TB Wood´s

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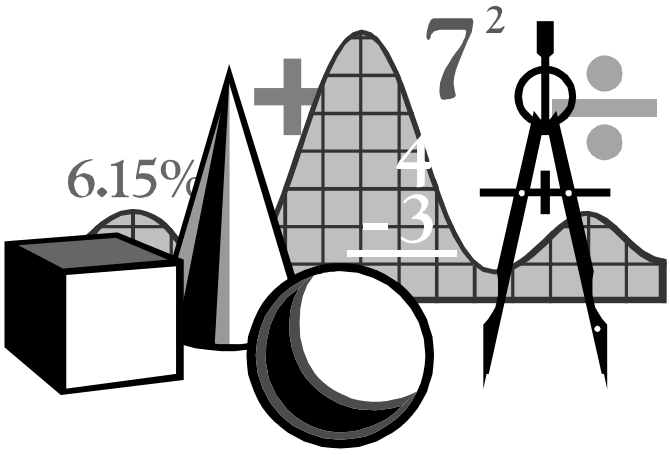
UD7000

Application "Open-Loop Tensile Force Control"

with FO, EC and SLV



As per: 05.08.03

Application
"Open-Loop Tensile Force Control"

As of software version A18.07 / A17.07

Application

A material is wound up or unwound with a centre winder. A specific tensile force F at the material end is to be maintained despite changing winding diameter v and changing web speed v.

No tensile force measuring unit or diameter sensing unit are available. Information on the desired tensile force F and on the web speed v is preset for the inverter.

The motor must output a high torque with the winder full and a low torque with the winder empty.

The motor speed n is known in the inverter as the model or measurable variable (in the case of drives with feedback); the web speed v and the desired tensile force F are preset as analogue variables.

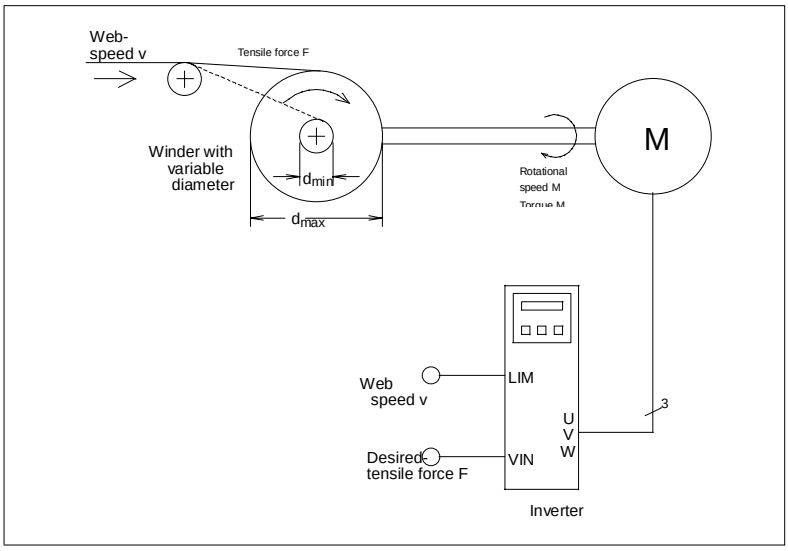


Figure : Mechanical system

Principle of the open-loop tensile force control

The open-loop tensile force control readjusts parameter 33 - torque factor[1] to apply a defined tensile force characteristic to the material as a function of the winding diameter. This characteristic may be constant, linearly degressive, linearly progressive and parabolic.

The web speed signal is preset as an analogue voltage. The range may be maximum 0..10 V. Adaptation is performed with parameter 34. The analogue voltage range in units [% of 10 V] is specified in parameter 34 (e.g. 45% for the range 0..4.5 V). The signal can be monitored in parameter D8: 0..1000‰ corresponds to 0..$v_{Web,max}$.

The motor speed extends from zero (standstill) to a maximum value (max. web speed with empty winder). This rotational speed is specified in parameter 41 - fixed frequency. The rotational speed information can be monitored in parameter D9: 0..1000‰ corresponds to 0..fixed frequency 1.

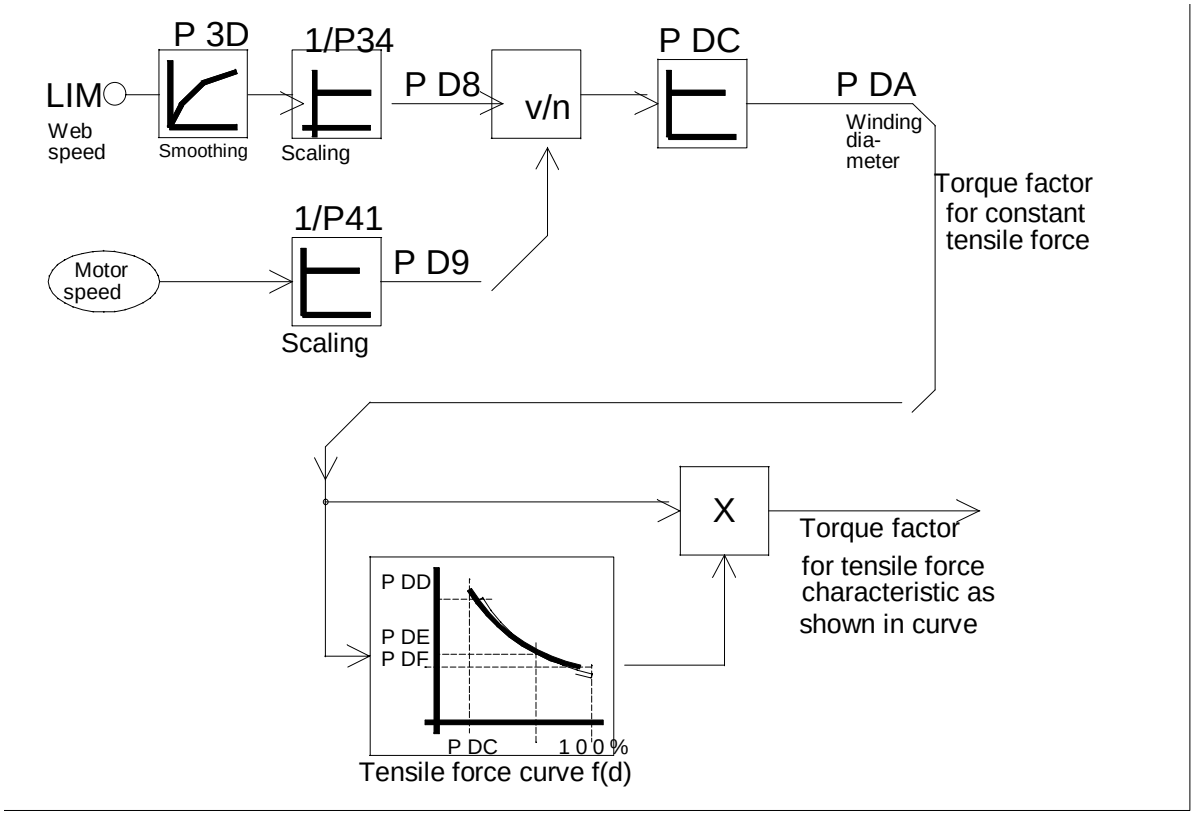


Figure 2: Controller structure, Part 1

The winding diameter is computed from the ratio of these two signals (model variable, division v/n). The winding diameter (parameter DA) ranges between d_{min} (empty) and d_{max} (full = 1000‰). This ratio is specified with parameter DC:
Parameter DC = 1000‰ * d_{min}/d_{max}

The winding diameter alone would precisely correspond to a torque factor for tensile force independent of winding diameter.

[1] Parameter 33 is referred to as parameter 33 - torque factor in these instructions and also acts as such in the tensile force application. Parameter 33 is referred to as the frequency factor in the parameter description of the UD7000.

The characteristic curve element generates an additional factor which varies the tensile force in the web dependent on the winding diameter. The tensile force can be varied with increasing winding diameter on the basis of a constant, a linear function or a parabolic function.

The torque factor established in this way serves as the input variable for correction (Figure 3). Correction smoothes the torque factor (slow ramp function). There is also an option for selecting start values via PS1, PS2 inputs.

Correction is performed only if the motor speed reaches a defined threshold (parameter 43) and the drive is enabled via FWD. Only then can a practical signal be computed in parameter DA. If correction is disabled, parameter DA has the value -1.

The correction rate can be set via parameter DB in the range 1 to 100 s. In addition, parameter 33 - torque factor can be set via binary inputs PS1 resp. PS2 to the upper resp. lower limit (P38, P39), which is helpful when changing a reel.

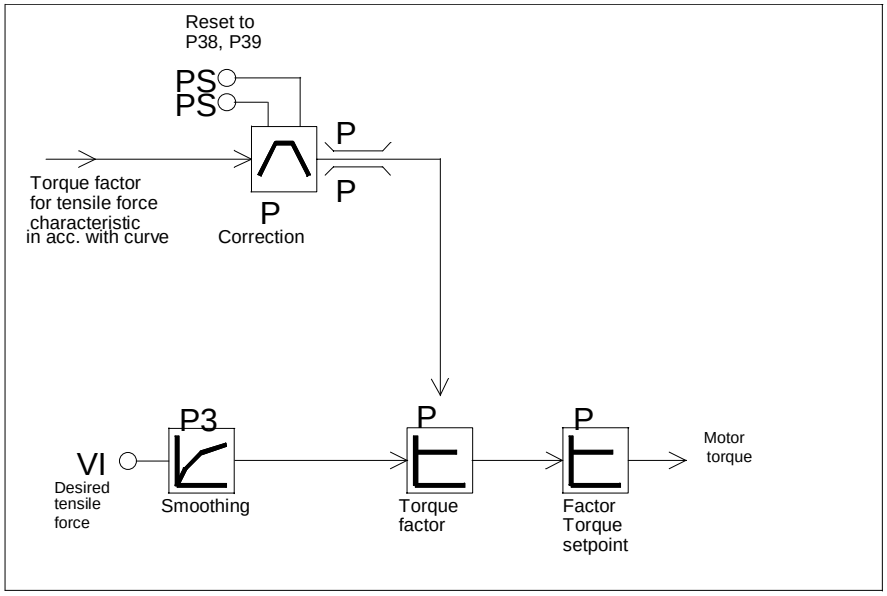


Figure 3: Controller structure, Part 2

Parameter 33 - torque factor generates the factor with which the desired tensile force is converted to the motor torque.

Parameter 5E - torque factor LIM input performs overall scaling.

Special operating states

Production interruption without reel change:
If the FWD terminal is disconnected, the last value of parameter 33 - torque factor found is retained. When the FWD terminal is reconnected, adaptation then continues from this value.

Reel change - Setting start values for parameter 33 - torque factor:
For this purpose, the binary inputs PS1 and PS2 must be programmed for function 12 (motor potentiometer - increment / decrement torque factor). When the binary inputs are activated, parameter 33 - torque factor changes in the time defined by parameters 7B resp. 7C to the upper resp. lower limit value (minimum 0.1 s for 100% change).

Reel change in the case of take-up winder application:
Reel change always occurs from "full" to "empty". For this purpose, parameter 33 - torque factor must be set by the open-loop control to the minimum value (parameter 38). This is performed with function "motor potentiometer decrement" (PS2, P9A = 12, P7C = 0.1s).

Reel change in the case of unwinder application:
Reel change is always performed from "empty" to "full". For this purpose, parameter 33 - torque factor must be set by the open-loop control to the maximum value (parameter 39). This is performed with function "motor potentiometer increment" (PS1, P99 = 12, P7B = 0.1s).

Output of parameter DA - Winding diameter:
It can be displayed on the standard display 2 and thus indicated analogue via the MET outputs.

Output of parameter 33 - Torque factor:
Parameter E3 is an image of parameter 33 - torque factor: This can be displayed on the standard display 2 and thus indicated analogue via the MET outputs.

Input and output terminals

LIM: Analogue input web speed 0..10 V
VIN: Analogue input desired tensile force value 0..10 V
CIN: Analogue input desired tensile force value 0..20 mA
FWD: Binary input Drive Enable
PS1/PS2 Binary input for setting the start value for parameter 33 - torque factor

Parameters

P 23: Maximum frequency
P 2C: Application 511, 521 or 551: Open-loop tensile force control with EC, FO or SLV
P 33: Torque factor
P 34: Scaling for web speed signal
P 38, P 39: Lower limit upper limit of parameter 33 - torque factor
P 3C: Smoothing time constant for VIN input
P 3D: Smoothing time constant for LIM input
P 41: Rotational speed reference value for empty winder and max. web speed
P 43: Threshold for correction of parameter 33 - torque factor
P 5E: Maximum motor torque, overall scaling
P 7B: Speed motor potentiometer increment
P 7C: Speed motor potentiometer decrement
P D8: Scaled web speed Unit [‰]
P D9: Scaled motor speed Unit [‰]
P DA: Diameter estimate, input to correction Unit [‰]
P DB: Time for 100% correction time Unit [s]
P DC: Diameter of empty winder Unit [‰]
P DD: Tensile force factor for empty winder Unit [‰]

P DE: Tensile force factor for half-full winder Unit [‰]
P DF: Tensile force factor for full winder Unit [‰]
P E3: Image of P 33 - torque factor, but View-Only for standard display 2 and MET output

Commissioning

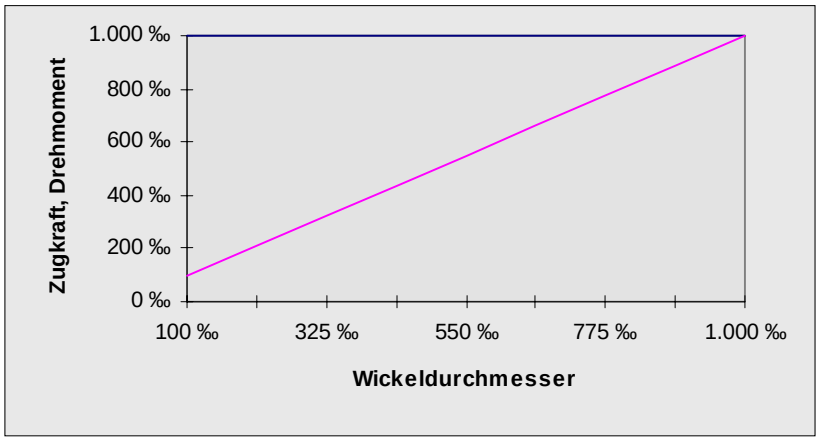
1. Place the motor into operation as EC, FO or SLV (rotational speed-controlled in each case) (parameter reset, choose application, switch the mains off and on, enter motor data, test run etc.) and then set test mode to 0.
2. Connect the motor so that, in the case of FWD, the motor turns in the correct direction (operating direction). This is absolutely essential in order for the closed-loop control system to operate correctly. If the direction of rotation is incorrect, reverse two motor supply leads and start commissioning again at Point 1.
3. Choose open-loop torque control application 511, 521 or 551 and switch the mains off and back on again.
4. Set parameter 23 - maximum frequency approx. 10% higher than the maximum motor speed occurring with empty winder.
5. Set parameter 34 - frequency factor LIM input in accordance with the analogue voltage range U of the web speed signal: P34 = U * 100% / 10 V
   Example: U is 0 .. 6 V => P34 = 60.0%
   Check this with parameter D8.
6. Parameter 41 = xx Hz (Maximum frequency occurring with empty winder)
   Check this with parameter D9.
7. Parameter 33 = 100.00% (Torque factor, proportional to winding diameter)
   Parameter 43 = 0.0 Hz (Threshold correction parameter 33 - torque factor)
   Parameter 99 = 12 (Increment parameter 33 - torque factor with PS1)
   Parameter 9A = 12 (Decrement parameter 33 - torque factor with PS2)
   Parameter 7B = 0.1 s (Increment speed motor potentiometer)
   Parameter 7C = 0.1 s (Decrement speed motor potentiometer)
   Parameter DB = 60 (Correction time parameter 33 - torque factor)
   Parameter DC = 1000‰ *d/D (Diameter of empty winder)
   Parameter DD = initially 1000‰ (Factor empty winder)
   Parameter DE = initially 1000‰ (Factor full winder)
8. Reel change take-up winder:
   Fit an empty reel, activate PS2 for 0.2 seconds and start the system up. Parameter 33 -torque factor must increase with increasing reel diameter.
   Reel change unwinder:
   Fit a full reel, activate PS1 for 0.2 seconds and start the system up. Parameter 33 - torque factor must decrease with decreasing reel diameter.
9. Define threshold for correction:
   With a full winder wherever possible and normal web speed v, read off the value from parameter 01 - output frequency and enter approx. 50% of this value in parameter 43. As a check, observe parameter DA - winding diameter at changing web speeds. It should correspond to the winding diameter in as many operating states as possible.
10. Optimise correction rate:
    Parameter DB should be approx. 1/10 of the time required for a winding operation.
11. Set parameters DD, DE, DF in accordance with the required characteristics.
    Examples:

1000‰	1000‰	1000‰	Constant characteristic
1000‰	900‰	800‰	Linearly degressive characteristic
500‰	750‰	1000‰	Linearly progressive characteristic
1000‰	800‰	900‰	Parabolic characteristic
1000‰	800‰	500‰	Parabolic characteristic
400‰	800‰	800‰	Parabolic characteristic

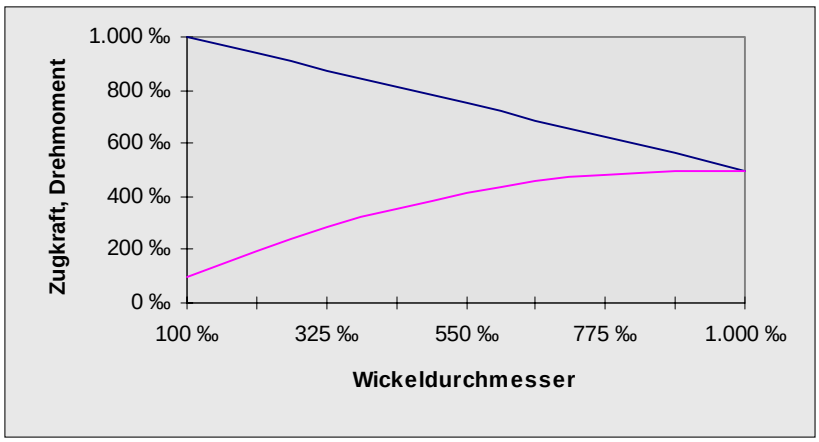
1. Final scaling of the tensile force: Adjust parameter 5E to the required ratio of tensile force/desired tensile force.

Examples of tensile force characteristics

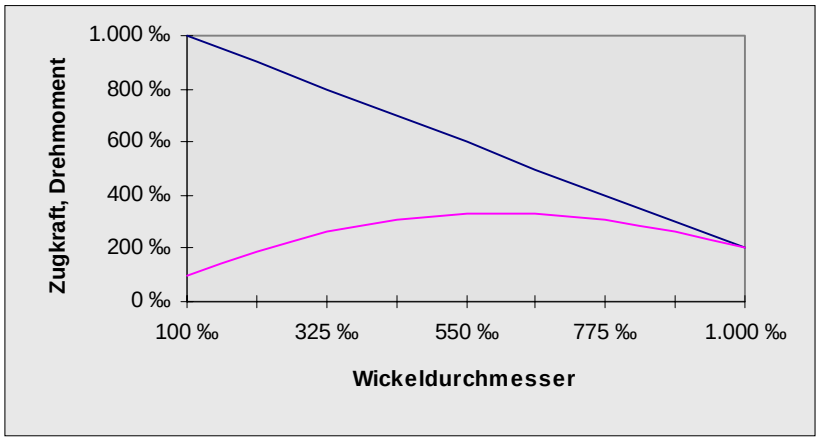
1. Constant tensile force characteristic:
   The shaft torque (P33 - torque factor) increases proportionally to the winding diameter:



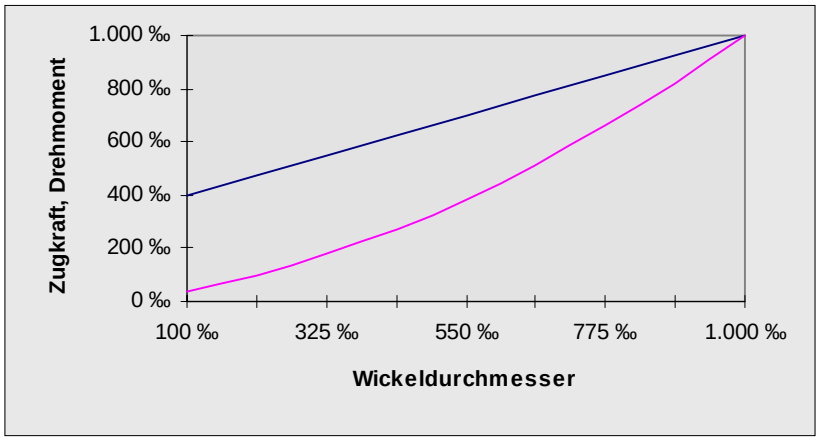
2. Linearly degressive tensile force characteristic:
   The shaft torque (P33 - torque factor) assumes a parabolic characteristic:



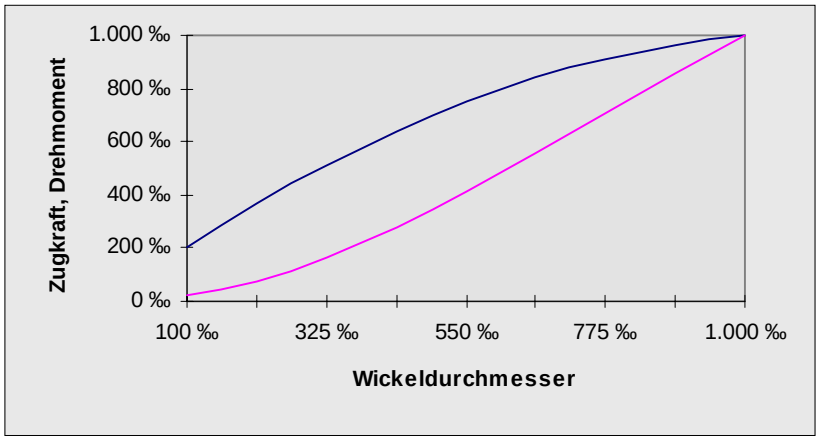
3. Linearly degressive tensile force characteristic (more degressive):
   The shaft torque (P33 - torque factor) assumes a parabolic characteristic with a vertex:

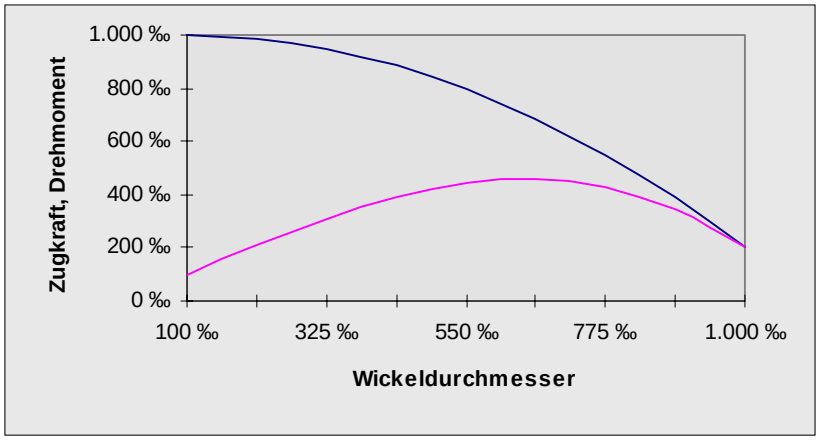


4. Linearly progressive tensile force characteristic:
   The shaft torque (P33 - torque factor) assumes an upward parabolic characteristic:



5. Various parabolic tensile force characteristics:
   The shaft torque (P33 - torque factor) assumes cubic parabolic characteristics (3rd order parabola):

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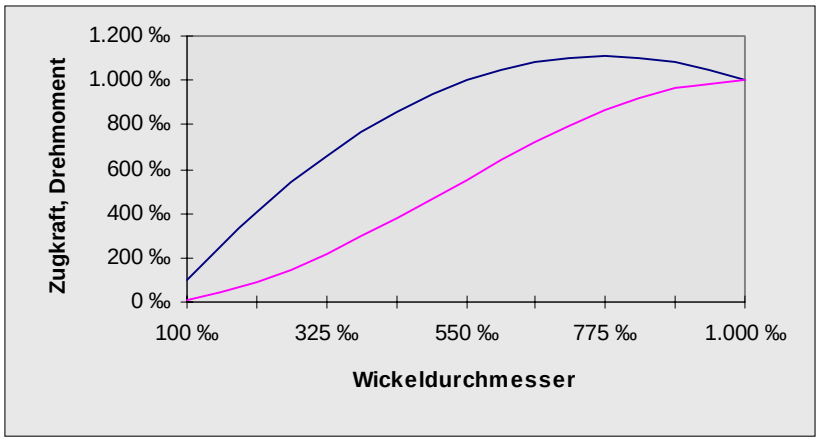
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