# Compound planetary friction drive

The invention relates to a compound planetary friction drive comprising a first sun wheel and planetary wheels, wherein said first sun wheel engages said planetary wheels, which planetary wheels are arranged with parts having different radii, wherein transition regions are provided between the parts, and wherein ring annuli are provided that are driven by the planetary wheels, wherein one of the parts of the planetary wheels is in frictional engagement with the first sun wheel and in frictional engagement with a ring annulus and another one of the parts of the planetary wheels is in frictional engagement with another ring annulus, wherein the planetary wheels are both hollow and compressible uninterruptedly along their entire length spanning the parts of the planetary wheels and the transition regions.

JP S58 - 65361 A discloses a planetary friction drive with non-symmetrical planetary rollers that have a different radius and are connected to each other coaxially.

A non-symmetrical version of a compound planetary friction drive is known from US 3 216 285 A. A compound planetary friction drive is well to be distinguished from a conventional compound planetary drive with discrete gear teeth. The invention is expressly restricted to compound planetary friction drives which do not have such discrete gear teeth.

There are difficulties within the design or implementation of the two cited compound planetary friction drives. Generally speaking, friction drives require a very high degree of precision to function efficiently, particularly when the drive is made from a material which is very rigid, such as steel. Due to steel having a high stress/strain relationship, a single 1/1000th of a millimeter out of tolerance can result in a compressing force in the hundreds or thousands of Newton, which exceeds the failure limits of the material. Friction drives also have a minimum practical size, which is constrained on the one hand by the total amount of torque that needs to be carried as well as the materials used. This is because when two cylinders are placed in contact, the line where they touch each other is deformed. The maximum stress experienced by two cylinders in contact is inversely proportional to the diameter of the smallest cylinder, and with all other things being equal this incites the designer of a friction drive to apply larger diameter cylinders.

configured symmetrically, i.e. with the two outer parts having the same length. However, it is also possible that they are not symmetrical, i.e. that the two outer parts have different lengths. In this context the word 'length' means the dimension of the planetary wheels in their longitudinal direction, or in other words along or parallel to their body axis. Thus, the length direction of the planetary wheels is the axial direction of the planetary wheels which is parallel to the rotational axis of the planetary wheels. A hollow interior means that the planetary wheel provides a hollow cavity which is inside the respective planetary wheel. An example is a tubular shape. Compressible means that the given shape of at least one planetary wheel may be deformed by an external force in the way that the volume of at least one planetary wheel decreases upon applying said external force. Preferably, the compound planetary friction drive according to the invention comprises at least three planetary wheels since this allows for a stable configuration of the different parts within the drive. For example, three planetary wheels might be arranged in a triangle-like arrangement if seen along a longitudinal direction of a planetary wheel. However, it may also be possible that the number of planetary wheels is two.

The compound planetary friction drive according to the invention may be operated in different ways of which one way is exemplarily described. When driving the first sun wheel, the rotational movement is transmitted to the planetary wheels due to their frictional engagement with the sun wheel. Furthermore, also the outer annulus will be driven due to the frictional engagement of the outer parts of the planetary wheels with the parts of the outer annulus. In addition, the central ring annulus is also driven due to engagement with the central part of the planetary wheels. Hence, via the frictional engagement of the different parts, the outer and central ring annuli are indirectly driven by the first sun wheel.

In any case, and independent of the way in which the drive is operated, during the friction based driving of the compound friction drive according to the invention, the axial twisting forces occurring during operation are balanced out due to the fact that the first sun wheel frictionally engages the planetary wheels on both sides of the central part of the planetary wheels. Hence, axial twisting of the planetary wheels is avoided and the planetary wheels do not move along their longitudinal axis. Moreover, fewer parts are used compared to WO 2016/043 579 A1, because no additional idler wheels and/or support elements are required, and the efficiency of the compound friction drive is increased.