Technology Offer

Magnetically Coupled Worm Gear using stationary (here permanent) Magnets

Ref.-No.: 0207-6160-WT

The invention relates to a new method of using magnetic forces in order to mechanically couple the worm of a worm gear with its corresponding worm wheel. According to the invented arrangement, a (permanent) magnet, i.e., a relatively hard magnetic material, magnetizes the worm, which is made from a relatively soft magnetic material. Thus, the magnetized worm develops attraction forces concerning the (also magnetically soft) tooth system of the worm wheel. In this way, it is sufficient to use comparably cheap soft magnetic materials (as compared to hard magnetic materials) as worm and worm wheel (tooth system) materials. Additionally, fatigue of both components is significantly reduced due to the contactless force transmission.

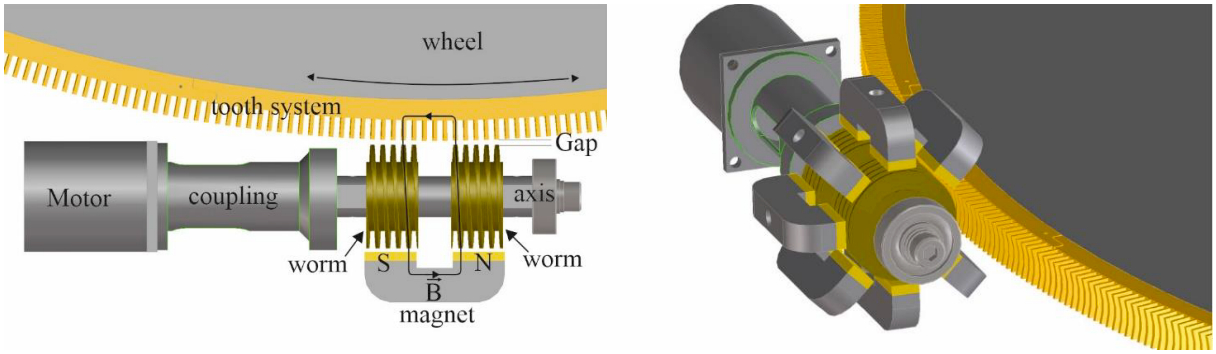

Fig. 1: On the left the basic principle of the magnetically coupled worm gear is sketched. Two spiral shaped worm elements are mounted on a common axis and can be rotated by the driving motor. A magnet system is brought close to the worm elements, such that one worm is close to the south, and the other to the north pole. On the other side a tooth system is mounted to the driven wheel, matching the pitch of the worms. With the worms and the tooth system being manufactured from a soft magnetic material, the field lines of the magnet are closed over the tooth system. To the right an arrangement with multiple discrete magnets is sketched. With the magnets arranged such that one worm is facing all the north, the other all the south poles, the magnetic flux closed over the tooth system is greatly enhanced. A continuous, single magnet surrounding the worms, could supplement the multiple discrete magnets.

Technology/Background

The basic principle of the magnetically coupled worm gear is sketched in Fig. 1. Two spiral shaped worm elements are mounted on a common non-magnetic axis and can be rotated by the driving motor. Between the worms a matching non-magnetic space ensures that the pitch of the worms match the tooth system on the wheel that shall be driven. A magnet system is brought close to the worm elements, such that one worm is close to the south, and the other to the north pole and the magnetic field lines in the magnet are closed. On the other side a tooth system is mounted to the driven wheel, matching the pitch of the worms and eventually possess a torus shape given by the radius of the worms. The worms and the tooth system are manufactured from a soft magnetic material. With the field lines from the magnets entering the worms over most of the surrounding, the tooth system will pick the lines up and close the magnetic field over its body. The dimension of the gap between the worm and the tooth system is kept small, compared to the distance between individual teeth. In this arrangement, the tooth system is dragged along with the rotation of the worm axis. To the right in Fig. 1 an arrangement with multiple discrete magnets is sketched. The magnets are arranged such that the north pole is always facing towards one worm, while the south pole is facing the other worm. In this arrangement, the magnetic flux from all magnets is closed over the tooth system and the coupling force is greatly enhanced. Replacing the discrete magnets by a continuous magnet surrounding the worms, as sketched in Fig. 2 facilitates this arrangement and leads to large possible fields in the coupling gap.

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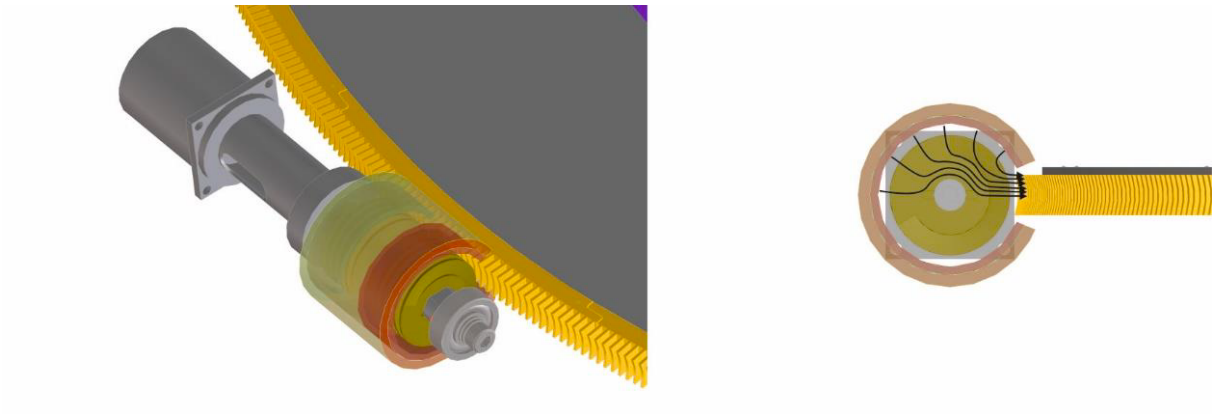

Fig. 2: Sketch of an arrangement with a continuous magnet surrounding the worms. The magnet can be built either monolithic or a central C-shaped magnet is packed with soft magnetic 'distribution' blocks, supplying the field to the rotating worms. To the right a sketch is drawn on the direction of the fields through the soft magnetic worms onto the toothed wheel. On both worms the surrounding of the magnet 'squeezes' the field into the worm and maximizes the field strength at the coupling gap to the toothed wheel.

Advantages/Applications

- Closing the gaps between the spirals of the worms and the teeth of the gear wheel with non-magnetic material, e.g. aluminum, CTE matched Al-Si alloy, polymers or others, leads to a closed continuous surface of the gears. This facilitates cleaning for high purity environments and reduces the free surface such reducing evacuation periods in vacuum systems.
- The worm with its axis and motor can be placed in a thin-walled non-magnetic tube, such that the volume can be completely separated from the driven gear wheel. In this arrangement, the motor volume could be exposed to a different gas / vacuum condition than the driven unit. One even could have the motor and worm axis exposed to the outside of a vacuum system, while the driven system is inside the vacuum system. This enables one to use lubricated bearing or non-vacuum compatible motors to drive the system. In that case a servicing or exchange of the drive system without opening the main chamber can be performed.
- The magnetic forces pulling radially on the worms can be balanced such, that the axis bearings are not under strong permanent load, enhancing the bearing lifetime.
- Driving the worm gear with a stepper motor results in discrete positions that the wheel can be driven to. The system will be self-holding at that location and the motor can be switched off, resulting in zero heat load when not used.
- Adding an encoder to the driven wheel and closed loop driving electronics will result in highest accuracy, eliminating hysteresis effects.
- Increasing the radius of the driven wheel to infinity, so generating a straight tooth system, a linear motion system can be realized in a similar way.

Publications

[1] Tlali, P. M., Wang, R. J., & Gerber, S. (2014). Magnetic gear technologies: A review. Proceedings - 2014 International Conference on Electrical Machines, ICEM 2014, 544–550. https://doi.org/10.1109/ICELMACH.2014.6960233

Patent Information

[2] PCT *(WO2022218524A1)*, EP

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