Concepts of Motion Control and Load-Holding Technologies

Kinatech

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Our tagline is "What Stops You", and although an obvious play on words, it is also a very interesting point to ponder. We at Kinatech have been discussing and pondering this point for some time and recognized some significant drawbacks to existing solutions. To address these, we've developed and patented the Kinatech non-back-drivable technology and incorporated it into a gearbox. Kinatech can take the place of technologies such as: friction brakes, clutches, or latches with the potential to save costs, maintenance, and improve reliability and safety.

Looking at technologies available to the marketplace, we see that most load-holding mechanisms fit into one of two categories: latching or friction. Latching technologies provide very positive load-holding and position control; however, it tends to place an enormous strain on the connector between the load and the controller. The "connector" is typically a cable, chain, or other flexible tension only device. The 'controller' refers to the drive that spools the connector, a motor driving into a cylinder or another force / torque imparting device.

The other common mechanism is a friction device. The load you are trying to control or hold, and the controlling mechanism (motor or other) is connected through a friction-based coupling of sorts. This connection provides a mean to smoothly and in a controlled manner bring the load to stop. It is based on a friction interface, which means that the controlling components wear. Thus, the response of the system will vary over time and varies as a function of temperature and other factors. This presents difficult challenges for automated controls.

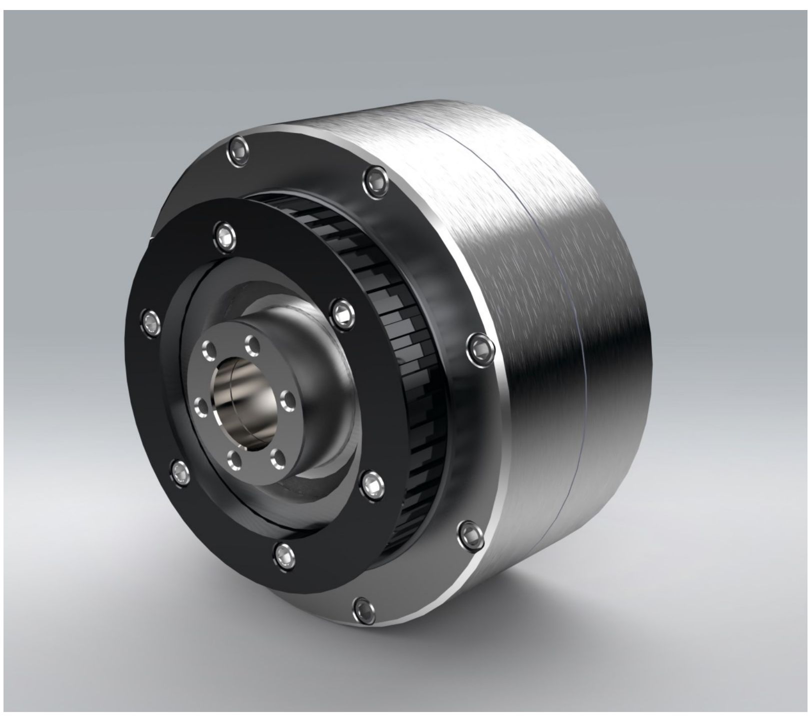
To elaborate, friction methods rely on component interfaces that dissipate relative motion as heat through surface wear. The friction holds them as long as the surface has not been damaged during the energy dissipation phase and the clamping force is sufficient. Friction-based motion control load-holding capacity is based on two factors: the local effective coefficient of friction and the realizable applied normal force. Assumptions made during the design of these systems are that the applied normal force is consistent across the entire friction face and uniform throughout the clutch pack if a multi-plate clutch pack is used. This assumption is easy to achieve in practice by ensuring a rigid structure and uniform normal force application mechanism.

The second assumption is that the local effective coefficient of friction during engagement and while in load-holding mode is constant. It is a function almost exclusively of the friction material and the lubricant used in the clutch. The effect of the lubricant on the energy dissipation during load deceleration is to manage the interface friction and to dissipate the deceleration energy as heat. The heat, however, causes changes in the viscosity of the lubricant, which cause changes in the effective coefficient of friction in an uncontrolled manner. Further, most mid-grade lubricants exhibit a different coefficient of friction during sliding than they do when the clutch is locked. This varying coefficient of effective friction between the two regimes are typically labeled dynamic or sliding friction, and static friction.

Clutch chatter (i.e.: chudder, shutter or shudder) is generally attributed to this very dynamic, almost stepwise, change in system response, especially as the rotational between the input and output come close to zero. Chatter can be very detrimental to either the load-holding and position control system and / or the load itself. Chatter is also very hard on internal components as it manifests itself large magnitude, high frequency vibration and the possibility of catastrophic failure and loss of load control.

The other common method to hold two rotating components together is the positive latch which does not rely on friction, but on a latch engaging one of the rotating components. If not done properly, the engagement places a great deal of shock loading on the latch and can cause it to break catastrophically or wear down the mating surface quickly. Latches have been used in many products; a simple latch and eyehook to hold a gate or door shut is an example. However, if there is any load on the door (such wind) then it is difficult to get the latch to line-up with the eyehook.

Neither of these two technologies provided the operational characteristics we are looking for. What we really need is to not separate the load-driving mechanism (in our example, the geartrain) from the motion -control mechanism. The technology we have developed in the Kinatech device provides a rotary path for torque to flow in the positive drive direction that also incorporates a mechanism to fully lock the applied torque load through that same gearset. The technology, and thus the mechanism, uses the geartrain that carries the driving torque load as the brake mechanism, thus its non-back-drivable load limit is the same as the power capacity of the geartrain.



It is based on the kinematic relationship of the driving geartrain to also lock the main power-path gears, thus the two components attached to those gears, to move and lock without any friction interface to wear or change characteristic responses over time or without any latch component that can fail in shock loading. Input of motion comes from the driver of the system (i.e. a motor or other source rotational energy). This input causes an unlock, which in turn allows rotation based on the input rotational speed of the driver. As part of the design and packaging, these mechanisms can also include a ratio as a function of common gear design considerations.

This aspect of the technology presents an interesting attribute of function that none of the other locking mechanisms have. In a friction-based device, the rate at which a load is slowed to a controlled stop is a function of the capacity of the friction interface, which means over time, changes in that interface cause the response characteristics of the friction device to change. Further, it is difficult to provide the user a consistent response or to integrate a control system that compensates for the time-varying response. The latching technology affords no control over slowing down the motion of the load. It can only hold the load once the system has caused it to stop moving (and the latching system is engaged).

In comparison, our patented technology uses the rotational speed of the drive motor as the control input to the load. This means as the drive motor slows, the Kinatech device slows the load in a controlled manner based on its ratio. When the drive motor stops, the device transmits this to the load and then holds the load stationary without any continued input from the drive motor. Therefore, a controlled acceleration or deceleration of the load is affected by the same device that provides the drive ratio between the motor and load. The mechanism that provides the connectivity between the motor and the load is one in the same as the device that will eventually hold the load stationary.

So, let me present our new technology and describe the benefits for your consideration.

Kinatech technology provides a means to bring a load to stop and hold that load in position until released. Consider the following:

- Kinatech is integrated technology; it is essentially a gearbox with all the known advantages of gear design and the abilities to design for an application and predict service, efficiency, NVH, etc.
- Kinatech technology does not shock the load during deceleration or acceleration; the device is basically a gearbox, and the deceleration / acceleration ramp is a function of the driver. If the driver is an electric motor with even the simplest controller, the control of motion is direct from the motor controller through the motor to the load.
- Kinatech does not require on-going energy application to hold a load; both a friction-based device and a latch-type device require external power to function.

Kinatech technology is based on the kinematic relationships of gears within a housing to carry a torque load. Whether this torque load is dynamic (rotating) or the rotational speed is zero (holding) the gears really do not care. The lubricant regime transitions from an elasto-hydrodynamic shear layer to a quasi-static compressive layer (or the mixed lubrication regime), the lubricant layer remains intact, and as such we know how to analyze it and manage it successfully. Kinatech technology thus is not based on contact friction, nor does it generate any stepwise change in the force presented to the load or the driver. Depending on the ratio you need, you will likely not need a secondary gearbox for your application.

Further, in the case of a friction device, an external source of normal force is required to clamp the friction plates together and then that normal force must remain to hold the load stationary. Even if you use a spring to clamp the clutch pack, you have to provide external energy to overcome the spring to release the clutch pack and continue to provide that energy (compressive force against the spring) while the clutch is disengaged. Either way, this external force is a cost to the system design / development and an on-going cost to operation and maintenance.

Kinatech technology does not require an external force to ‘engage’ or ‘disengage’. This technology does not change state from engaged to disengaged or vis-versa. The internal mechanism of the Kinatech device is always engaged, thus it does not have to change state to change function from a gearbox to a brake, or from a brake to a gearbox. And don’t forget about the embedded gear ratio that is inherent to our technology.

Please visit kinatech.com to explore more about Kinatech, and contact us about your needs.