

History, present situation and future trends in ensuring constant and consistent wire tension in stranding machines

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A composite graphic. On the left, a technical cross-section drawing of a wire stranding machine component with various dimensions labeled: d_1 , d_2 , l_1 , l_2 , l_3 , and l_4 . A red dotted line with a red dot in the center points from the text 'The Point is Technology' to a specific point in the drawing. On the right, the word 'QUALITY' is written in large, bold, black letters. Below it is a red circle containing a white upward-pointing arrow. At the bottom left, the website 'www.fms-technology.com' is written in white. At the bottom right, the text 'SWISSMADE' is written in white with a small white plus sign to its right.

QUALITY

The Point is Technology

www.fms-technology.com

SWISSMADE⁺

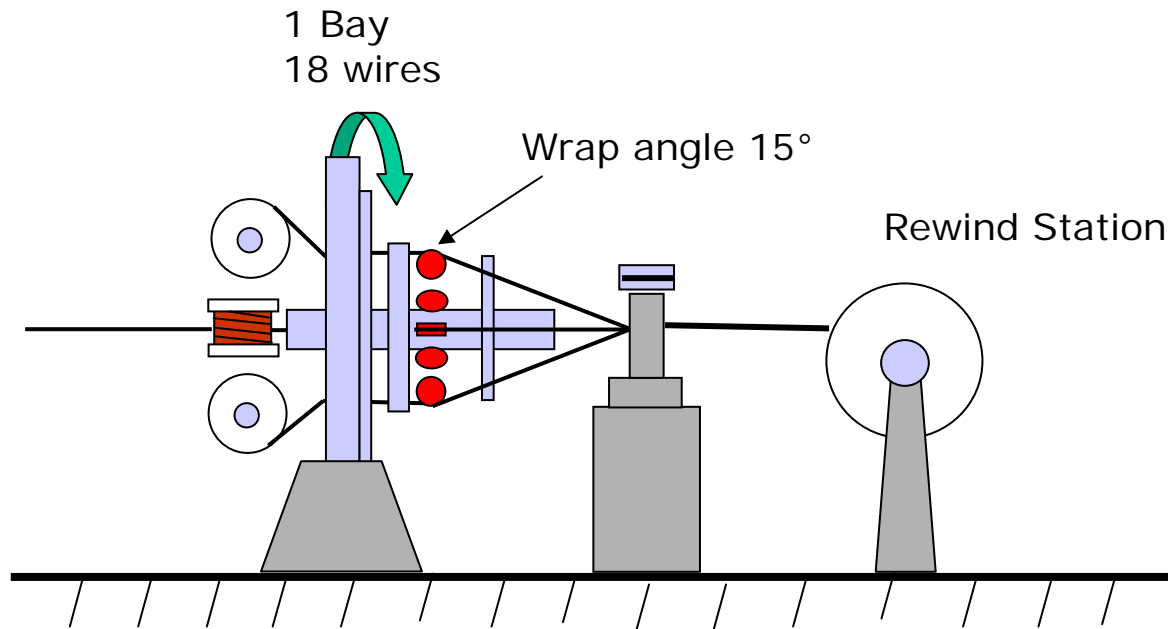
A solid red square is positioned to the left of the main title.

Contents

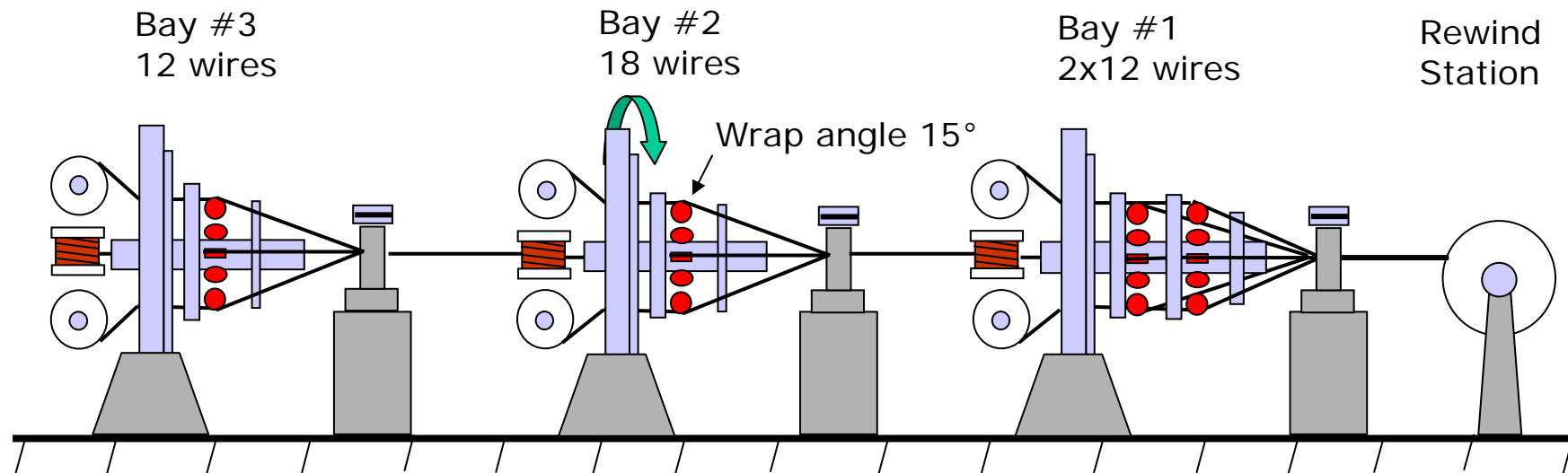
1. Introduction, Definitions
 - Different applications of stranded products
 - Meaning of material tension in stranded products
 - Creation of tension in pay-off
 - How can tension be measured
 - Tension indication vs. closed loop tension control
 - Difficulties with accurate measurement in rotating systems
2. Historic development of tension control
3. Current solutions
4. Design criteria for the evaluation of tension control systems on stranders
5. Application examples
6. Future trends

Strander Types

Example of Cage Strander

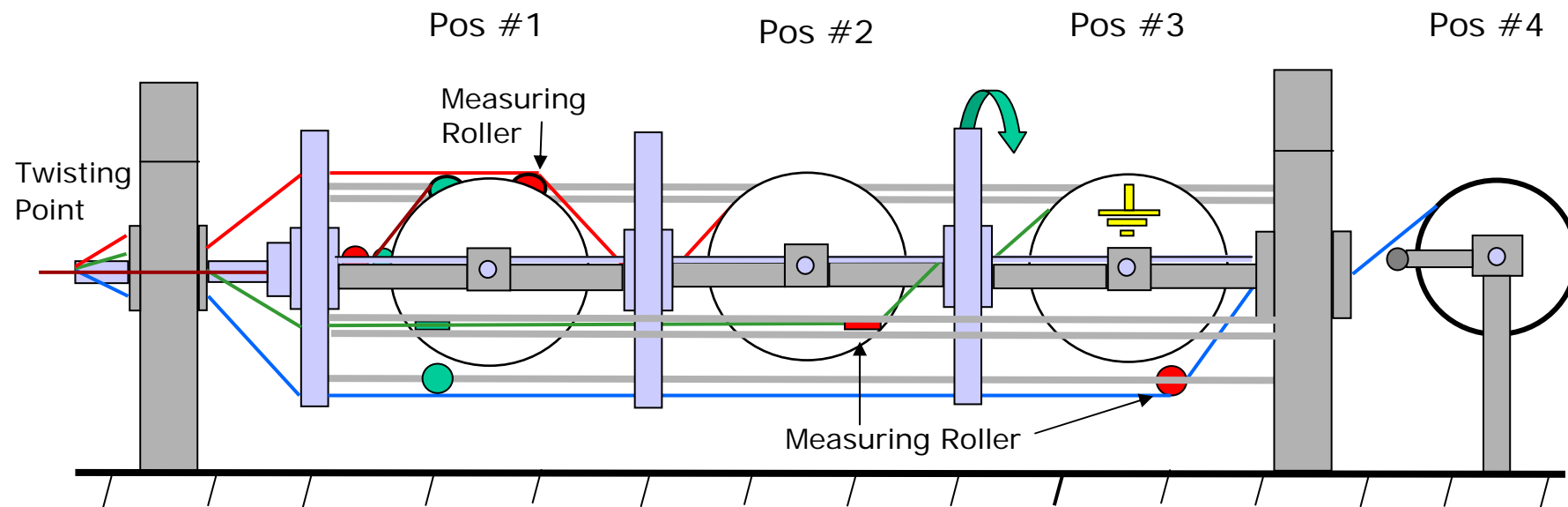


Example of Multi-Cage Strander



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Example of a Tube Strander



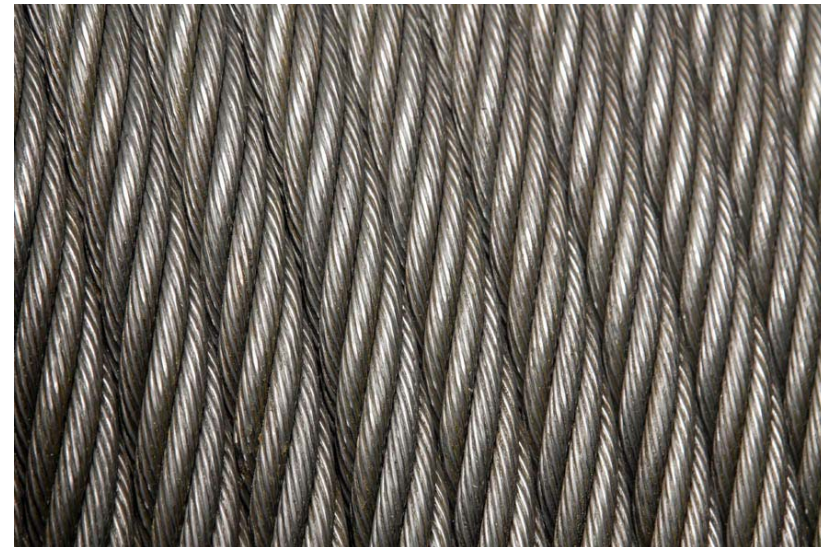
Different Applications of Stranded Products

- Controlled tension can improve product quality in :
 - Ropes for transportation purposes (aerial cable-cars, elevator lifting cables, cranes aso)
 - Data cable in network applications,
 - Submarine cables for power and data,
 - Fiber-optical cables aso



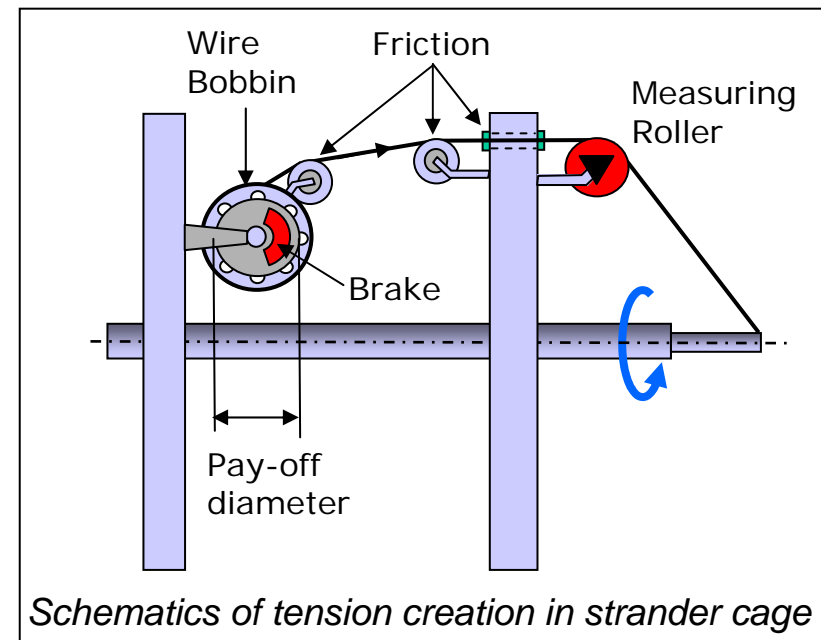
■ Meaning of Material Tension in Stranded Products

- Absolute tension in each wire/strand:
The absolute tension determines how tight the strand will be made, e.g. how much air is left in between strands
- Consistency of tension amongst different strands/wires:
 - It influences the strength of a rope due to its uniformed load distribution over the individual strands.
- It influences electrical behaviour cable
 - controlled and even tension
 - defined cross-talk
 - defined capacitance between 2 wires
aso)



Creation of Tension in Pay-off

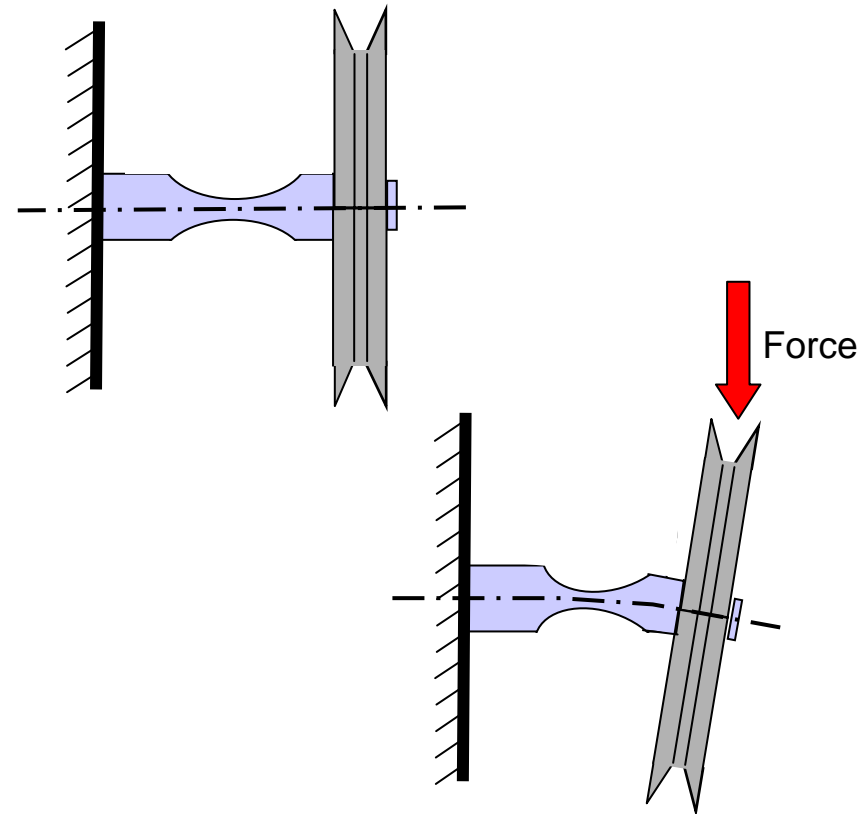
- Tension in a strand is created by braking the wire bobbin and reducing pay-off.
- The tension is a function of braking torque, diameter of coil, friction over rollers and strand ducts in the lay plate.
- As friction can be assumed more or less constant over a short period of time, tension changes due to the continuously changing diameter of the coil.
- Without any changes to the brake force through a complete run the machine starts with low tension at full coil and at the end of the coil the tension is higher by approximately the factor of full vs empty coil.



$$\text{strand tension} = c * \frac{F_{\text{brake}}}{d_{\text{pay-off}}} + \text{friction}$$

How Can Tension Be Measured

- Industry knows sensors for tension measurement since decades, most of them using strain gauges to convert mechanical stress into an electrical signal.
- These sensors always require an amplifier to get a standardized 0-10V signal for indication on a meter or further calculation in a closed-loop control. The mechanical side of the measurement is always a shieve sitting on a sensor that is wrapped by the wire or strand in a certain angle.



Wrap Angle and Tension

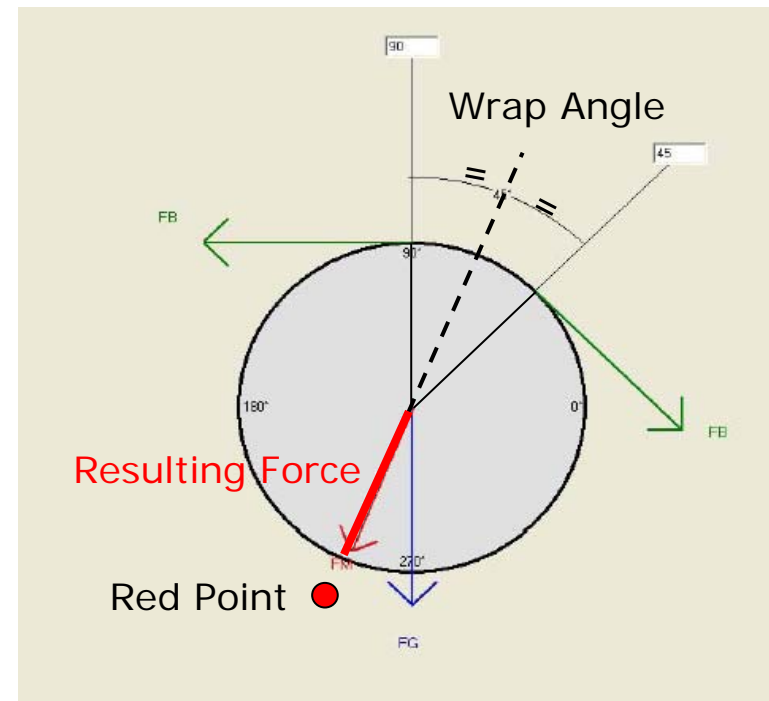
- This wrap angle and the tension in the material create a force on the sheave and therefore on the sensor that is proportional to the tension in the wire:

$$\text{Force} = 2 * \text{Tension} * \sin\left(\frac{\text{wrap angle}}{2}\right)$$

FB: Wire tension

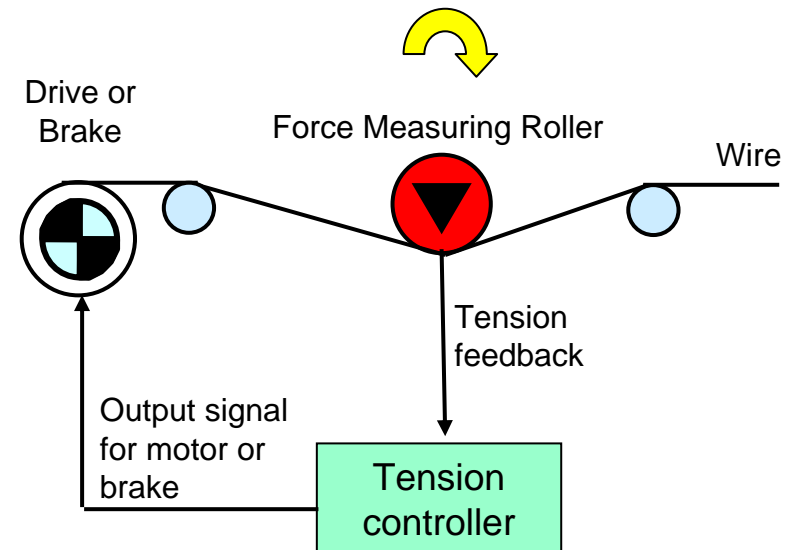
FG: Force of sheave weight

FR: Resulting Force



Tension indication vs. Closed Loop Tension Control

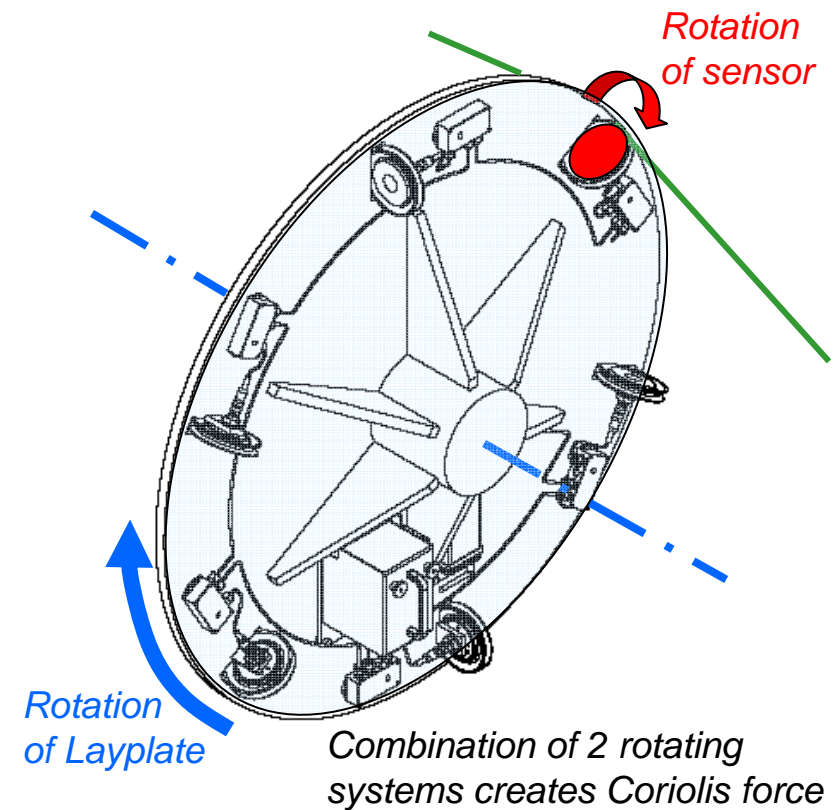
- Measurement enables the operator to see if the machine is running with proper tension; if any adjustment is required the machine needs to be stopped and the adjustments made to the pay-off.
- With a closed-loop tension control any variations in the tension are corrected automatically and continuously by the controller.
- Where closed-loop tension control is state of the art in converting applications. It is not so easy to adapt them to rotating machines. It requires special concepts of data transfer between layplate, individual payoff/brake and MMI on the static side.



Schematic diagram of closed loop Tension control system

Difficulties with Accurate Measurement in Rotating Systems

- In contrary to a wire running through an static annealing or insulation process where measurement of tension can simply be achieved, it is much more tricky on a rotating machine:
 - Centrifugal forces influence the measurement
 - Coriolis forces act on the load cell.
Coriolis force is the force created by 2 rotational movements, (which stabilizes your bicycle for example): one rotation is the lay plate and the second one is the sheave that rotates within the rotating cage.



Historic Development of Tension Control

- The wish to keep constant tension in the individual strands is as old as stranders exist. In the beginning simple mechanical spring-operated strap brake with a leather strip were used to adjust the tension for each individual pay-off. The Machine needed to be stopped to readjust the strap brake when the bobbin got empty.
- The operator needed to feel the tension in the strands manually. There were skilled operators that had a real good feeling and could do a good job of ensuring consistent tension throughout a full production run. Next day another operator did job not understand it as well. This leads to a high variation in quality and is no longer tolerable for modern processes.
- In the 80s there were sensors available for wire tension measurement. A few machines were fitted with tension measurement, using slip rings to bring the signals to the static side. This technology was simply too expensive and error-prone.
- With technology moving on there were new possibilities available: Bus systems became available and allowed the reduction of the number of slip rings and also radio transmission systems developed further at reduced cost.
- Parallel with these developments also the technology of the stranders developed: there were pneumatic and magnetic brakes available that allowed a more reproducible tension setting and also – and this is one of the main targets of any machine builder- higher speeds.

Current Solutions

- A certain percentage of new machines is currently equipped with tension control systems; some open loop and some closed-loop (examples are Sket [FMS], Lesmo [FMS], Queins [FMS], GCR [FMS], NMC [FMS], Caballé, Pourtier and others)
- There are thousands of older machines in the field. A very small percentage of them has been retrofitted with tension control, but many of them remain to be retrofitted, and for many of them it is quite simple to retrofit them.
- Amongst the current retrofit solutions the following ones are most common:
 - Slip rings for analogue signals. This principle is not seen very often anymore.
 - Bus systems and slip rings is quite common. If the slip rings are of good quality, one can obtain reliable results.
 - Bus systems with Radio transmission is getting more and more common with the availability of inexpensive and reliable radio transmission modules.
- Common to all known systems is that the amplifiers are always placed on the rotating part. This has electrical reasons. The load cell's output is only a milliVolt signal and those can not be handled by bus systems directly nor be transferred over slip rings.
- The majority of the tension control systems in today's stranders are open-loop systems.

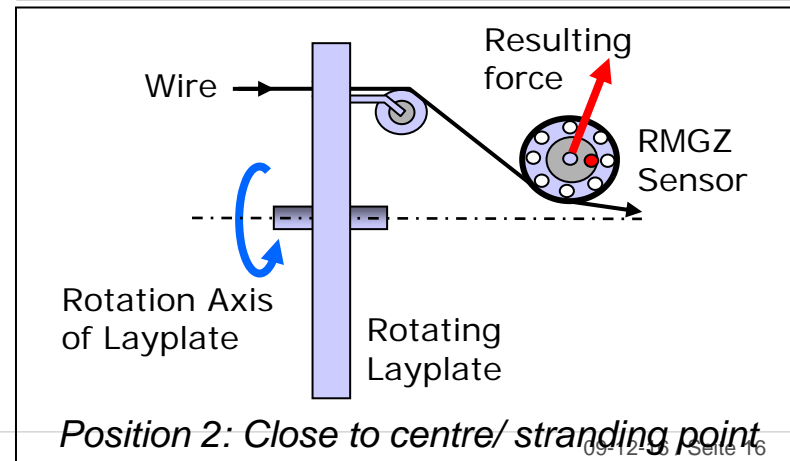
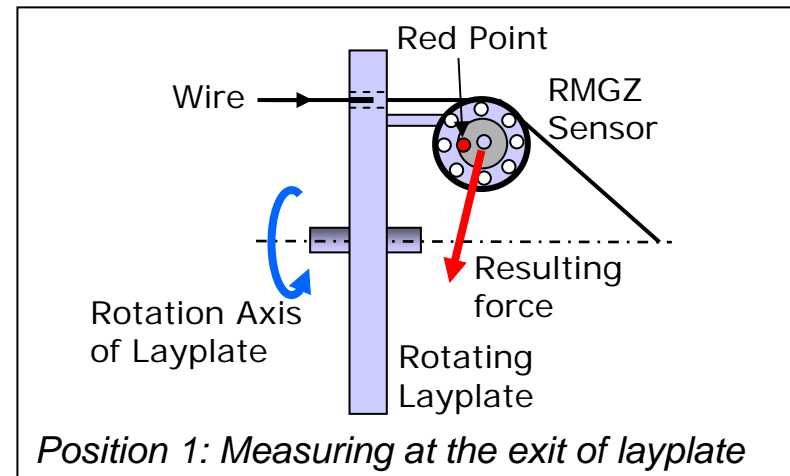
● **The Point is Technology**



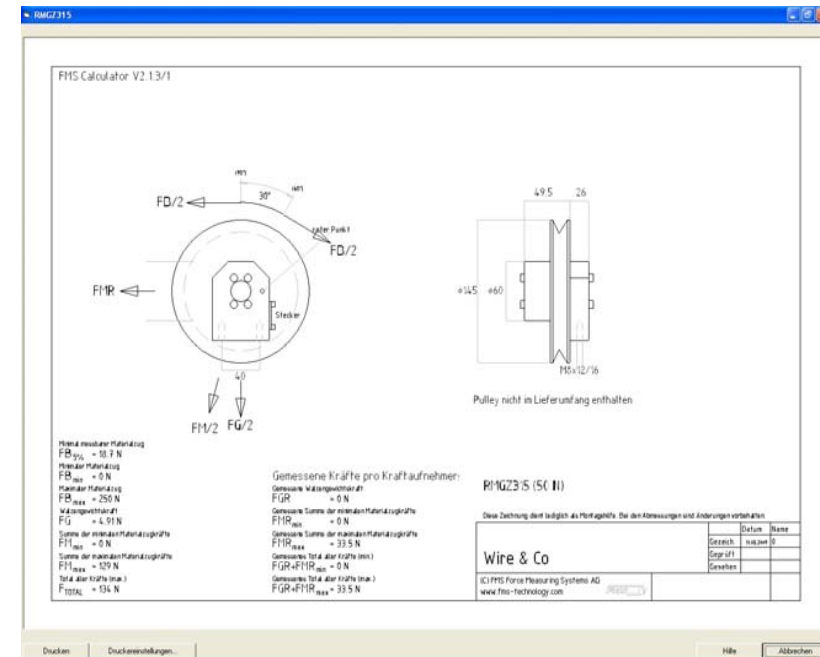
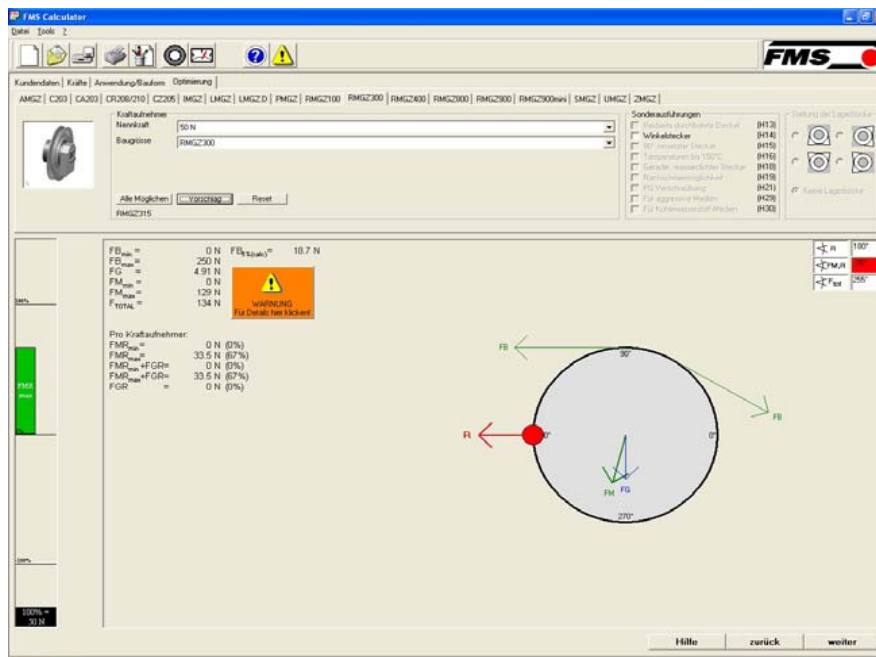
Design Criteria for Tension Control in Stranders

Position of the Measuring Device

- In general there are 2 suitable positions to measure the tension:
 - One is where the strand / wire exits the layplate is directed to the stranding point.
 - Another position is near the center, near the stranding point
- It depends on the specific circumstances (mainly space) which position is better suitable.
- Position 2 offers the advantage of lower centrifugal forces.



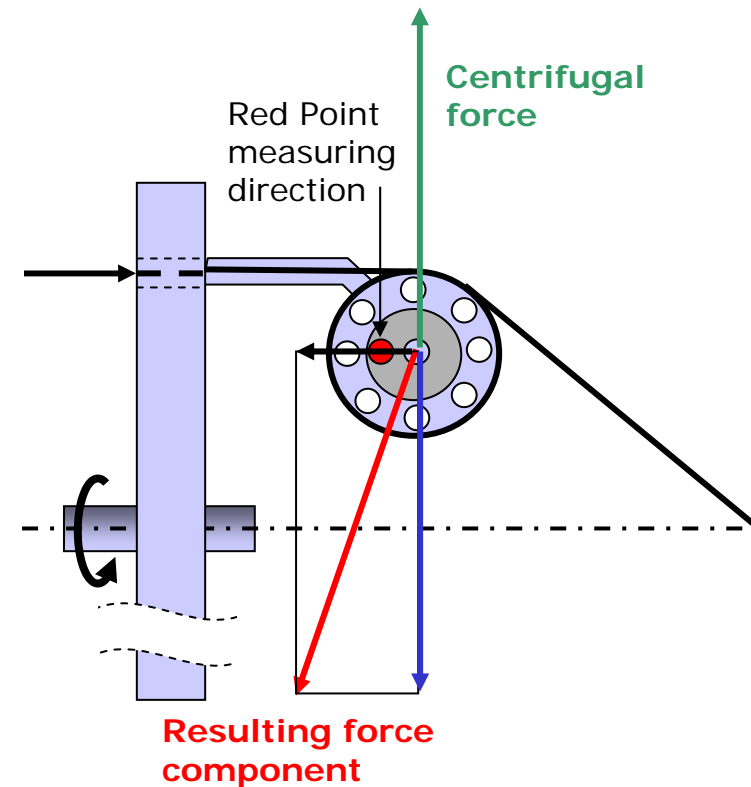
Calculation of Required Nominal Force of the Sensor



2 screenshots from the calculator software from FMS to determine the correct type and nominal force of sensor .

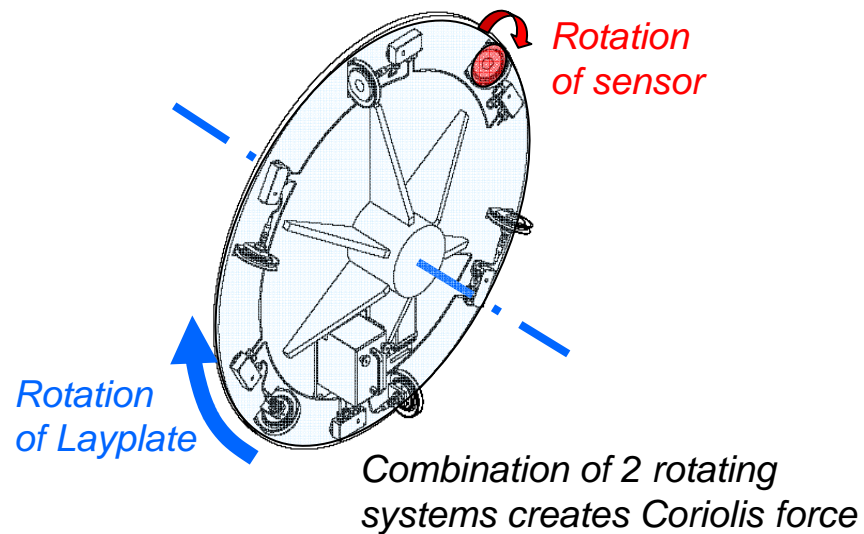
Influence of Centrifugal Forces

- Depending on the application data (rotational speed, weight of sheave, sensor design etc.) it can be necessary to do accurate calculations of the effects of the centrifugal forces to get a measurement that is not affected by them. To eliminate the influence of centrifugal forces several measures must be taken:
 - requires very accurate positioning of the sensor.
 - sensors that are designed to withstand these high loads rectangular to the measuring direction
 - other design measures



Influence of Coriolis Force

- The influence of the Coriolis force can only be compensated by a proper design of the sensor which makes it insensitive in the direction of the Coriolis force.



Example of a sensor that is insensitive to Coriolis forces

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Application Examples

Application in Germany

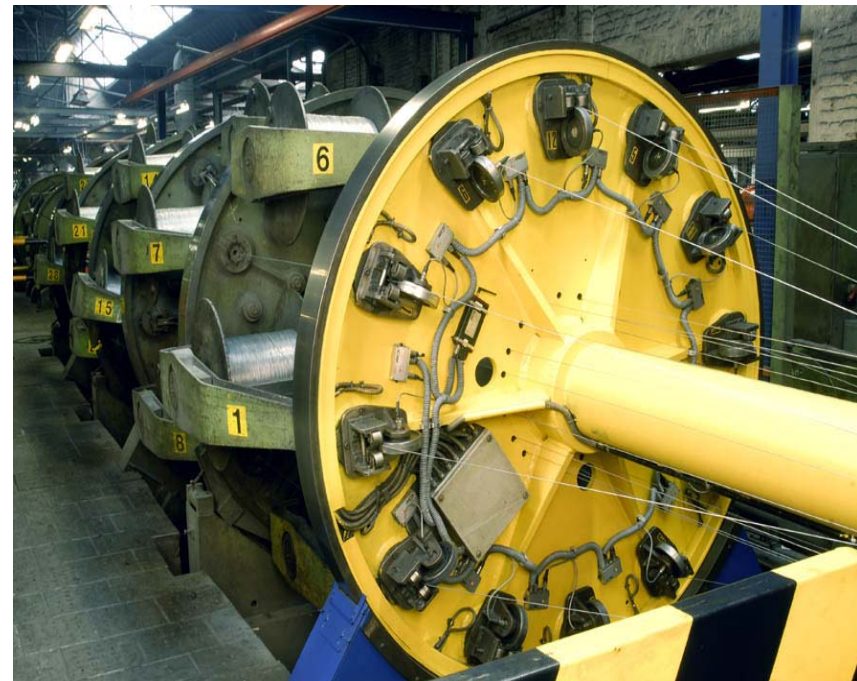
Description:

Application of a steel wire strander with tension measurement and data transfer through Radio transmission. All tension data can be monitored on PC screen. Using a CAN bus to connect all amplifiers and RF to transmit signals to PC.

System: RTM02, 12 channels

Load Cells: RMGZ531B

Material: Steel cables \varnothing 30-60mm
from strands \varnothing 4-10mm



RMGZ400 Force Measuring Roller

Description:

Application of copper wire strander for the production of electrical cables.

System: 24 EMGZ306A Amplifier

Load Cells: 24 RMGZ422

Material: Copper cables



RMGZ422B Force Measuring Roller

System Description:

Application of closed-loop tension control:
12 FMS loadcells and amplifiers connected
to PLC (rotating!) which controls each
individual payoff drive to maintain
constant tension.

System: 12 EMGZ306A Amplifier

Load Cells: 12 RMGZ421B

Material: Multipolar electrical cables
strands \varnothing 0.5-1.0mm



High Performance Steel Cables for US Navy Aircraft Carriers.

System Description:

Application of 4m diameter strander for steel ropes for military applications. Each strand is measured individually with one FMS load cell. Amplifiers are connected through a ProfiBus and the bus signals transferred over slip rings.

System: 6 EMGZ470 ProfiBus Amp.

Load Cells: 6 RMGZ838

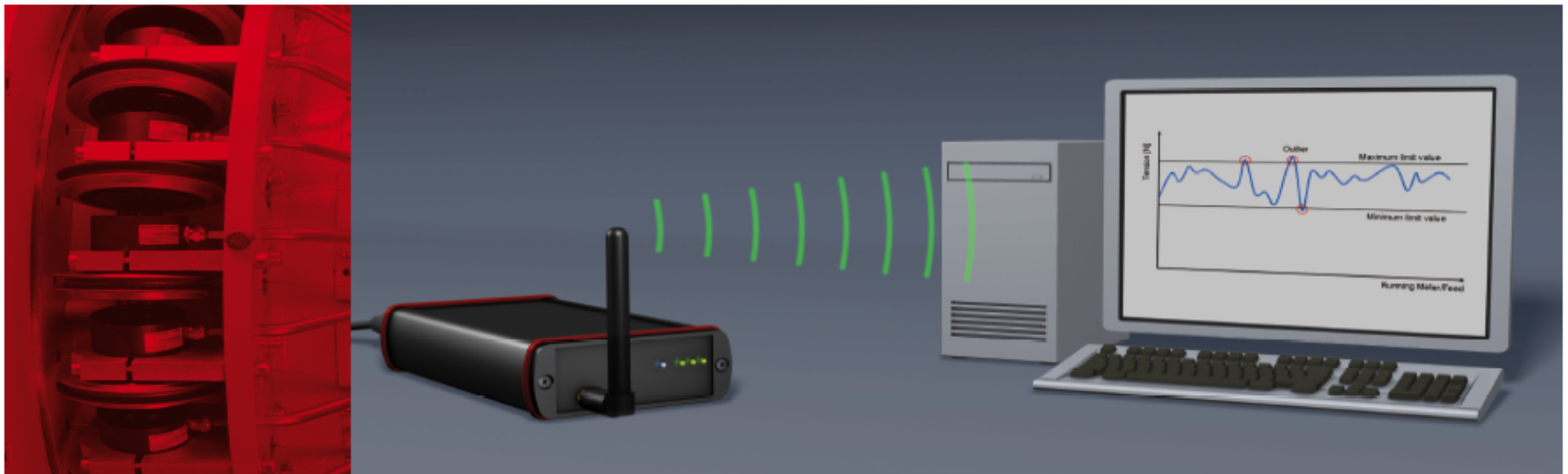
Material: Steel cables \varnothing 30-60mm
strands of \varnothing 4-10mm



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Future Trends



Tension Indication vs. Closed Loop Tension Control

- To be able to meet the future quality demands generally speaking there needs to be:
 - higher process stability
 - higher process reliability
 - better documentation of process variables
- Amongst other parameters tension of the single wires / strands is a very important one



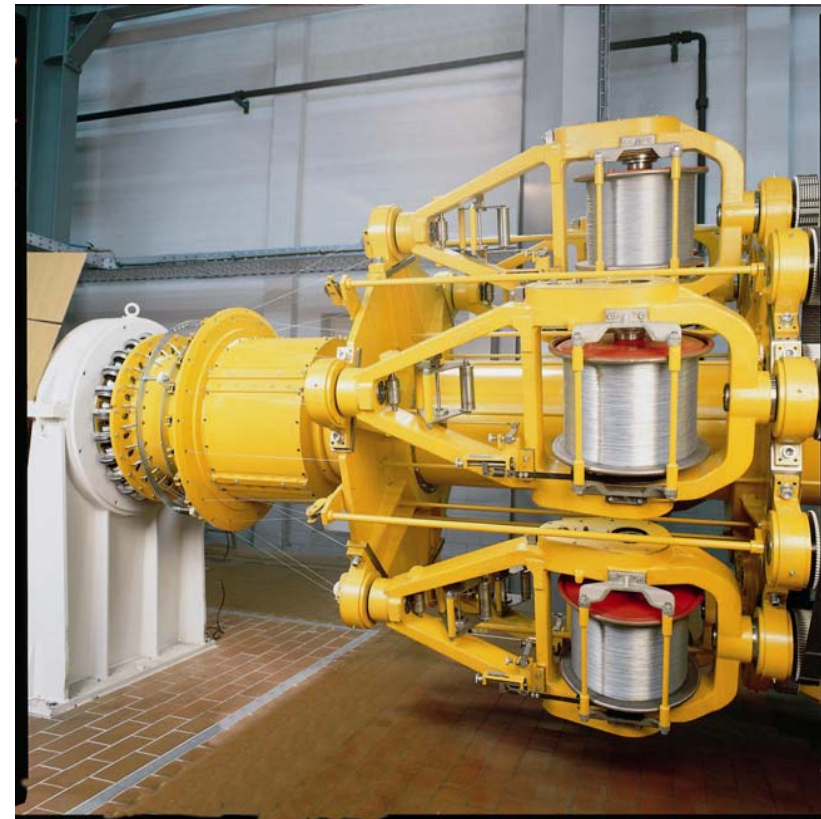
Tension Control Providers Can Support these Improvements with:

- Optimized load cells for rotating applications
- Closed-loop tension control systems
- Standardized systems for data exchange between rotating and static part
- Provide easy connection to PLC or PC to document process parameters



■ Machine Builders can Support these Improvements with:

- Design load cells as standard
- Make each individual payoff easily accessible for 2 electrical conductors



Users of Stranders Can Support these Improvements with:

- Ask their machine suppliers for tension control solutions
- Get aware of the possibilities and advantages of tension measurement and control

