Influence of Cabling on Current Carrying Properties of MgB_2 Superconductors

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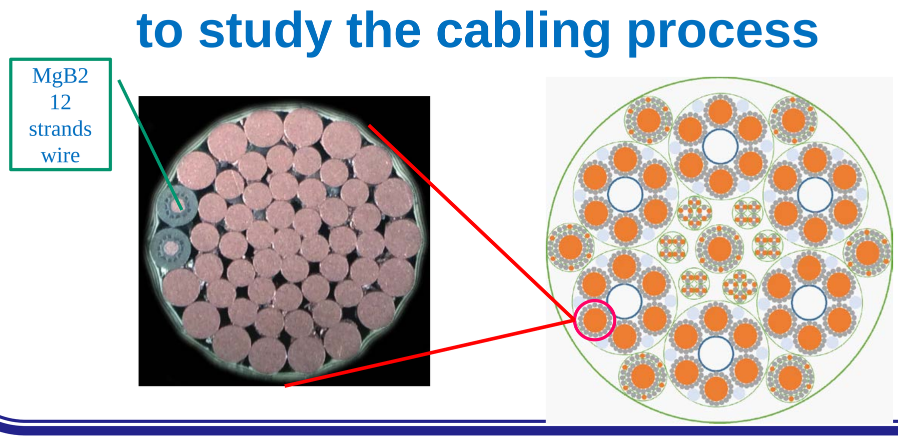
Objectives.

High- current links based on MgB2 superconductors (SC-Links) are being developed at CERN for the feeding of the superconducting magnets of the LHC High-Luminosity project. The MgB_2 superconductors are very sensitive to the strains that naturally happen during cabling. Several studies were performed recently to evaluate the electromechanical characteristics of MgB_2 conductor for both tapes and round wires. The degradation of critical current with applied loading and limited strain values were found for different types of MgB_2 wires.

However, it is difficult to find out real deformations that can happen during cable manufacturing with industrial cabling machines. Therefore, the good idea is the experimental "step-by-step" control of the critical current during cabling with subsequent modification of the cabling machine to minimize the Ic degradation of MgB2 wires. We performed the practical study of the model cables using both round and flat MgB_2 wires manufactured by real cabling machines. The measured critical currents of the MgB2 wires e at different stages of the fabrication and after modification of cabling machines are compared with the critical currents of the virgin MgB_2 wire. The comparisons are presented as temperature dependences of critical currents from 10 to 30 K.

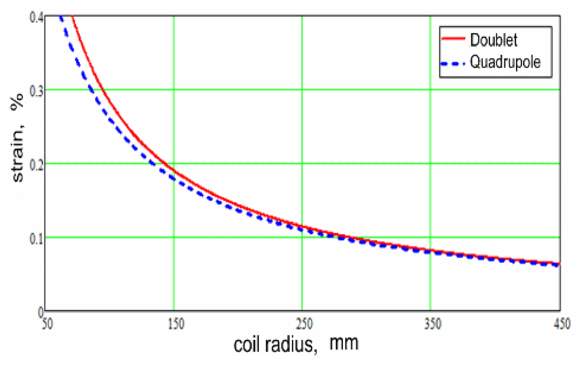
Basic 18 strands cable was used to study the cabling process

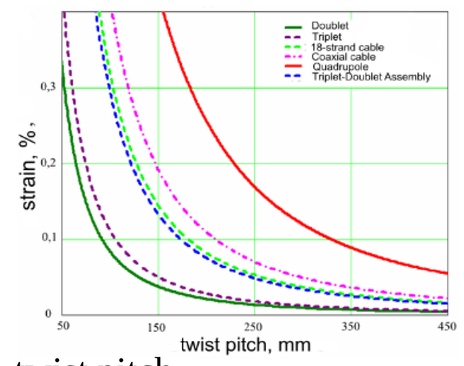


Preliminary calculation based on data from [5] returned allowed twist pitch and bobbin radii

$$\varepsilon_t = \frac{F}{S \times E}$$

$$\varepsilon_{\max} \geq \frac{2\delta}{D_i} \cdot \sin^2 \beta_i$$

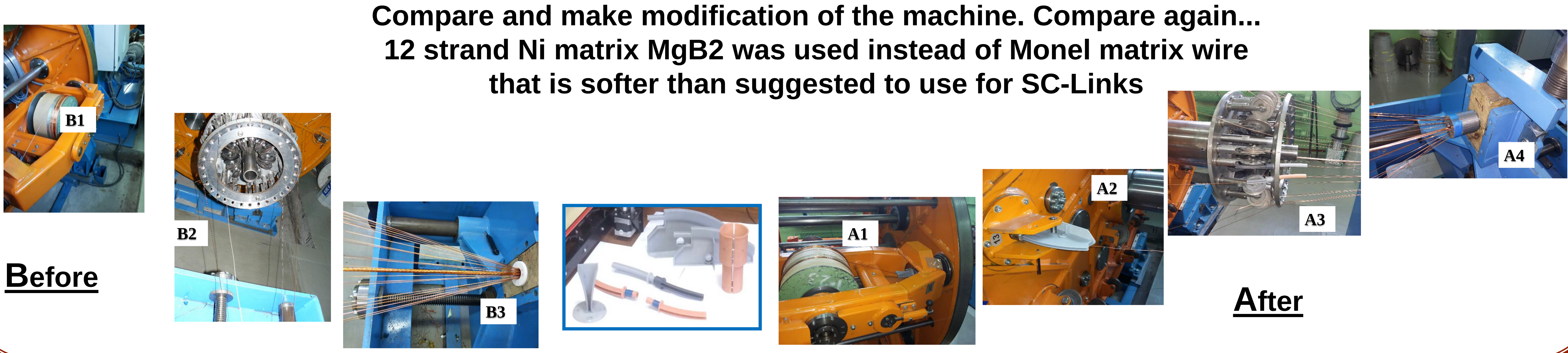




Calculated dependencies of strain in the SC-Link components on coil radii and the twist pitch.

EXPERIMENTAL : take wires from the machine at different cabling stages and measure $I_c(T)$. Compare and make modification of the machine. Compare again... 12 strand Ni matrix MgB2 was used instead of Monel matrix wire that is softer than suggested to use for SC-Links

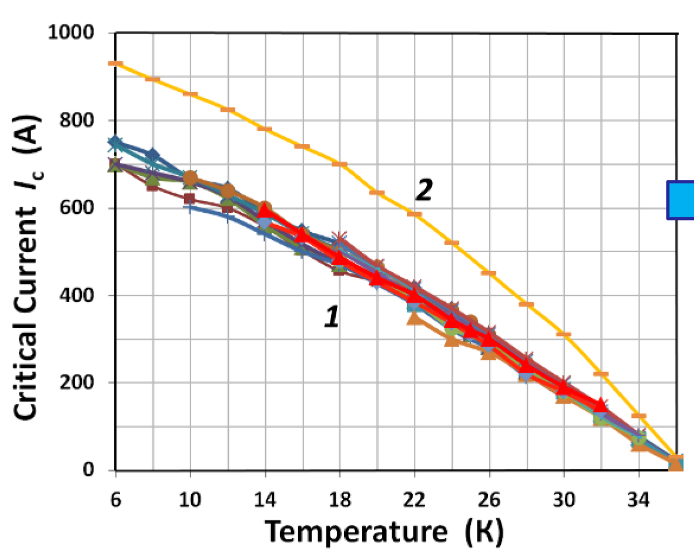
Before



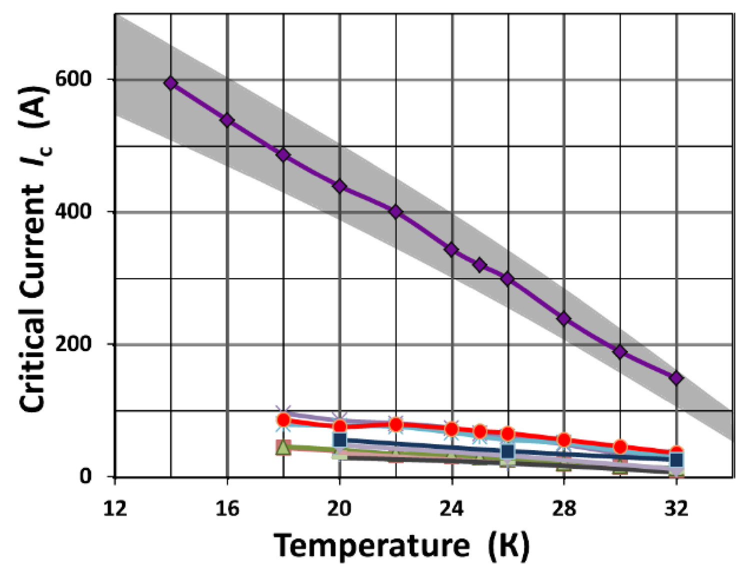
After

RESULTS:

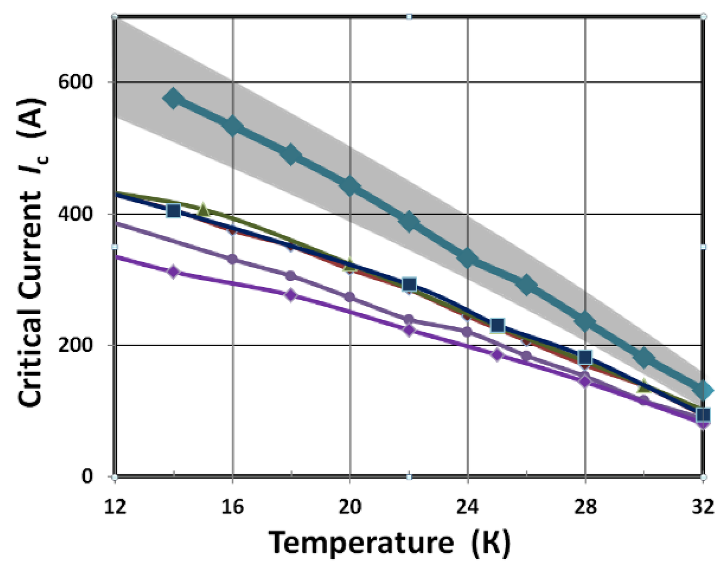
Grey area represents Ic scattering in the initial wire



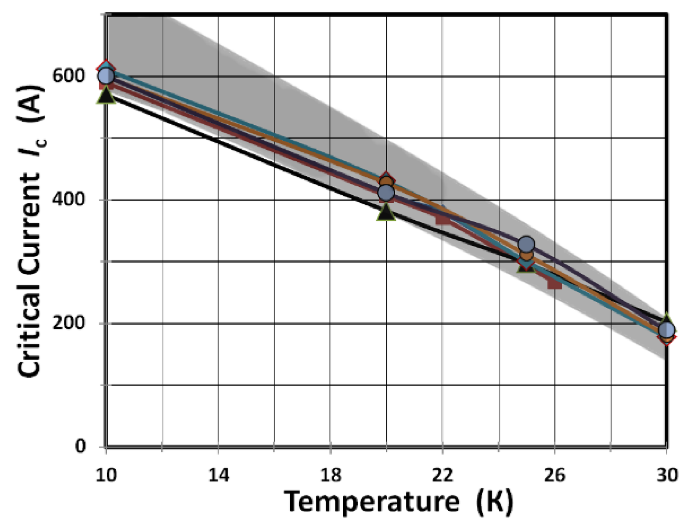
Virgin wires
1 - 12 filament round wire in nickel matrix;
2 – 37 filament round wire in Monel matrix
If we will be able to handle Ni matrix wire – we could work with Monel wires



Top – initial wire and wire after winding onto pay-off reel (point B3)
Bottom - at the exit of the cabling machine (point B3) (before twisting the cable)
Pay off coil is OK, machine has to be modified.

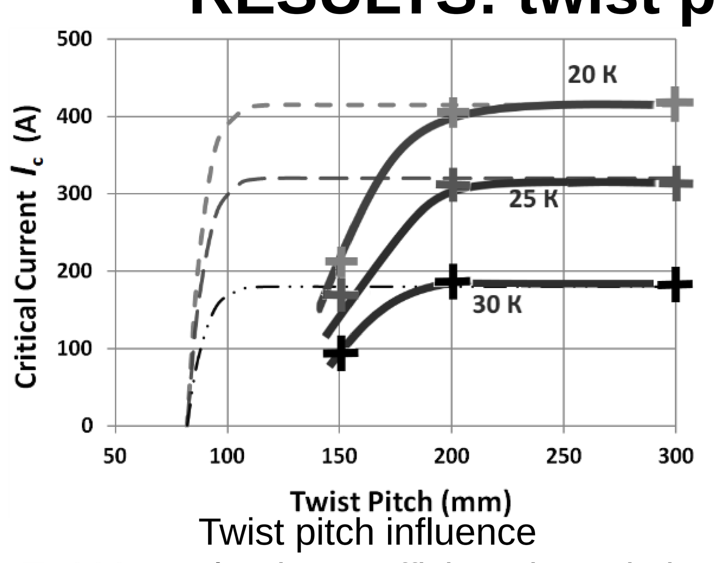


After modification of the machine
Top – the virgin wire and after point A4;
Bottom - cable twisted with T_p = 200 mm
More modification have been done.

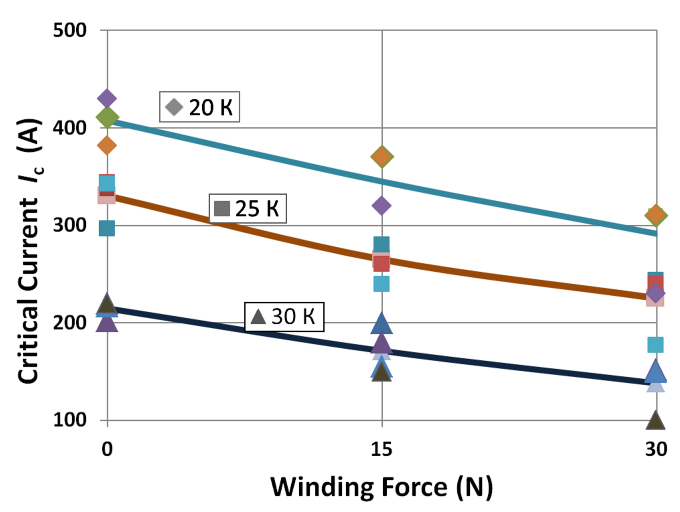


Twist pitch study
▲, ○ - 300 mm twist pitch before (A4) and after twisting unit;
■, ♦ - 200 mm twist pitch before (A4) and after twisting unit.
We overcame machine problems for 18 strand cable.
Passing machine does not affect wires
Twist pitch as short as 200 mm – is OK for the 18 strands basic cable for 18 strand cable diameter

RESULTS: twist pitch and insulation

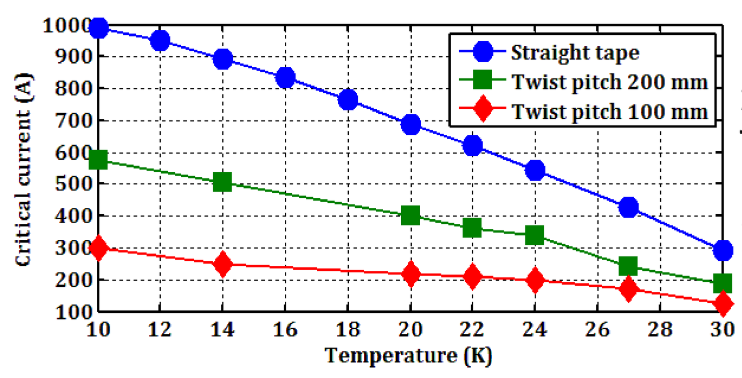


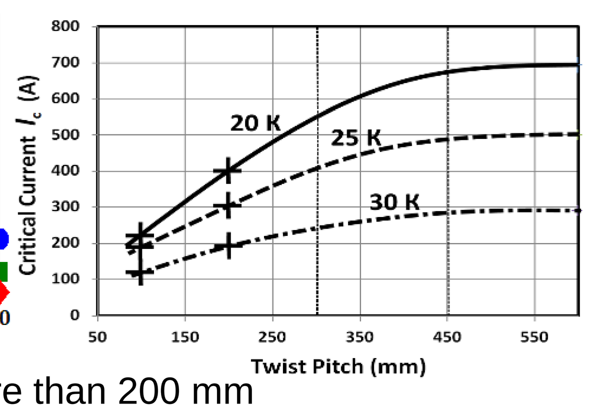
Twist pitch influence
T_p 200 mm leads to sufficient degradation of I_c, that is more than it was expected from estimations.



Two layers insulation influence .
18-strand model cable with a twist pitch of 200 mm

Experience from previous studies: flat wire for hybrid energy transport line [2, 3]





Twist pitch should be more than 200 mm
If T_p have to be less (to bend entire cable) consider some controlled degradation: <10% in straight cable with Tp~450 mm, or ~20% in 30 m flexible cable with T_p~330 m with cable bending to ~ ∅2 m

Direct pay-off to twisting could be used for cabling as well. Similar to flat MgB2 cables of to 1G HTS power cables

Conclusions

Experimental study has been performed to find out how the cabling on industrial cabling machines affects critical currents MgB_2 wires.
Proper upgrading of cabling machine allows to minimize current degradation I_c in the cable, in spite of a sensitivity of the MgB_2 wires to strain.
Sometimes a compromise is required to simultaneously provide acceptable flexibility and the demanded I_c of the MgB_2 cable.

1. REFERENCES
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