due to the polygon effect.

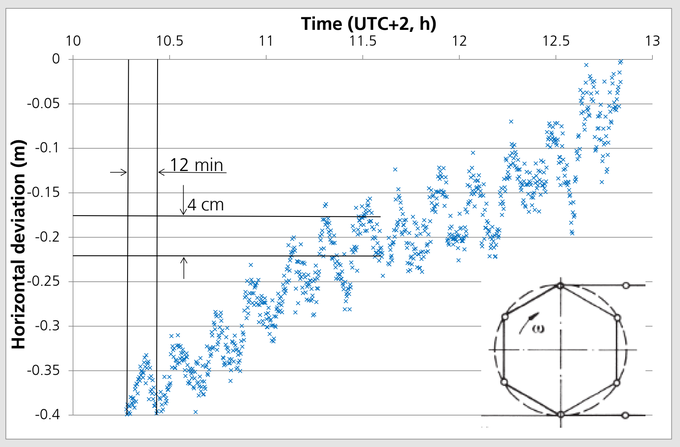

Fig. 4: Fluctuating focal spot due to polygon effect

The polygon effect is caused by the chain´s inability to follow an ideal cycle (Fig. 5). The resulting periodic deviation of the focal spot can be eliminated by the control system.

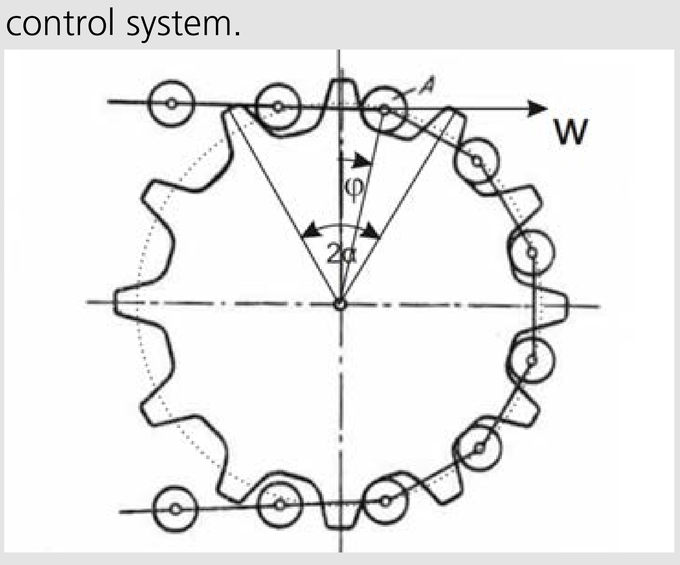

Fig. 5: Chain around sprocket shows polygon; pretensioned chain has nearly no backlash

Intermediate Gear Stage

An intermediate chain gear was designed as replacement of the intermediate spur gear. The lower gear ratio of 1:10 instead of 1:49 will be compensated by a stronger but still low cost stepper drive. Pretension is realized by a low cost telescope mechanism to tension the chain. A test setup was designed to analyze the relation between wear, pretension and efficiency over time (Fig. 6). It consists of two chain gears coupled by a clutch and a cardan shaft. This arrangement provides a closed power circuit. Therefore, the power for the loading of the chain gears does not need to be provided by the drive of the test rig, no brake is needed and two chain gears can be tested at once.

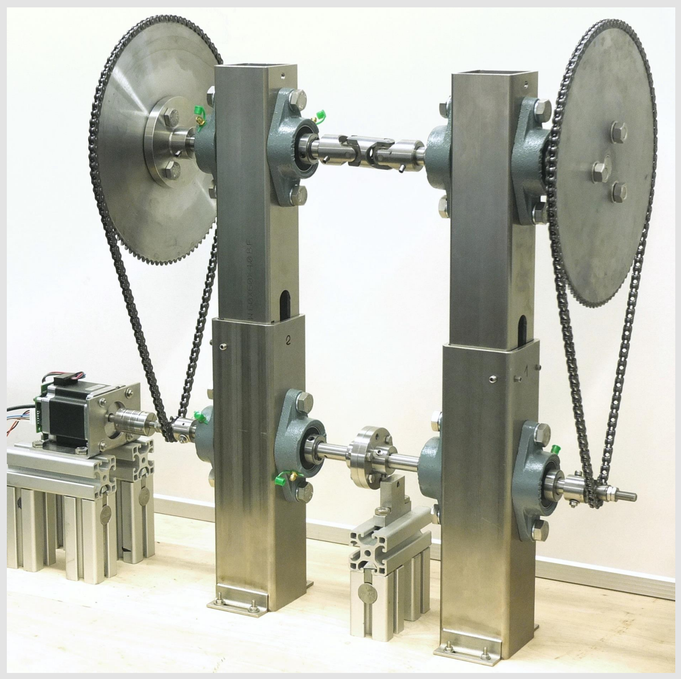

Fig. 6: Test rig for intermediate chain gear

Summary

- Chain gears are a low cost option for rim drive heliostats.
- Low backlash is possible with pretensioned chains.
- For the required slow movement, wearing and friction losses are negligible.
- First tests with a rim drive prototype proved the concept.
- The polygon effect would lead to a fluctuating focal spot but can be eliminated by the control system.
- Long term tests are in preparation.

[1] A. Pfahl, M. Randt, S. Kubisch, C. Holze, H. Brüggen, (2012). Autonomous light-weight heliostat with rim drives. In: Proceedings SolarPACES 2012, Marrakesh, Marokko.

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