Compression testing results

UBS n°10 – 12/10/22

Objectives

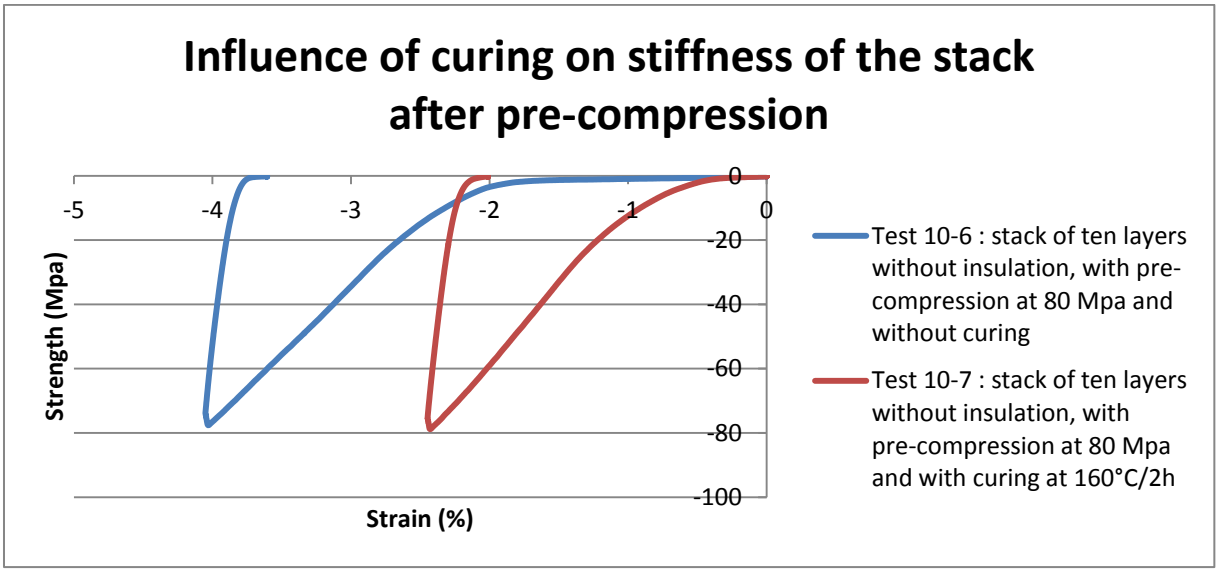
- To know the influence of curing process on the evolution of mechanical properties.
- To determine the influence of interfaces between layers on the stiffness of the stack.
- To check the measurement method by using solid copper samples.

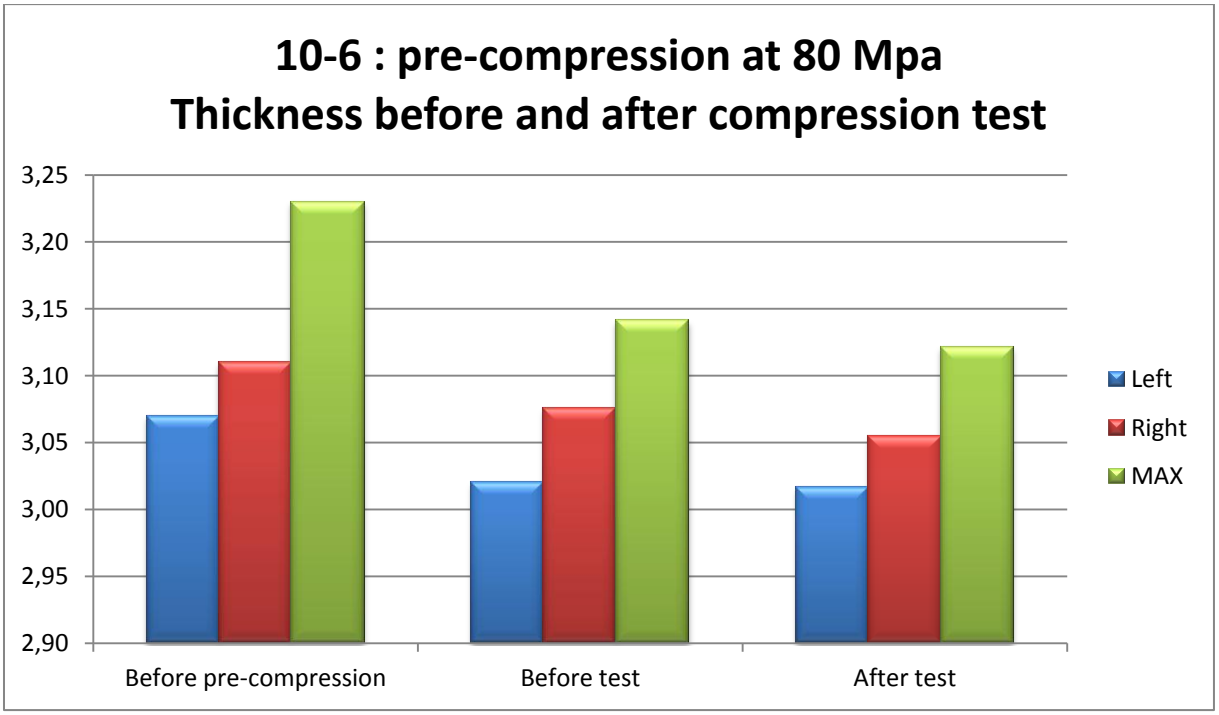
Materials and methods

Sample	Manufacturing process	Compression test
Stack 10-2	Stack of 10 full copper layers at 160°C / 2h Dimensions : 40 x 25 x 3 mm	2 cycles at 80 Mpa
Stack 10-3	Stack of 10 full copper layers with insulation and curing at 160°C / 2h	2 cycles at 80 Mpa
Stack 10-4	Stack of ten conductor layers without insulation and without curing	-000 : 1st cycle at 80 Mpa -001 : 2nd cycle without moving the stack -002 : 3rd cycle with layers removed and replaced in the same order -003 : 4th cycle by changing the order of layers -004 : 5th cycle without moving the stack
Stack 10-5	Stack of ten conductor layers without insulation and with curing at 160°C / 2h	Compression of each layer at 80 Mpa then compression test at 80 Mpa on the stack of pre-compressed layers
Stack 10-6	Pre-compression at 80 Mpa	Compression at 80 Mpa
Stack 10-7	Pre-compression at 80 Mpa then curing at 160°C / 2h	Compression at 80 Mpa

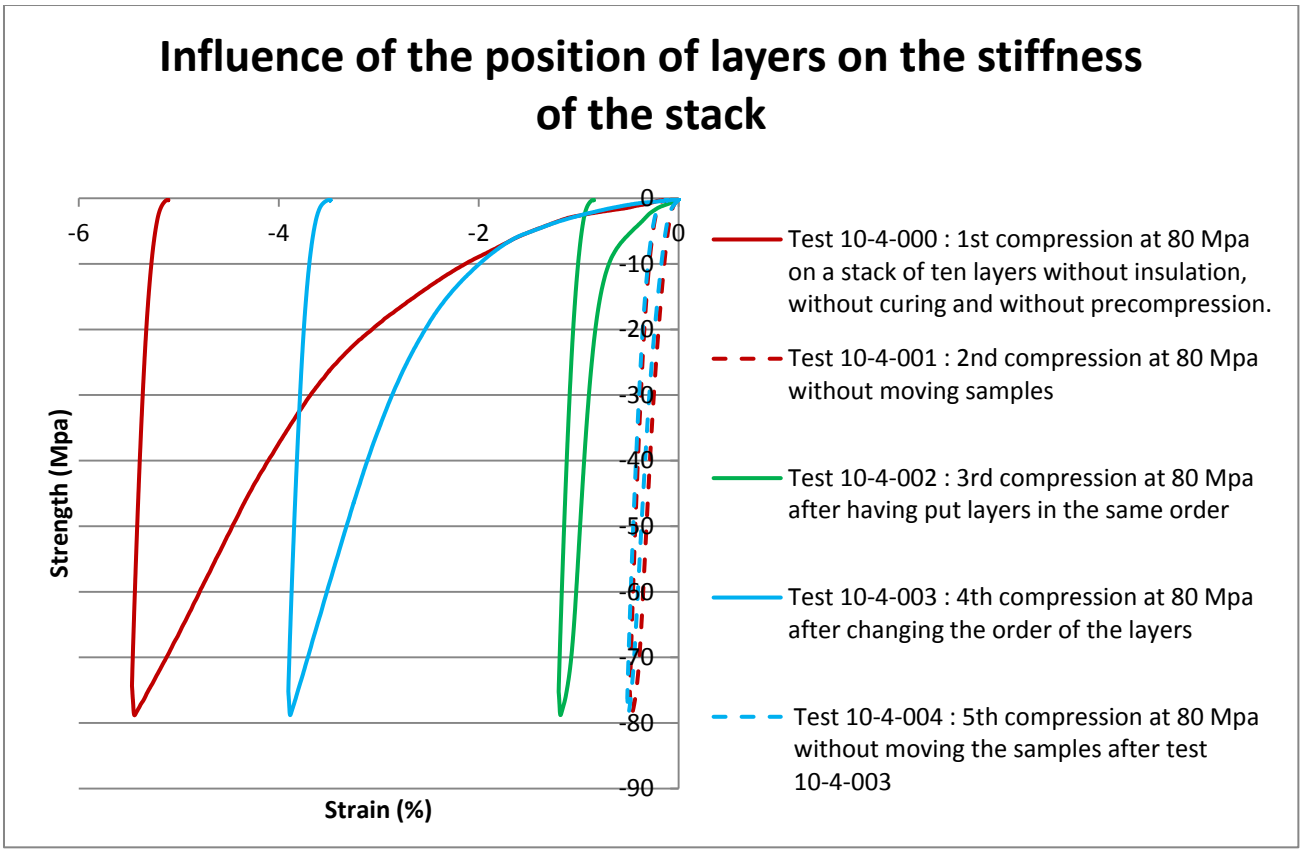
Results

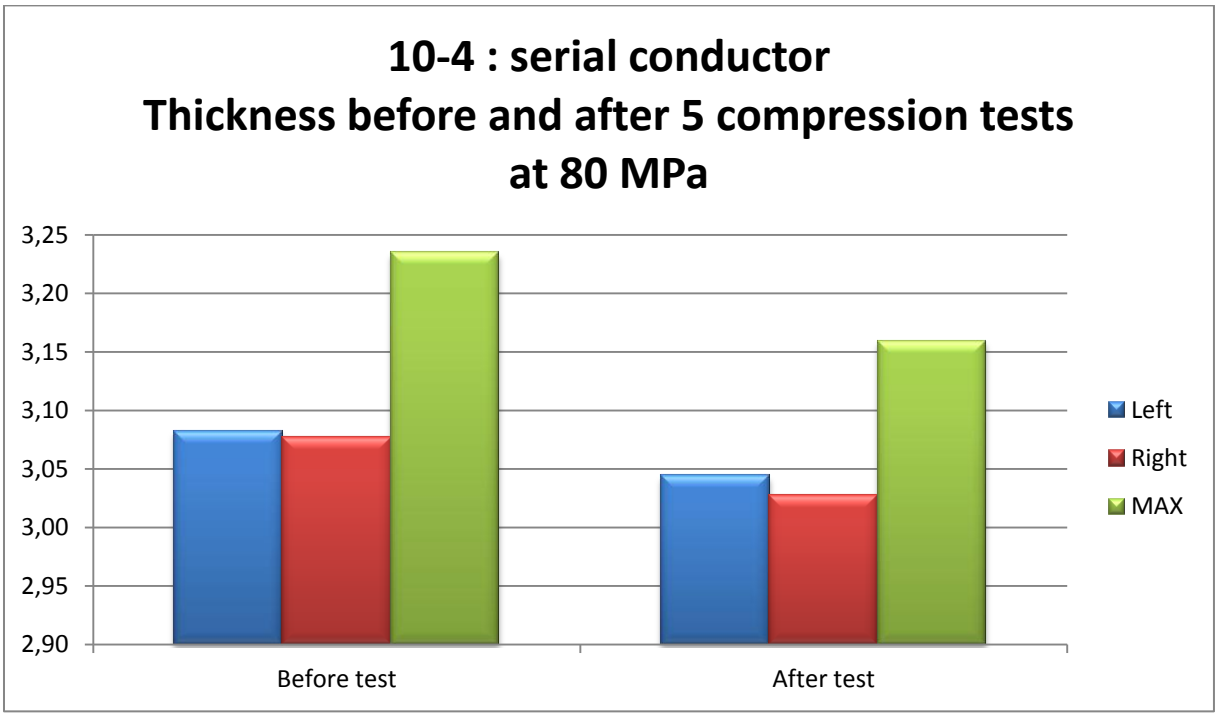
- The stack has the same stiffness before and after curing process. Consequently this range of temperature doesn't degrade mechanical properties.



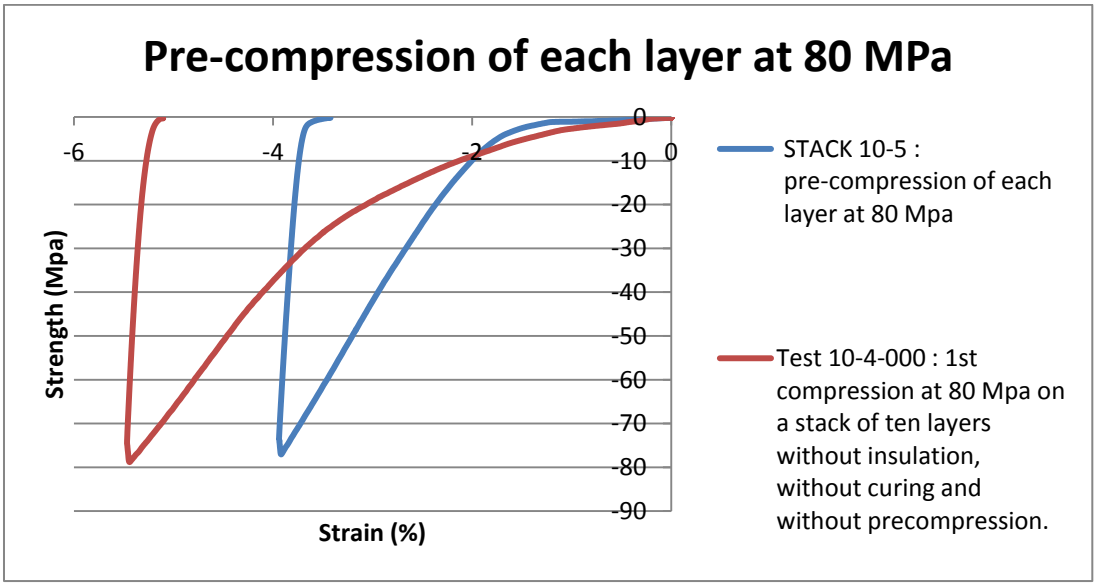


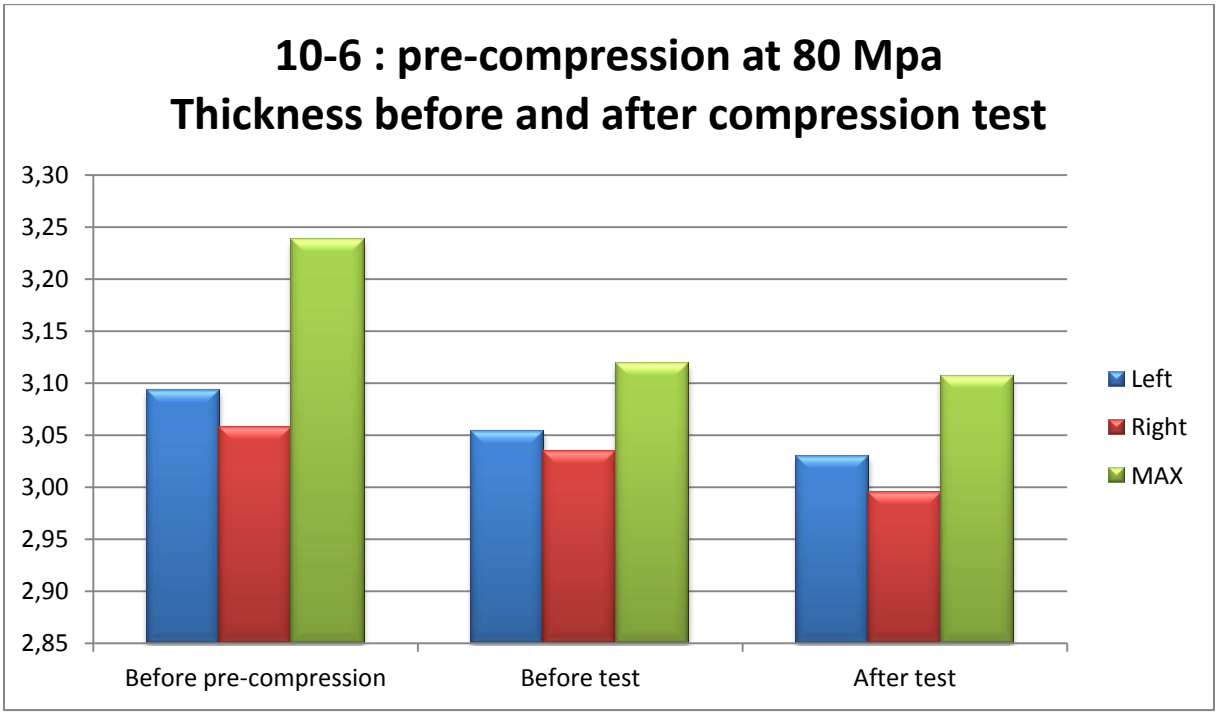
- We observe that interfaces between layers have a strong influence on the stiffness of the stack. It seems that this lack of stiffness comes from flatness defects and gaps between layers. These defects have a more significant impact on the stiffness than mechanical properties of the conductor.



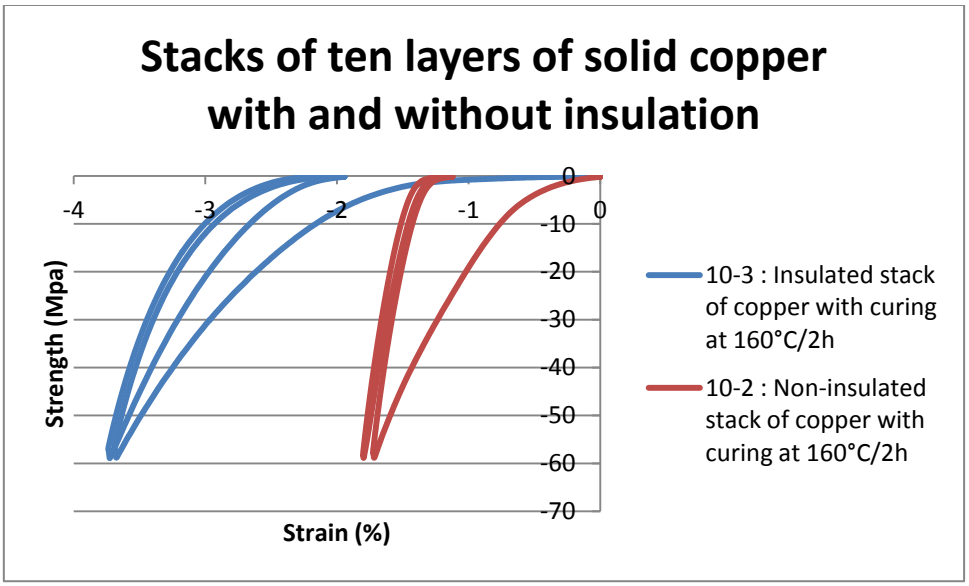


- After pre-compression of each layer, there is no improvement of the mechanical properties of the stack. It's not coherent with testing results of June on the prototype conductor. Other tests have to be performed on prototype conductor in order to understand this difference.





- Tests performed on solid copper samples with and without insulation prove two things :
  - Stiffness is less significant with insulation (Kapton + BStage + curing at 160°C/2h).
  - The lack of stiffness during the first cycle is probably induced by the interface between layers because there is no plastic strain of the solid copper (3 measurements on each layer before and after test). It's the same phenomenon than for the conductor except that strain at the end of the test is less significant than with a stack of conductor.



However there are between two and three times more strain at the end of the compression test with a stack of conductors (irregular interface) than with a stack of solid copper (interface supposed perfect).

Next compression tests

Sample	Manufacturing process	Compression test
Test 11-1	Cut of the serial conductor (E002) L =10x300mm Wrapping without Kapton Curing at 160°C/2h with a realistic torque on screws Cut of the samples every 40mm	Compression test at 80 Mpa in order to observe if there is a stiffness improvement without Kapton
Test 11-2	Pre-compression at 120 Mpa (1m already manufactured) Wrapping without Kapton Cut of the samples at L = 70mm Curing at 160°C/2h with a realistic torque on screws Cut of the samples at L = 40 mm	Compression test at 80 Mpa in order to observe if there is a stiffness improvement without Kapton and with pre-compression
Test 11-3	Pre-compression at 2.95mm (1m already manufactured) Wrapping without Kapton Cut of the samples at L = 70mm Curing at 160°C/2h with a realistic torque on screws Cut of the samples at L = 40 mm	Compression test at 80 Mpa in order to observe if there is a stiffness improvement without Kapton and with pre-compression
Test 11-4	Cut of 20 samples of serial conductor E002 (L=40 mm maxi)	Compression test at 80 Mpa in order to compare with prototype conductor
Test 11-5	Cut of 20 samples of prototype conductor (L=40 mm maxi)	Compression test at 80 Mpa in order to compare with testing results of June.
Test 11-6	Pre-compression of serial conductor at 80, 100, 120 Mpa and at 2.95mm (L=1m)	Preparation of samples for critical current measurements.