will push the other, causing both to rotate at the same speed. While such a design offers the advantage of a power transmission through the clutch without slip, there may occur situations in which an operator cannot quickly engage the two parts of the clutch, because they are in an unsuitable relative rotational position. This poses a severe security issue, as the manual-drive-mode may not easily be available at all times without a prior repositioning of the handwheel's and/or the dog's respective rotational position(s) (relative to each other).

Starting from this background, it is an object of the current invention to increase the security of operation of such a manual-drive mode. In particular, it is desirable that the handwheel can be connected to the drivetrain of the actuator under all circumstances.

Summary

In one aspect, the present disclosure provides an actuator for actuating a control element, such as a valve, by a driven member of the actuator, the actuator comprising, - a drive motor, - a handwheel (3), - a motor clutch (5) for interrupting a first drivetrain from the drive motor to the driven member (2), and - a handwheel clutch (6) for interrupting a second drivetrain from the handwheel (3) to the driven member (2), characterized in that - the motor clutch (5) and the handwheel clutch (6) share a common coupling element (7), which can be switched from - engagement with a counter coupling element (9) of the motor clutch (5) to - engagement with a protrusion (12) of the handwheel clutch (6) that is axially movable along a coupling axis (11) of the handwheel clutch (6) using a lever-arm-mechanism that can be manually operated, - the handwheel clutch (6) is formed by the common coupling element (7) and by a corresponding counter

coupling element (8) that is rotationally coupled to the handwheel (3), – the coupling element (7) can be moved axially and relatively to the counter coupling element (8) along longitudinal serrations (10) of the driven member (2) in a first axial movement (19) using said lever-arm-mechanism, and – said protrusion (12) of the handwheel clutch (6) can perform a second axial movement (20) independent of the first axial movement (19).

In accordance with the present disclosure, a clutch is provided, which solves the afore-mentioned problem, as the clutch may be used as a handwheel clutch for coupling a handwheel to the drivetrain of an actuator. In particular a clutch as introduced at the beginning is proposed, which, in addition, is characterized in that the clutch comprises a protrusion that can perform a second axial movement independent of the first axial movement (leading to the engagement or disengagement between the coupling element and the counter coupling element). In other words, this protrusion can perform the second axial movement, when either (or both) of the coupling elements are at rest.

Such a clutch may be used, in particular, for interrupting a drivetrain from a handwheel to a driven member of an actuator featuring a drive motor, as will be outlined below. The same

clutch can also be designed to allow transmission of a force and/or torque from a drive motor of the actuator to the driven member, as will be explained in greater detail below.

The clutch proposed herein can be understood as a mechanical device that engages and disengages a power transmission, especially from a drive shaft (driving member) to a driven shaft (driven member); the driven member can thus provide an output power for actuating the control element, and it may have the form of an output shaft. The driving member can be part of a transmission, that is driven by a drive motor (in case of a motor clutch); or the driving member may be handwheel, for example (in case of a handwheel clutch).

The protrusion that performs the second axial movement (movable protrusion) may be designed in various shapes; for example, the clutch may feature, for example, two such movable protrusions that can perform the second axial movement (either together in unison or independent from each other) or it can have only one such movable protrusion. In the case of using two movable protrusions, it is preferable if these protrusions are positioned within two opposing half-spaces divided by a plane that encompasses a coupling axis of the clutch. Thereby higher torques may be transmitted by the clutch safely.

In some advantageous examples, the protrusion may be axially oriented, for instance like a dog of a dog clutch.

A major advantage of such a clutch is that - due to the additional freedom of degree provided by the second axial movement - the clutching and declutching can be done independent of any accidental rotational position of the coupling element or the counter coupling element, as will become apparent from further explanations below. In other words, the clutch can be operated under all circumstances, in

particular independent of an actual rotational position of one of the coupling elements, in particular a coupling element connected to a drivetrain of an actuator.

There exist further advantageous examples solving the aforementioned problems, which are described in the examples and in the following:

For example, it is generally suggested that the coupling element and/or the counter coupling element is/are movable into an axial engagement position by the first axial movement.

For example, according to a first example, the counter coupling element may be axially non-movable/fixated (i.e. arrested in adjustment/non-adjustable); in this particular case, the coupling element may be moved relative to the counter coupling element into the axial engagement position.

According to a second example, the coupling element may be axially non-movable / fixated; in this case, the counter coupling element may be moved relative to the coupling element into the axial engagement position.

These two examples may also be mixed, in which case both elements can be axially moved, such that the first axial movement may be split up in an axial movement of the counter coupling element and an axial movement of the coupling element (typically, these two movements may occur in opposite directions).

Concerning the (at least one) movable protrusion, this protrusion may be movable into an axial engagement position by the second axial movement. By performing this second engagement movement of the movable protrusion, a force and/or torque may be transmitted (or at least it may be transmittable) between the two elements of the clutch, as soon

recess onto the protrusion.

To achieve the object mentioned at the beginning, there is also provided an actuator which solves the afore-mentioned problem. In particular there is provided an actuator as introduced at the beginning, further characterized in that the handwheel clutch is a clutch as described before or according to one of the examples directed towards a clutch. In particular, in this actuator design, the coupling element may be shared by both the handwheel and the motor clutch.
An additional or alternative way of distinguishing this particular actuator from known devices is thus that the motor clutch and the handwheel clutch share a common coupling element which can be switched from engagement with a counter coupling element of the motor clutch to engagement with a protrusion of the handwheel clutch, wherein this clutch is axially movable along a coupling axis of the handwheel clutch.

As has been explained above, the actuator may use different kinds of main power source such that the drive motor may be a hydraulic, pneumatic or electric drive motor.

The proposed switching may be easily achieved using a lever-arm-mechanism, as will be explained in greater detail below. Such a mechanism may be manually operated to move the common coupling element out of engagement with the motor clutch and thus to declutch the motor from the drivetrain / the output of the actuator.

Using such a switch-over mechanism, the actuator can thus be switched from a motor-driven-operation mode, in which the driven member can be driven by the drive motor, to a manual-operation-mode, in which the driven member can be manually driven by manually operating the handwheel.

clutch. The counter coupling element of the motor clutch may thus be axially non-movable/fixated.

Preferably, a coupling axis of the handwheel clutch can coincide with a coupling axis of the motor clutch (co-linear design). In this case, the coupling element may thus be axially movable along the common coupling axis to allow the switching, and this may be done, preferably, against a restoring force provided by a restoring member (which can thus define a default position of the coupling element).

According to another example, an axial length of a contact face of the protrusion may be longer than a maximum depth of an axial engagement between the protrusion and the coupling element. In this case, it is preferable, if the axial length is longer than the sum of a maximum depth of axial engagement between the protrusion and the coupling element and a minimum depth of axial engagement between the protrusion and a counter coupling element of the handwheel clutch. These conditions are preferred, because it allows a situation in which the protrusion is in engagement with both the coupling element and the counter coupling element, when these two elements are still axially separated from each other.

The protrusion of the handwheel clutch may be non-rotatably connected to the handwheel. If the protrusion is relatively movable axially with respect to the handwheel, which is one possible implementation, the protrusion may be axially movable in a corresponding recess of the handwheel, in particular such that the handwheel can drive the protrusion into rotation, as long as the protrusion is axially within the recess.

In addition, the protrusion of the handwheel clutch may be axially movable along a coupling axis that is common to the motor clutch and the handwheel clutch, preferably against a

restoring force provided by a restoring member.

It is understood that both the motor clutch and/or the handwheel clutch may thus be designed as a dog clutch. Each dog clutch can feature, for example, one pair of a protrusion and a corresponding recess (which may be formed as a gap between two neighboring counter protrusions) designed for axial engagement with that particular protrusion. Preferably however, each dog clutch should show two pairs (or more) of corresponding protrusions and recesses/counter-protrusions, for robust transmission of a driving torque.

There is also provided a first method, which solves the afore-mentioned problem. In particular there is provided a method for engaging a coupling element and a counter coupling element of a clutch as introduced at the beginning, which is further characterized in that the coupling element and the counter coupling element are moved relative to each other in a first axial movement; this first step may be done, in particular, by moving one of the elements, preferably the coupling element, into an axial engagement position (for example by approaching it to the counter coupling element).

Furthermore, the method is characterized in that the elements are engaged with each other by moving a protrusion into an axial engagement position in a second axial movement, which is independent of the first axial movement.

This second step may be done, in particular, while the two coupling elements rest, whereas the protrusion is moving into said engagement position.

To allow the second axial movement of the protrusion, the two coupling elements may be rotated relative to each other. This will be necessary, however, only in cases in which the second

axial movement is temporarily blocked, because the protrusion is in an unsuited rotational position, which may be altered by rotating the protrusion together with the element that carries the protrusion around the coupling axis of the clutch (into a coupling position).

In other words, there may be at least one relative rotational orientation between the coupling element and the counter coupling element, in which the second axial movement of the protrusion is inhibited and/or at least one relative rotational orientation between the coupling element and the counter coupling element, in which the clutch can perform the second axial movement to engage the clutch.

To achieve the object of the disclosure, there is also provided another method, which solves the afore-mentioned problem. In particular there is provided a method for switching between two drivetrains of an actuator (which may be designed as described previously or as defined by one of the examples directed towards an actuator) as introduced at the beginning, which is further characterized in that a coupling element is disengaged from a counter coupling element of a motor clutch of the actuator, thereby interrupting a first drivetrain from the drive motor to the driven member. This disengagement may be done, preferably, by axially moving the coupling element.

The method is further characterized in that a handwheel of the actuator is rotated to drive a protrusion of a handwheel clutch of the actuator around a coupling axis until the protrusion is oriented in a relative rotational coupling position with respect to the coupling element, and the protrusion is moved axially, to engage with the coupling element, thereby establishing a second drivetrain from the handwheel to the driven member. This second axial movement of the protrusion, leading to engagement of the handwheel clutch of the actuator may be, preferably, actuated by

of the actuator. Due to the design of the clutch, this switching can be performed under all circumstances, with a slight rotation of the handwheel being necessary in certain circumstances, namely when the clutch is not yet in the correct rotational coupling position.

A preferred example will now be described in more detail, although the present disclosure is not limited to this example: for those skilled in the art it is obvious that further examples of the present disclosure may be obtained by combining features of one or more of the patent claims with each other and/or with one or more features of an example described or illustrated herein.

Description of the figures

With reference to the accompanying drawings, where features with corresponding technical function are referenced with same numerals even when these features differ in shape or design:

Fig. 1 is a cross-section through a motor clutch with added components that realize an additional handwheel clutch of the actuator,

Fig.2 is a side view on the assembly shown in Figure 1,

Fig. 3 to 8 illustrate consecutively by corresponding side views as the one of Figure 1, how the motor clutch can first be disengaged (Figure 3 to 5), followed by engaging the handwheel clutch (Figures 6 to 8), to switch between a motor-driven drivetrain and a manually operated drivetrain of the actuator, and

Fig. 9 to 11 show similar side views as the previous Figures 3 to 8 but now illustrating the back-switching from manual operation to motor driven operation of the

CLAIMS

1. **Actuator (1)** for actuating a control element, such as a valve, by a driven member (2) of the actuator (1), the actuator (1) comprising,
   - a drive motor,
   - a handwheel (3),
   - a motor clutch (5) for interrupting a first drivetrain from the drive motor to the driven member (2), and
   - a handwheel clutch (6) for interrupting a second drivetrain from the handwheel (3) to the driven member (2),

   characterized in that
   - the motor clutch (5) and the handwheel clutch (6) share a common coupling element (7), which can be switched from
     - engagement with a counter coupling element (9) of the motor clutch (5) to
     - engagement with a protrusion (12) of the handwheel clutch (6) that is axially movable along a coupling axis (11) of the handwheel clutch (6)

   using a lever-arm-mechanism that can be manually operated,
   - the handwheel clutch (6) is formed by the common coupling element (7) and by a corresponding counter coupling element (8) that is rotationally coupled to the handwheel (3),
   - the coupling element (7) can be moved axially and relatively to the counter coupling element (8) along longitudinal serrations (10) of the driven member (2) in a first axial movement (19) using said lever-arm-mechanism, and
   - said protrusion (12) of the handwheel clutch (6) can perform a second axial movement (20) independent of the first axial movement (19).

2. Actuator (1) according to claim 1,
   - wherein the protrusion (12) is axially movable relative to the handwheel (3) to come into engagement with the coupling element (7),
   - in particular wherein,
     - the coupling element (7) is axially movable relative to the handwheel (3) to come into engagement
       - with the protrusion (12) of the handwheel clutch (6) and/or
       - with the counter coupling element (9) of the motor clutch (5)

     or
     - the counter coupling element (9) of the motor clutch (5) is axially movable relative to the handwheel (3) to come into engagement with the coupling element (7).

3. Actuator (1) according to one of the claims 1 or 2, wherein the coupling element (7) can be driven indirectly by the handwheel (3) via the protrusion (12) of the handwheel clutch (6),
   - in particular without direct engagement between the handwheel (3) and the coupling element (7).

4. Actuator (1) according to any one of the claims 1 to 3, wherein the coupling element (7) is arranged in between the counter coupling element (9) and the protrusion (12)/the handwheel (3),
   - in particular such that the protrusion (12) of the handwheel clutch (6) can only be engaged with the coupling element (7) as soon as the coupling element (7) is disengaged from the counter coupling element (9) of the motor clutch (5).

5. Actuator (1) according to any one of the claims 1 to 4, wherein an axial length (15) of a contact face (16) of the

protrusion (12) is longer than a maximum depth of axial engagement between the protrusion (12) and the coupling element (7),

- most preferably the axial length (15) is longer than the sum of a maximum depth of axial engagement between the protrusion (12) and the coupling element (7) and a minimum depth of axial engagement between the protrusion (12) and a counter coupling element (8) of the handwheel clutch (6).

6. Actuator (1) according to claim 1,

- wherein the coupling element (7) and the counter coupling element (8) of the handwheel clutch (6) are movable relative to each other in the first axial movement (19) to engage or disengage by using the manually operatable lever-arm-mechanism and

- the protrusion (12) is moveable into an axial engagement position (21) by the second axial movement (20).

7. Actuator (1) according to claim 6, wherein

- the coupling element (7) and/or

- the counter coupling element (8)

is/are movable into an axial engagement position (22) by the first axial movement (19).

8. Actuator (1) according to any of the claims 6 or 7,

- wherein a force and/or torque can be transmitted between the two coupling elements (7, 8) as soon as the protrusion (12) is in the axial engagement position (21),

- preferably wherein the force and/or torque can be transmitted via the protrusion (12).

9. Actuator (1) according to any of the claims 6 to 8,

- wherein the protrusion (12) is designed for direct engagement with the coupling element (7), in particular wherein the protrusion (12) is

- carried by the counter coupling element (8) and/or is
- movable relative to the counter coupling element (8),

or

- wherein the protrusion (12) is designed for direct engagement with the counter coupling element (8), in particular wherein the protrusion (12) is
  - carried by the coupling element (7) and/or is
  - movable relative to the coupling element (7).

10. Actuator (1) according to any of claims 6 to 9,
- wherein the handwheel (3) is non-rotatably connected to the counter coupling element (8) or the coupling element (7),
- in particular wherein the protrusion (12)
  - is carried by the handwheel (3) and/or
  - is axially movable relative to the handwheel (3).

11. Actuator (1) according to claim 10,
- wherein the handwheel (3) is axially movable relative to the coupling element (7) or the counter coupling element (8) and can perform at least part of the second axial movement (20), in particular
  - wherein the protrusion (12) is non-movable relative to the handwheel (3) such that the protrusion (12) and the handwheel (3) perform the second axial movement (20) together

    or

  - wherein the protrusion (12) is axially movable relative to the handwheel (3).

12. Actuator (1) according to any of the claims 6 to 11, wherein the coupling element (7) is designed
- to be engaged with the counter coupling element (9) of the motor clutch (5), in particular by featuring another

protrusion (12’) for engagement with the counter coupling element (9) and/or
– to be engaged with the driven member (2) or to form the driven member (2).

13. Actuator (1) according to any of the claims 6 to 12,
– wherein the protrusion (12) is reversely movable along a coupling axis (11) of the handwheel clutch (6) against a restoring force provided by a restoring member (17’),
– preferably, wherein the restoring member (17’) pushes the protrusion (12) into engagement with the coupling element (7) or the counter coupling element (8) of the handwheel clutch (6).

14. Actuator (1) according to any of the claims 6 to 13,
– wherein the element (7, 8, 3) carrying the protrusion (12) features a recess (13) in which the protrusion (12) can move axially and relative to said element (7, 8, 3) along an axial range (14),
– in particular such that said element (7, 8, 3) can drive the protrusion (12) into rotation around a coupling axis (11) of the handwheel clutch (6), as long as the protrusion (12) is within said axial range (14).