rexroth
A Bosch Company

Smart Function Kit Pressing - Expert Note Force Control

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The information in this manual is for product description purposes only. Any information on how to use the product is only an example and a recommendation. Catalog information is not binding. The information in this manual does not release the user from exercising their own judgment and conducting their own tests. Our products are subject to natural wear and aging.

The cover depicts a sample configuration. The actual product may vary.

The original manual is in German.

Table of Contents

1 Software version

This document is valid from software version 5.3.114.

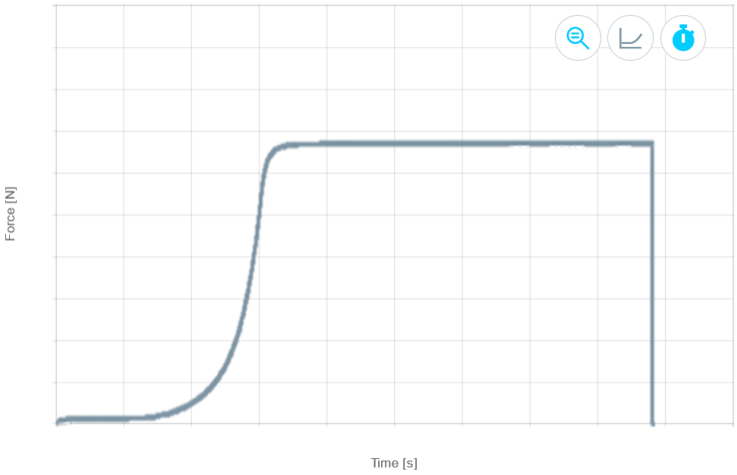
2 Description

2.1 Functionality

The force control function in the "Force-controlled joining" module enables you to implement processes in which the target force must be kept constant for a defined period of time, even if the size of the workpiece changes or the position varies.

Once the target force is reached, the position remains variable and is automatically adjusted, so that the force remains constant. The maximum position and the maximum force are monitored, to prevent damage to the system and the tool.

To better visualize and analyze the process, you can switch in the curve diagram from force/position view to force/time view.



2.2 Distinctions

In contrast to the "Force-controlled joining"module, the "Join to force" and "Join to position" modules work on the basis of position control.

When these modules are used, the next travel command (e.g. return stroke) is usually executed directly after the target force or target position is reached.

If there is no travel command, the position is kept constant. The system can not react and adjust to a possible change in the workpiece size, which means that the force increases when the workpiece gets larger and decreases when it gets smaller.

2.3 Limitations

The force control function has the following limitations:

- The force control function can only be used in combination with a force sensor.
- The holding time is limited to a maximum of 10 minutes (the thermal utilization of the motor or drive controller can further limit the possible holding time).
- The holding time and target force that you can enter in the "Force-controlled joining" module are not restricted based on thermal utilization of the motor, servo drive and cylinder (if applicable). You must take these limits into consideration during the project planning phase. They can be calculated using the LinSelect tool (see the Project planning chapter).

Note
If the motor or drive controller experience a thermal overload during operation, the system first issues a warning message and then an error message when the permissible maximum temperature is reached. The motor and drive controller are then automatically switched off to avoid damage.

- Evaluation elements (windows, limits, envelopes) can only be created in the force/position view of the curve diagram, not in the force/time view.
- It is not possible to enter tensile forces.
- There is a downtime of up to 30 ms between two successive “Force-controlled joining” modules. During this time, the system keeps the position constant.
- For processes > 10 s, the curve diagram in the dashboard is updated only every 500 ms. This does not affect data recording, which will continue throughout the entire process at the parameterized rate (usually 4 ms).

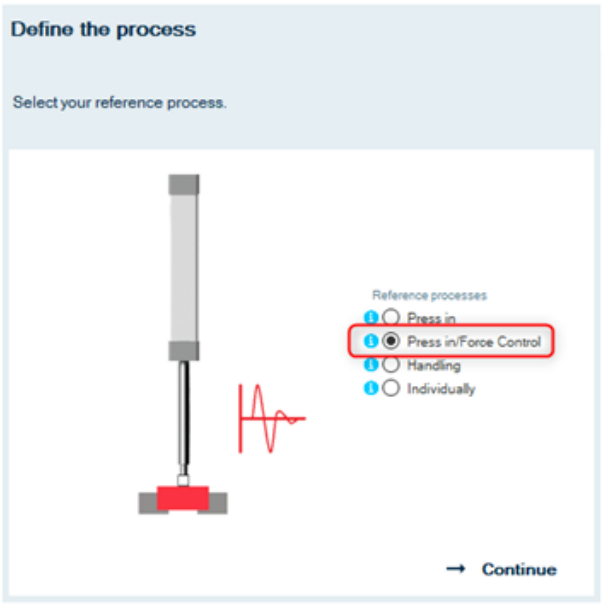
3 Project planning

To ensure that the system can maintain the target force over the required period of time, it is essential to perform a calculation in the LinSelect tool.

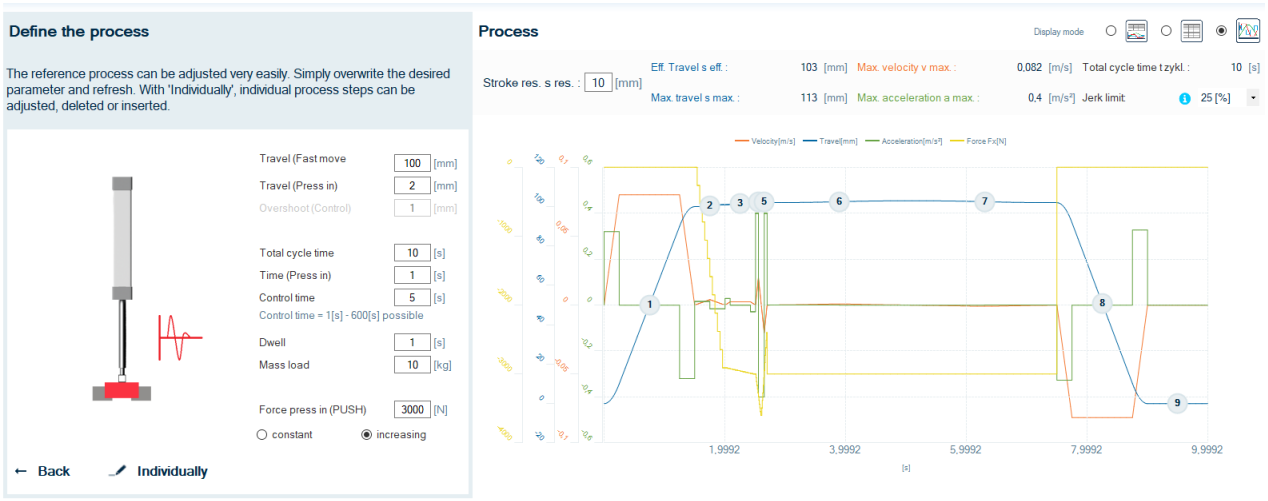
This tool is available for download on the Rexroth homepage.

You can enter all calculation-relevant process data in the tool to ensure that the system is adequately dimensioned in terms of mechanical, electrical and thermal utilization.

Select the reference process “Press-in/Force control”:



Enter the process parameters:



Result:

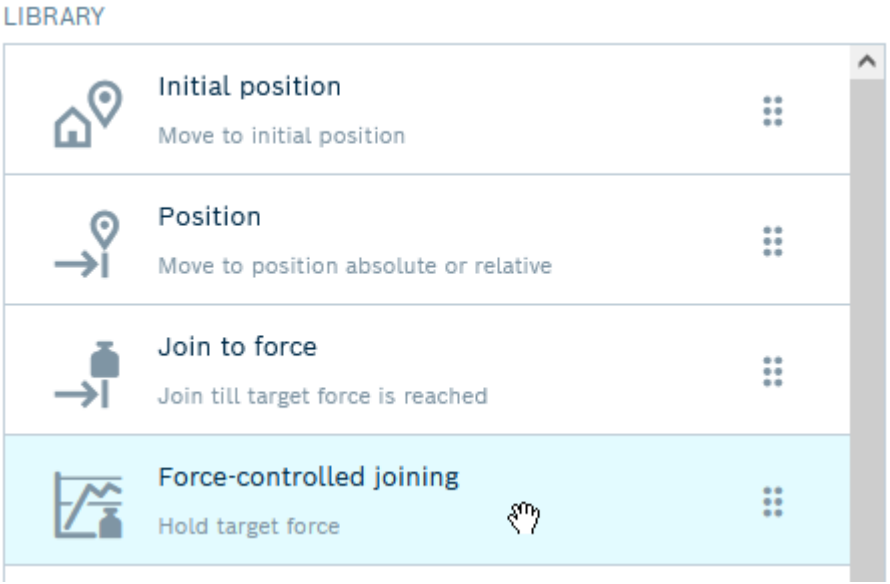
Note
For support with project planning and selection, please contact your local Rexroth contact person.
Contact locator: www.boschrexroth.com/contact

4 Instructions for operation

4.1 Module and parameters

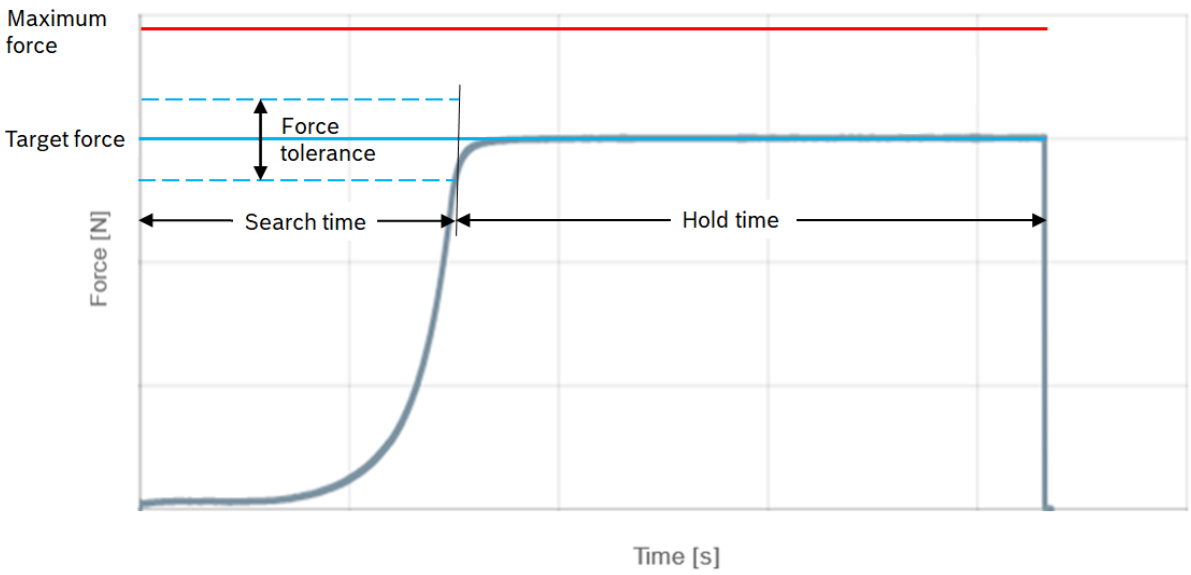
The module can be found in the library under the name “Force-controlled joining”.

It can be inserted into the sequence using drag&drop or by clicking on it.

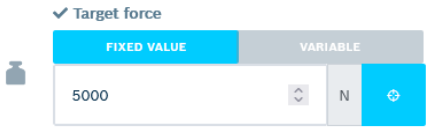
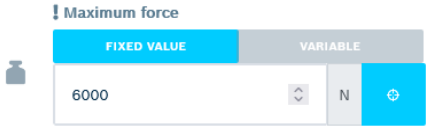


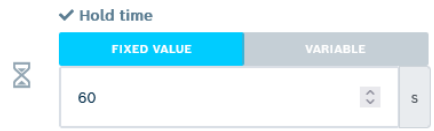
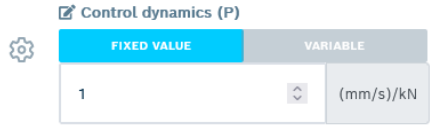
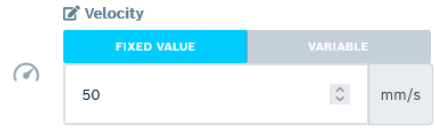
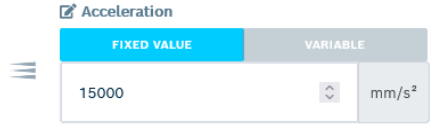
4.1.1 Basic description of the module

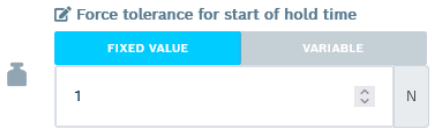
- The module continuously calculates the difference between the current force of the system and the specified target force and reduces it accordingly (continuous control).
- The module distinguishes between two modes: search mode and control mode.
  - Search mode:
    - The system tries to reach the target force.
    - In the module you can limit the maximum time that the system can spend in search mode.
    - If the system does not reach the target force within the specified time, an error appears, the program is aborted and the position is held.
  - Control mode:
    - The target force (taking into account the defined force tolerance) was reached at least once.
    - The holding time starts.
    - The system keeps the force constant for the defined holding time.
- In both modes, force control is active with the same parameters.
- Once the holding time is over, the system remains in its current position until the next movement command is issued.
- The module can be slurred with previous modules, i.e. the system does not completely stop the movement between two blocks (v=0) but only adapts the speed to the new target.
- The module can be used several times in a row in the program sequence.
- The maximum position, maximum force and maximum time to reach target force are monitored.
- The data is usually recorded every 4 ms. If necessary (e.g. to reduce the amount of data), the data recording rate can be adjusted/reduced using the parameter P-0-0279 "Trending rate" in the settings.



4.1.2 Parameters in the module

	The force that should be reached and maintained while the module is running. The target force can be higher or lower than the most recently applied force (but not negative). Any value within the system limits is possible. The parameter can be specified as a fixed value or as a variable. Unit: Newtons
	Maximum force that is valid while the module is running. Preset and limited to the maximum force of the system. Lower values can be entered. The maximum force must be higher than the target force. If the maximum force is exceeded, the sequence is aborted with an error. The parameter can be specified as a fixed value or as a variable. Unit: Newtons

	Holding time in control mode. Entries between 0 and 600 seconds are possible. The holding time begins as soon as the module is in control mode (target force has been reached at least once, taking into account the defined force tolerance). Once the holding time is over, the system remains in its current position until the next movement command is issued. The parameter can be specified as a fixed value or as a variable. Unit: seconds
	Control parameter P. P determines the velocity of the system based on the formula: v = P * (target force [kN] – current force [kN]) Preset with P = 1, which is the recommended starting value. Entries between -1,000,000 and 1,000,000 are possible, but not 0. For standard applications where force is built up by extending the cylinder and force is reduced by retracting the cylinder, P must be entered as a positive value. The parameter can be specified as a fixed value or as a variable. Unit: (mm/s) / kN
	Maximum velocity while the module is running. Input limited to maximum velocity of the system. The parameter can be specified as a fixed value or as a variable. Unit: mm/s
	Maximum acceleration rate while the module is running. Preset and limited to the maximum acceleration of the system. The parameter can be specified as a fixed value or as a variable. Unit: mm/s²

	Force tolerance for the transition from search mode to control mode and thus the start of the holding time. The transition occurs as soon as |target force [N] - current force [N]| < force tolerance. Even after the tolerance range has been reached, the system attempts to get closer to the specified target force. Preset with 1 N and limited to the maximum force of the system. Only positive values (or 0) can be entered, but the value is applied as a tolerance in both directions (coming from a larger or a smaller force value when approaching the target force). The parameter can be specified as a fixed value or as a variable. Unit: Newtons
	Maximum time in search mode. Preset and limited to 600 s. If you enter the value 0, the search mode is skipped and the control mode begins immediately (if the target force is already applied). If the system does not reach the target force within the specified time, error 041027 *"Program error: Error in the 'Force control' function block: time for reaching the target force exceeded"* appears and the program is aborted. The position is held. The parameter can be specified as a fixed value or as a variable. Unit: seconds
	The maximum position that is valid while the module is running. Preset and limited to the maximum position of the system. Lower values can be entered. If the maximum position is exceeded, the sequence is aborted with an error. The parameter can be specified as a fixed value or as a variable. Unit: millimeters

Note
The maximum force in the module following the "Force-controlled joining" module must be higher than the target force in the "Force-controlled joining" module.

4.2 Process optimization

Depending on the workpiece properties and the required accuracy, different parameters in the “Force-controlled joining” module can lead to the best process result.

Several influencing factors for optimizing the process are described below.

Parameter P:

The higher the (absolute) value of the parameter P, the faster the system attempts to reduce the difference between the target force and the current force.

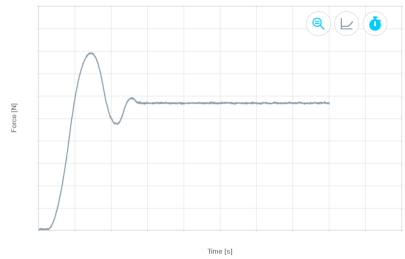
However, if the value of P is too high, the system may overshoot the force, possibly resulting in subsequent oscillation.

→ Increase P to reach the target force faster

→ Reduce P to increase control quality and reduce overshoot

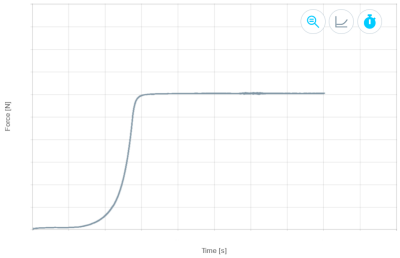
The parameter P must be determined for each application as part of the process optimization. We cannot provide a generally applicable value.

Recommendation: Low P for hard workpieces (high stiffness), higher P for soft workpieces (low stiffness). Start with P = 1.



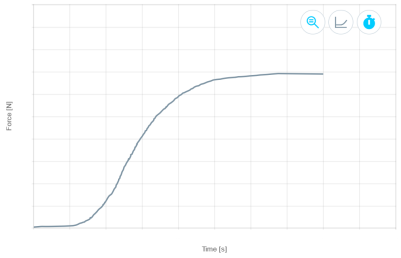
P too high:

Target force reached very quickly, but risk of overshooting and oscillation.



Appropriate P:

Target force reached quickly without overshooting/oscillation.



P too low:

Target force reached very slowly, with possible negative effect on cycle time.

Acceleration:

High acceleration has a beneficial effect on the system's response time. Recommendation: Start with the system maximum.

Velocity:

The velocity parameter is the upper limit for the velocity resulting from the specified value for parameter P.

(v = P * (target force [kN] – current force [kN]))

If increasing the parameter P has no effect on how quickly the target force is reached, increase the velocity parameter.

Stroke:

To achieve short cycle times, it can be beneficial to move as close as possible to the workpiece using a positioning command and only then switch to force control.

Note
The exact response time of the system cannot be determined in advance because it depends on many influencing factors.
In addition to the parameters described in the module, both the system configuration (inertia, stiffness) and, above all, the workpiece properties (stiffness) have a decisive influence.