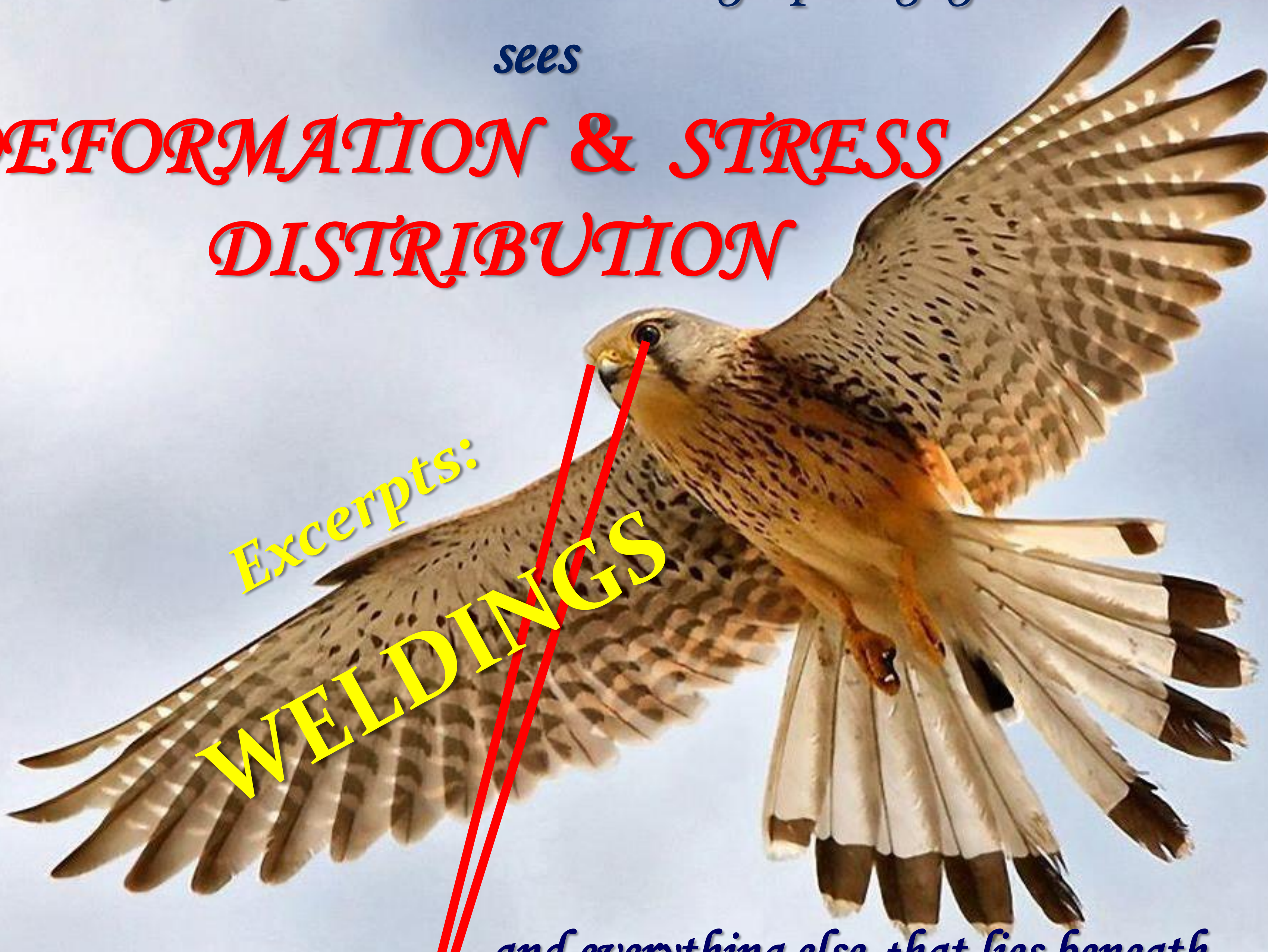
"Laser-FALCONEYE" holographic gage-camera

sees

DEFORMATION & STRESS DISTRIBUTION



Excerpts:

WELDINGS

and everything else that lies beneath...

„Laser-FALCONEYE /V-H”

holographic gage-camera

application possibilities:

3D VECTOR measurement of

DEFORMATION and STRESS

DISTRIBUTION

to control:

deformation & distortion...

load-carrying capacity & load transfer...

structural integrity & shape stability...

(Januar 2015)

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The followings are only excerpts for WELDINGS

For complete brochure of L-FE gauge camera, please, contact

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HOLOMETROX
Holographic Metrology Ltd.
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Basic function and basic requirements

3D surface measurement of

DEFORMATION (SHAPE CHANGE)

/ and what can be calculated from it:

DEFORMATION QUANTITIES (RELATIVE DEFORMATION)

STRESS DISTRIBUTION /

with submicron/nanometer sensitivity

Applies holographic „photography” with laser light

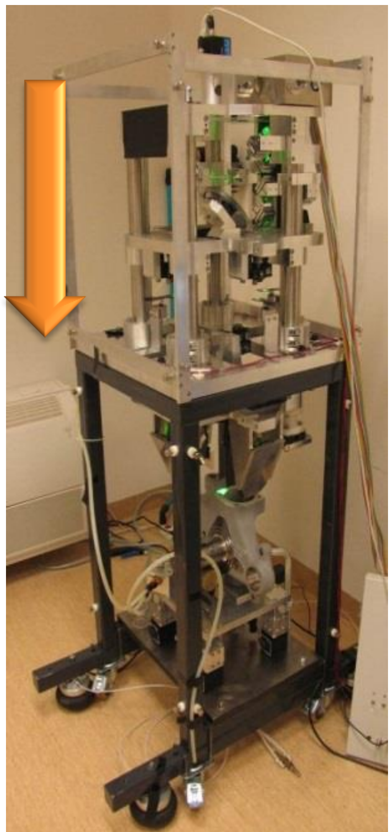
- using the records of the states before and after deformation
while the object can even be removed from the measurement
between the records

- using diffusely reflecting (painted, if necessary) surfaces
with unchanged surface microstructures

2. Hardware realizations

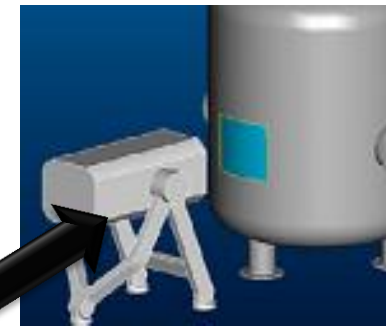
Present
/multi-purpose instrument under development/

and the near future...

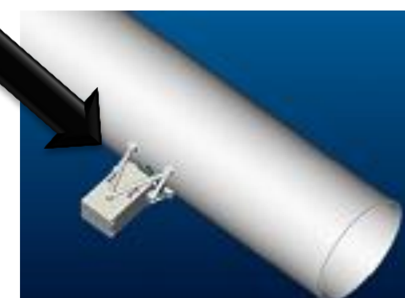


Laser-FALCONEYE/V1 and V2
(upper and lower object clamping)

Laser-FALCONEYE/H
with horizontal (sidewise)
object clamping



separate
Laser-FALCONEYE / Def-XL
for measuring deformation of
large objects



miniaturized
Laser-FALCONEYE / Str-XS
for stress measurement

3. Technical parameters

SENSITIVITY	
Basic value	**0,05 μm**
Extendable to:	0,005 μm

MEASURING RANGE	
Basic value	**0,25 μm – 25 μm**
Extendable to:	0,25 μm – 500 μm

FIELD OF VIEW	
Basic value	**35 mm x 50 mm**
Extendable to:	350 mm x 500 mm

SPATIAL RESOLUTION OF MEASURING POINTS	
Basic value	**0,5 mm**
Extendable to:	0,005 mm

I. and II.
GENERAL TRENDS of application

I. *Actually formed* DEFORMATION

The goal: measuring actual deformation of an object,
as well as directly calculable quantities:
e.g. deformation and deformational stress change from change of shape...

II. *Applied* DEFORMATION – *for diagnostic purposes*

The goal: *not the measurement of actual deformation,*
but measuring other physical quantities,
which can be made measurable indirectly
by deliberately causing deformation in the object:
e.g. material deficiency, weak joints, material inhomogeneity,
***+ stress** (residual and entire, also) ...*

II. *Applied* DEFORMATION – *for diagnostic purposes*

NDT

II/A. STRUCTURAL INTEGRITY (I-II-III.)

(measuring the deformation from a proper diagnostic load:

hydraulic, pneumatic, mechanical, heat based..)

1. Material deficiency defects (wall thickness defects)
2. Material bonding defects (qualification of joints)
3. *Material structure homogeneity defects... /planned/*

semi-NDT...

II/B. and II/C. *Properties accessible from*

STRESS (DISTRIBUTION) and its CHANGE

(measuring the deformation from stress-releasing at blind hole drilling)

LOAD-CARRYING CAPACITY, STRUCTURAL INTEGRITY (I –II–III.), SHAPE STABILITY

/+ STRESS CORROSION...(planned)/

Specifically for qualification of weldings…

PRESSURE VESSEL - EXAMPLES

II/A. STRUCTURAL INTEGRITY (I-II-III.) /determined by deformation/

(measuring the deformation from a proper diagnostic load)

1. Material deficiency defects (wall thickness defects)

2. Material bonding defects,

by <u>DEFORMATION</u>

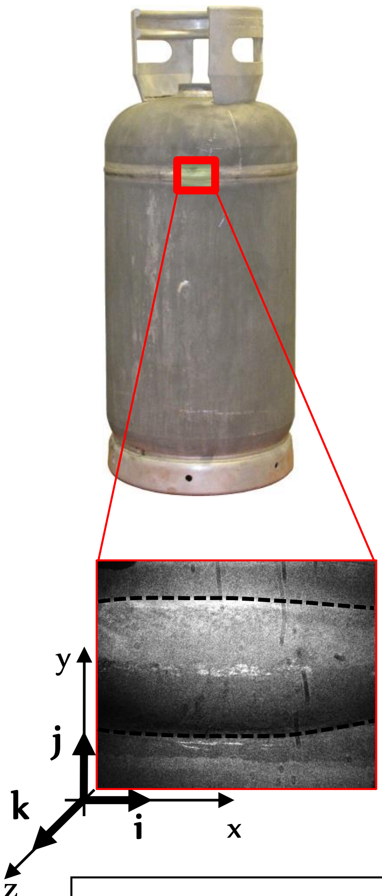
3. Material structure homogeneity defects… /planned/

Examined IN ITSELF

II/A. STRUCTURAL INTEGRITY (I-II-III.)

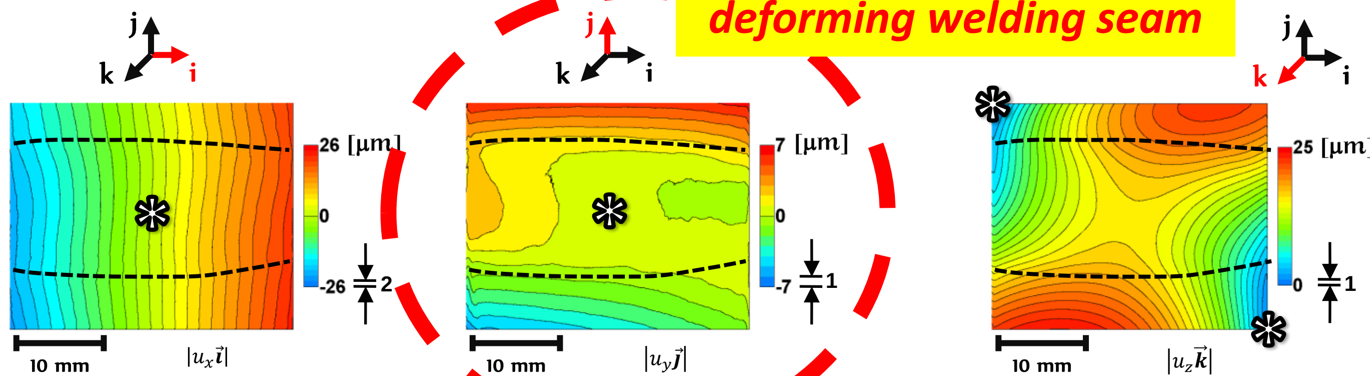
2. Material bonding defects (qualification of joints)

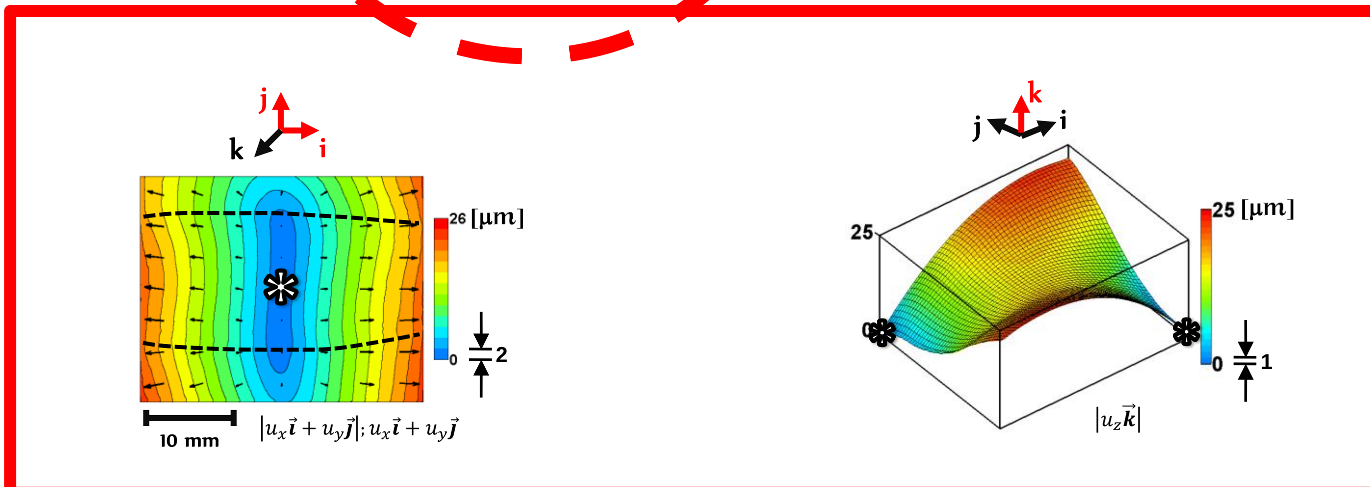
a. Welded aluminum gas cilinder



30 bar inner test pressure

Longitudinal non deforming welding seam





Deformation distribution of aluminum gas cylinder at 30 bar test pressure - with the deformation of welding seam

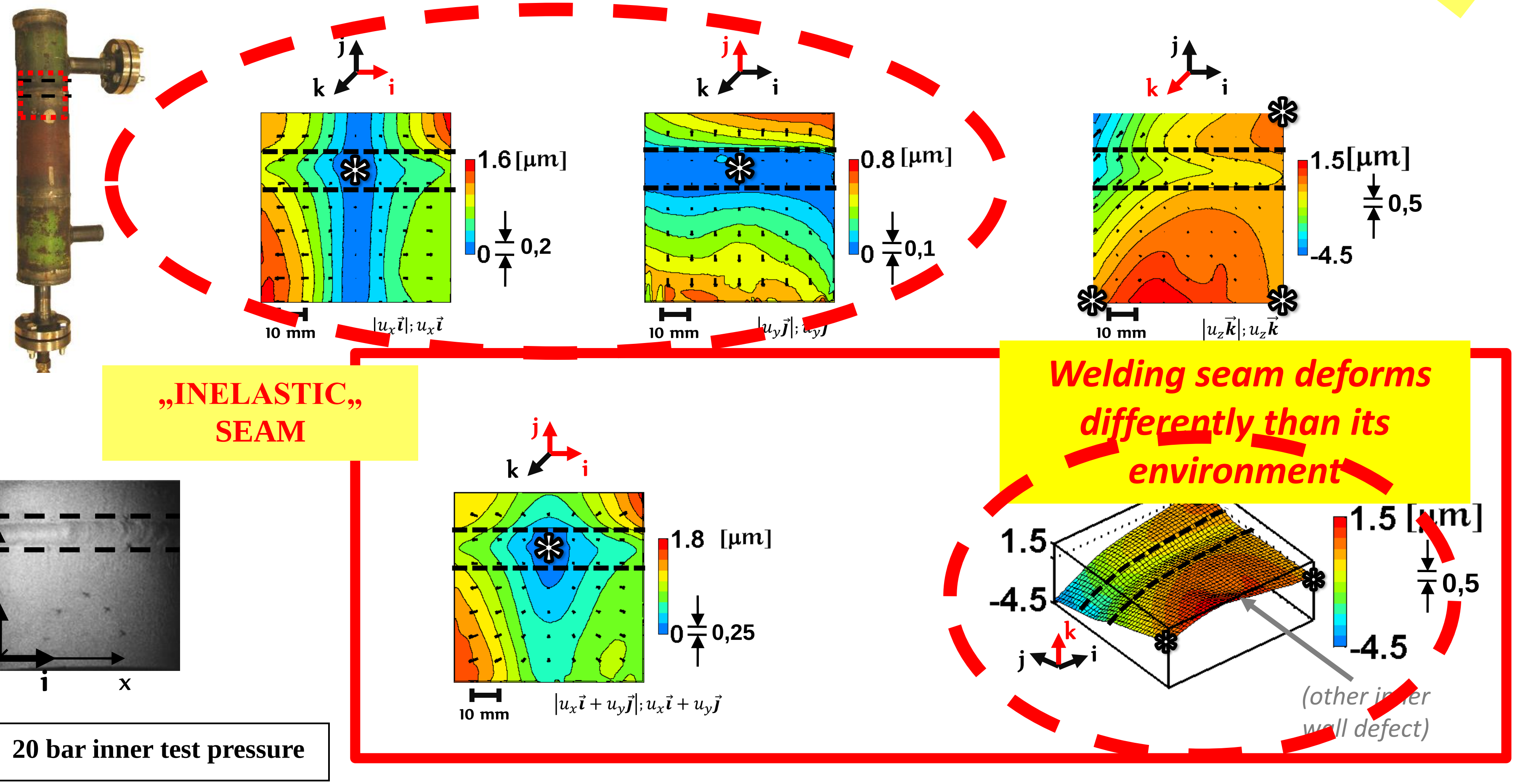
II. *Applied* DEFORMATION – *for diagnostic purposes*

II/A. STRUCTURAL INTEGRITY (I-II-III.)

2. Material bonding defects (qualification of joints)

a. Welded pipe (I – II.)

Examined IN ITSELF



20 bar inner test pressure

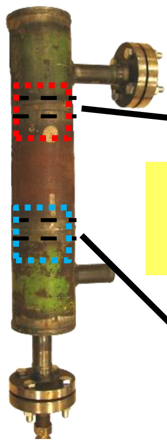
Strain distribution of a welded pipe at 20 bar test pressure
- with the “tightening” deformation of the seam

II/A. STRUCTURAL INTEGRITY (I-II-III.)

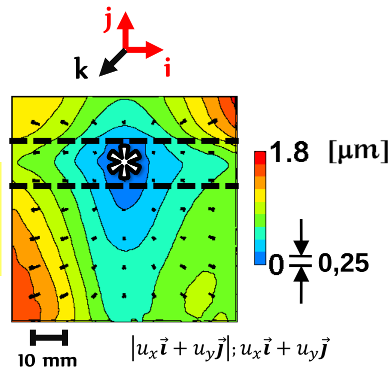
2. Material bonding defects (qualification of joints)

a. Welded pipe (I – II.)

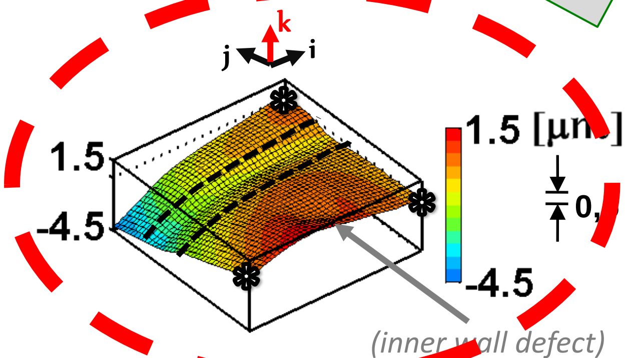
COMPARISON WITH REFERENCE



"INELASTIC" SEAM



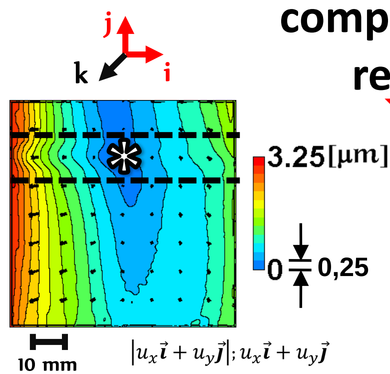
20 bar inner test pressure



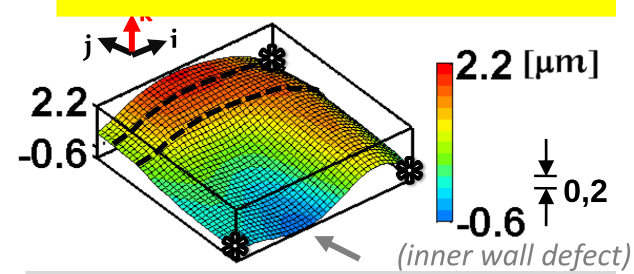
Welding seam deforms differently than its environment

optional comparison with reference

"ELASTIC" SEAM



20 bar inner test pressure



Welding seam deforms equally as its environment

Strain distribution of a welded pipe at 20 bar test pressure – comparison with the "elastic reference"

Specifically for qualification of weldings…

BASIC WELDING TYPE EXAMPLES

II/B. and II/C. ***Properties accessible from***

STRESS (DISTRIBUTION)

and its CHANGE

(measuring the deformation from stress-releasing at blind hole drilling)

***5** advantages of the Laser–FALCONEYE holographic gage-camera*
in stress measurement /compared to classical strain gage methods/

5 main advantages of the Laser-FALCONEYE holographic gage-camera
- compared to the strain gage rosette

I. HIGHER ACCURACY AND RELIABILITY

*because of the more complete displacement information (in 3D form and available on a surface at any distance from the edge of the hole), any theory of the stress measurement via stress-releasing can be fitted in more places and in more ways, too, to the multitude of the holographically measured values – furthermore, **the presence of inhomogeneous stress distribution is immediately visually detectable from the distortion of the interferometric fringe pattern!***

II. FASTER REPRODUCIBILITY - THEREFORE IT IS SUITIBLE FOR DETAILED SCANNING OF STRESS DISTRIBUTION!

because it is applicable faster and more simply in nearby points, even in the nodes of a dense measuring grid – which only requires „sewing machine-like” drilling sequences (which does not require precise drill-hole positioning)

III. FEWER REQUIREMENTS OF SURFACE QUALITY

because it does not come in contact with the surface of the object – aside from the drilling

IV. FEWER REQUIREMENTS OF THE SIZE, SHAPE AND ACCESSIBILITY OF THE SURFACE AROUND THE MEASURING POINT

because it only examines the area near the drill-hole – to about two times the hole radius

V. NO NEED FOR DIMINISHING MATERIALS (except for drill bits)

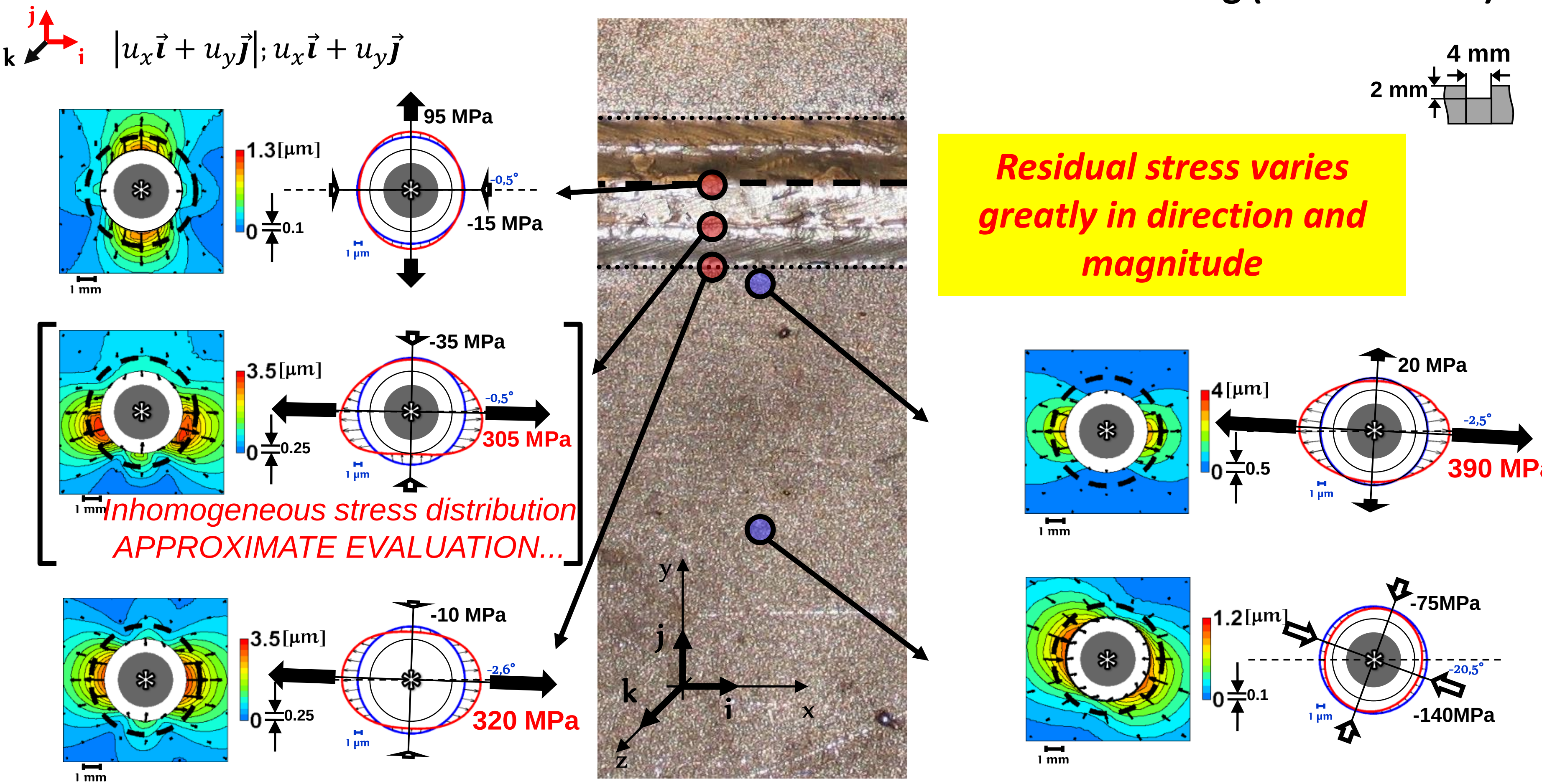
II. *Applied* DEFORMATION – *for diagnostic purposes*

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

1.1.3. DURING MANUFACTURING: b. Welding (I – II – III – IV.)



Stress distribution of the welding seam and its surrounding area in steel – for qualification of the welding technology

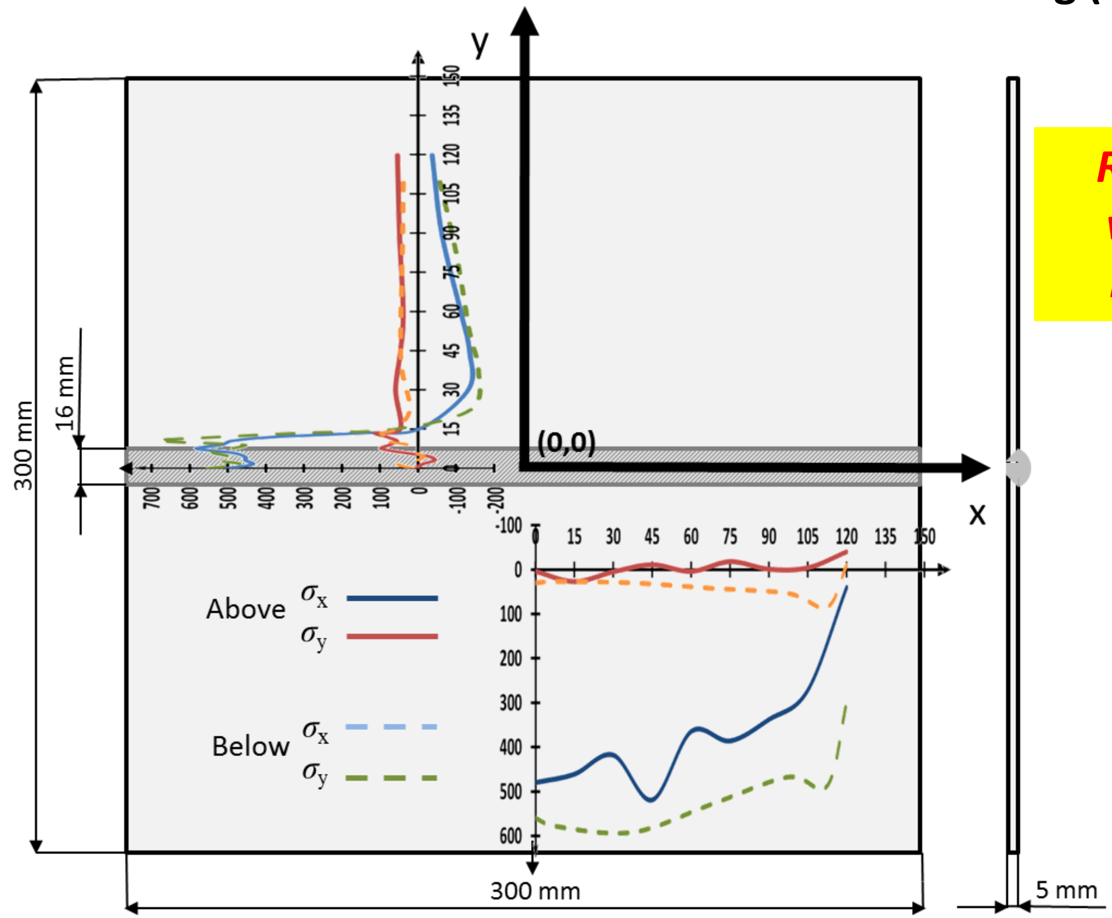
II. *Applied* DEFORMATION – *for diagnostic purposes*

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

1.1.3. DURING MANUFACTURING: b. Welding (I' – II – III – IV.)



Residual stress varies greatly in magnitude

Stress distribution graph of the welding seam and its surrounding area in stainless steel – for qualification of the welding technology

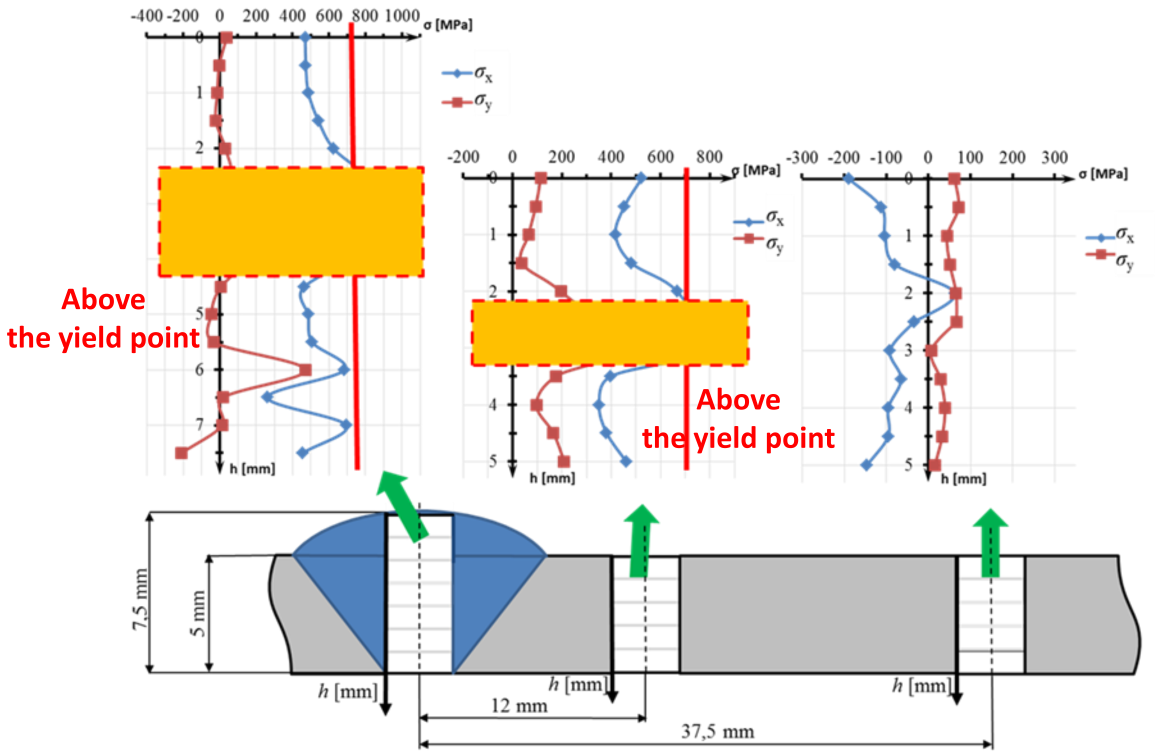
II. *Applied* DEFORMATION – *for diagnostic purposes*

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

1.1.3. DURING MANUFACTURING: b. Welding (I'' – II – III – IV.)



Residual stress varies greatly in magnitude,

above the yield point, too!!

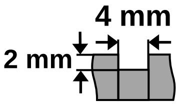
In-depth **stress distribution graphs of the welding seam and its surrounding area in stainless steel – for qualification of the welding technology**

II. *Applied* DEFORMATION – *for diagnostic purposes*

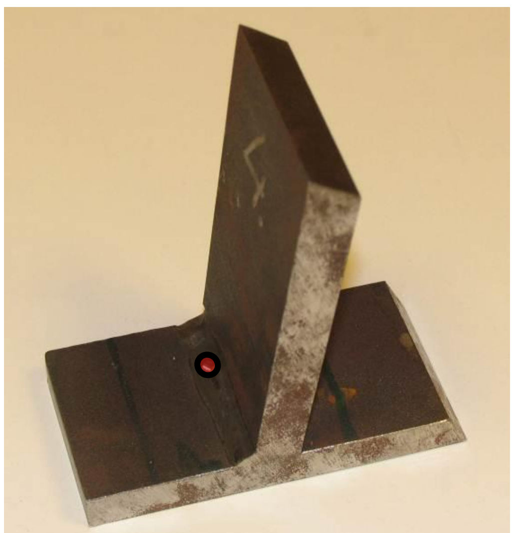
II/B. *Properties accessible from STRESS (DISTRIBUTION)*

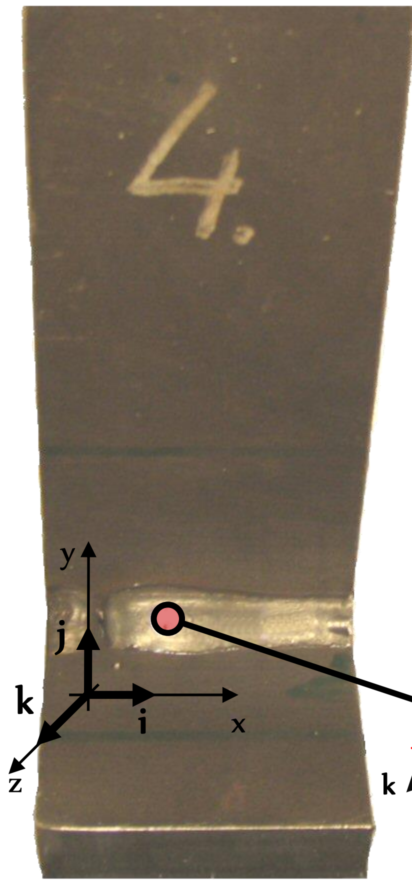
1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

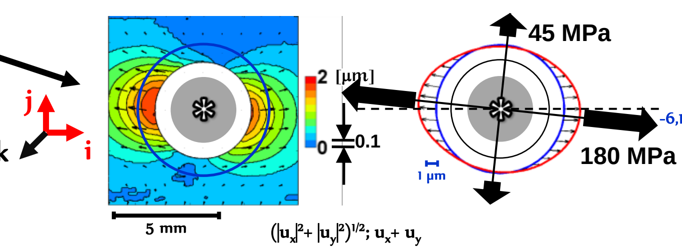


1.1.3. DURING MANUFACTURING: b. Welding (I – II – III – IV.)





Residual stress measured at an "inaccessible" region



Stress of corner weld (in one measuring point)

- for qualification of the welding technology

II/B. *Properties accessible from STRESS (DISTR*

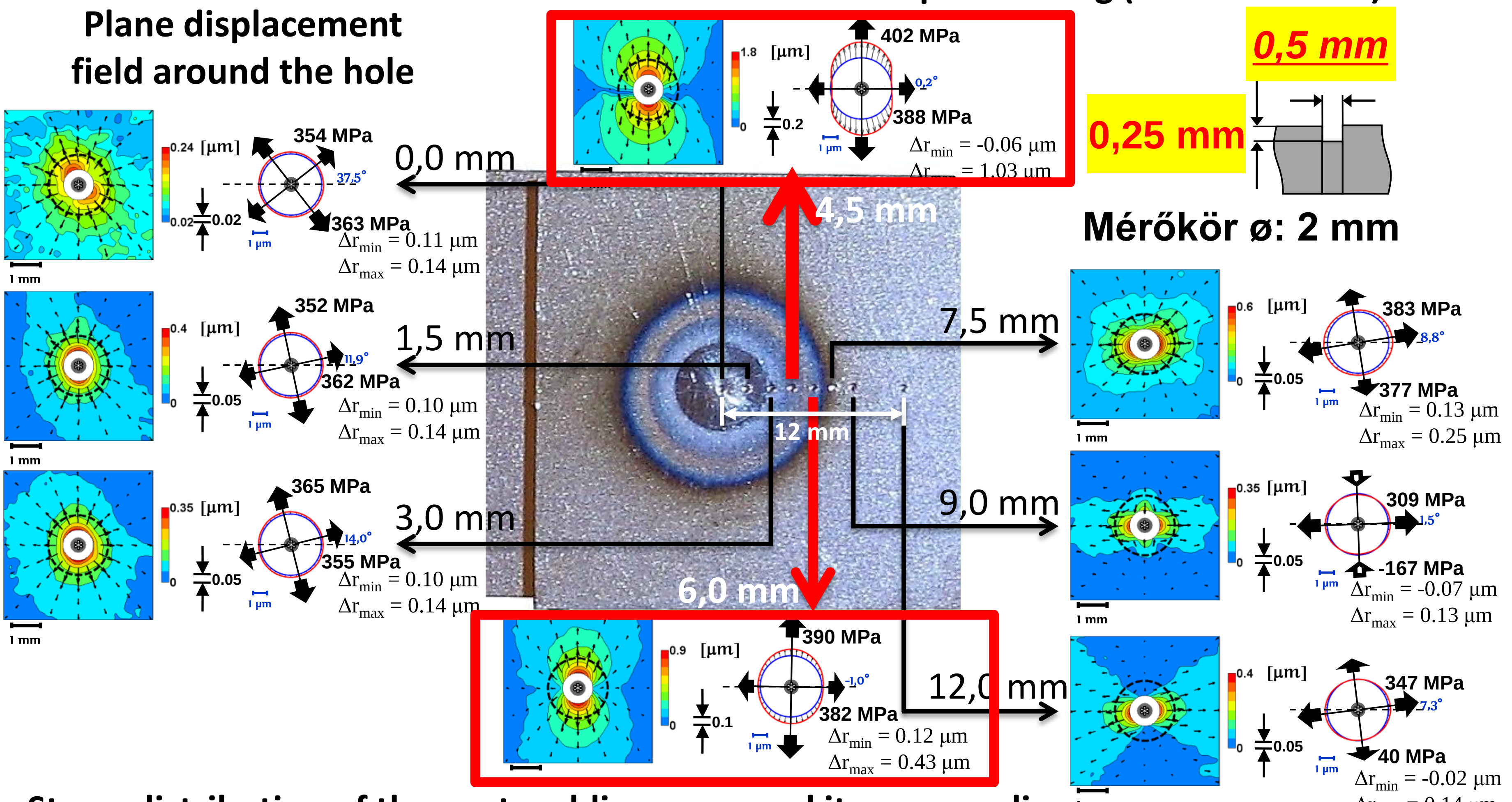
SEMI-NONDESTRUCTIVE with MINI-HOLE!!!

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY a

1.1.3. DURING MANUFACTURING: b. Spot welding (I – II – IIIa – IV.)

Plane displacement field around the hole



Stress distribution of the spot welding seam and its surrounding area

- for qualification of the welding technology

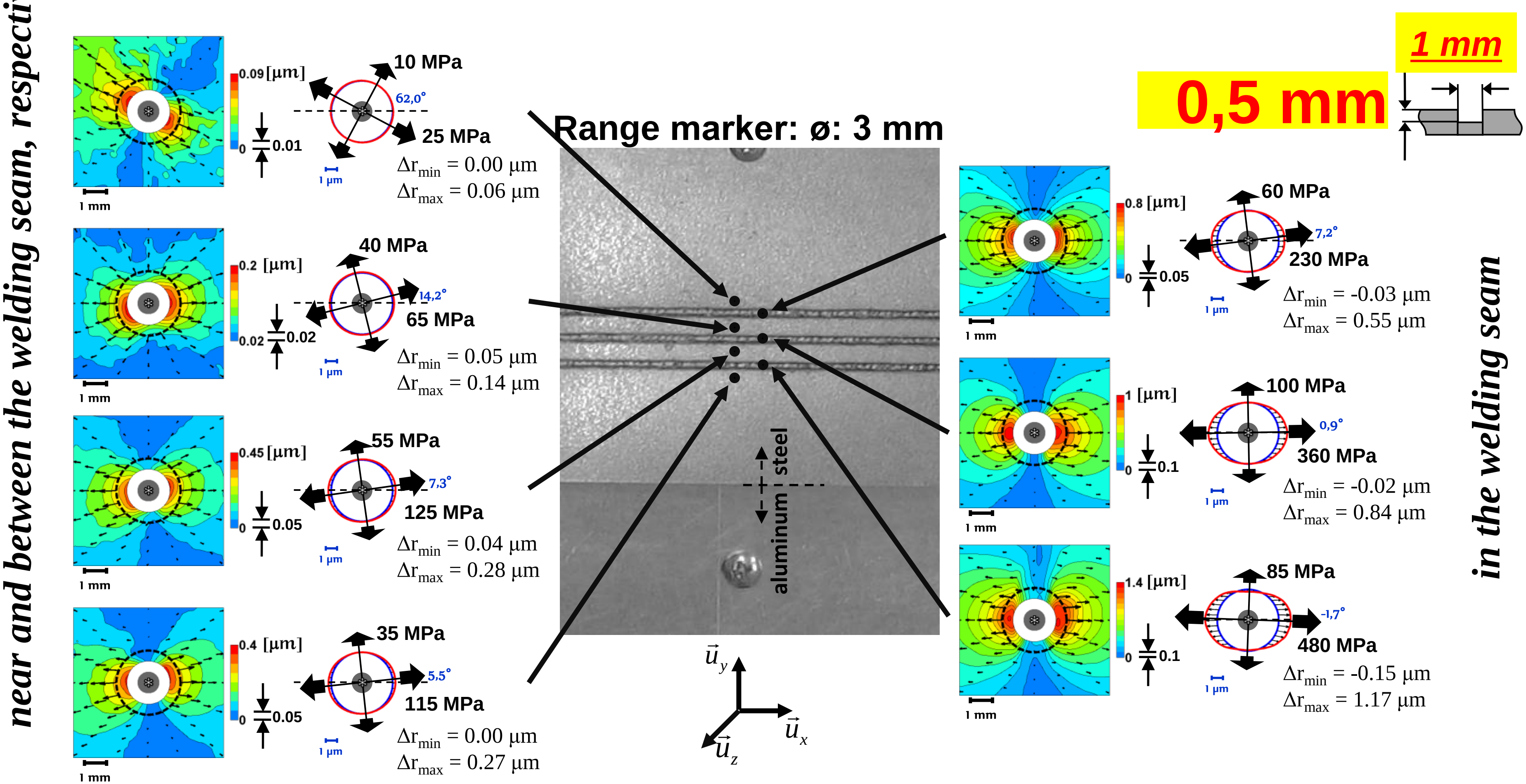
II/B. *Properties accessible from STRESS (DISTR*

SEMI-NONDESTRUCTIVE with MINI-HOLE!!!

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY a

1.1.3. DURING MANUFACTURING: b. Laser welding (I – II – IIIb – IV.)



Stress distribution of the laser welding of welded steel and aluminum plate - for qualification of the welding technology

II. *Applied* DEFORMATION – *for diagnostic purposes*

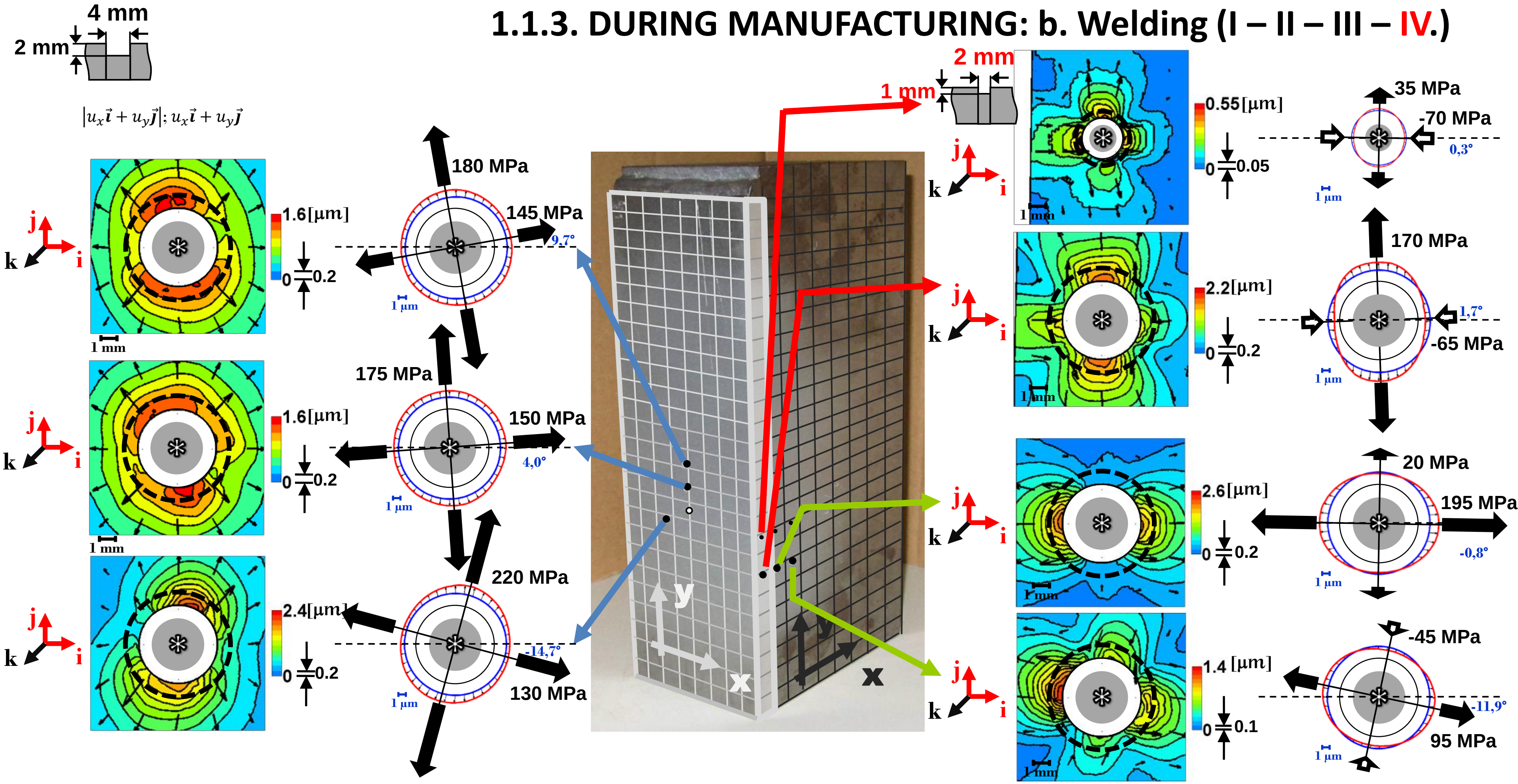
II/B. *Properties accessible from STRESS (DISTRIBU*

Residual stress varies greatly in direction and magnitude

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

1.1.3. DURING MANUFACTURING: b. Welding (I – II – III – IV.)



Stress distribution of the deposited layer of deposition welding and the substrate - for qualification of the welding technology (II.)

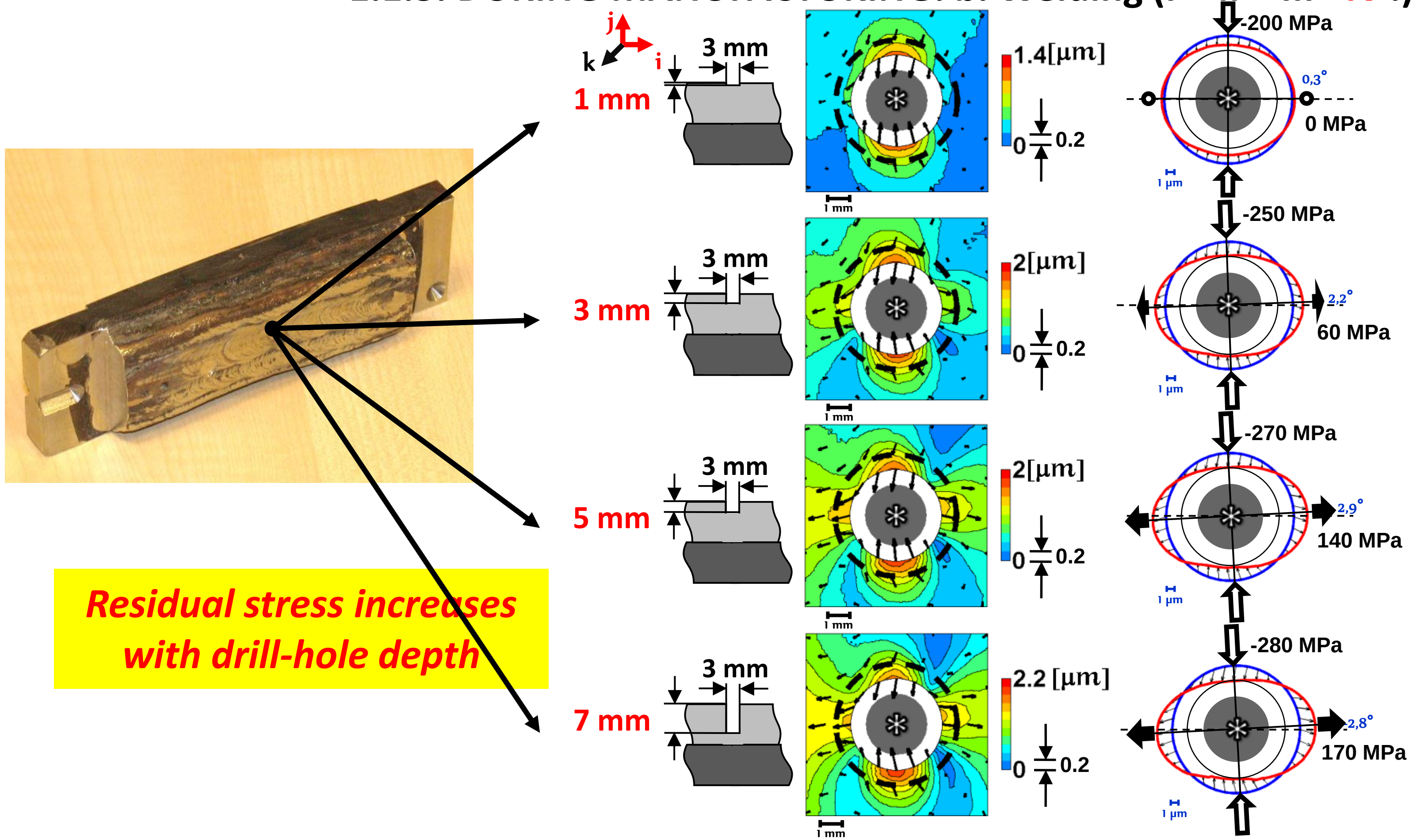
II. *Applied* DEFORMATION – *for diagnostic purposes*

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

1.1.3. DURING MANUFACTURING: b. Welding (I – II – III– IV'.)



Residual stress increases with drill-hole depth

Stress distribution of the deposited layer of deposition welding and the substrate - for qualification of the welding technology (Ia.)

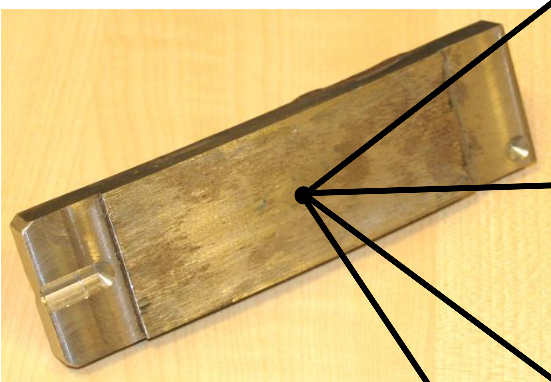
II. *Applied* DEFORMATION – *for diagnostic purposes*

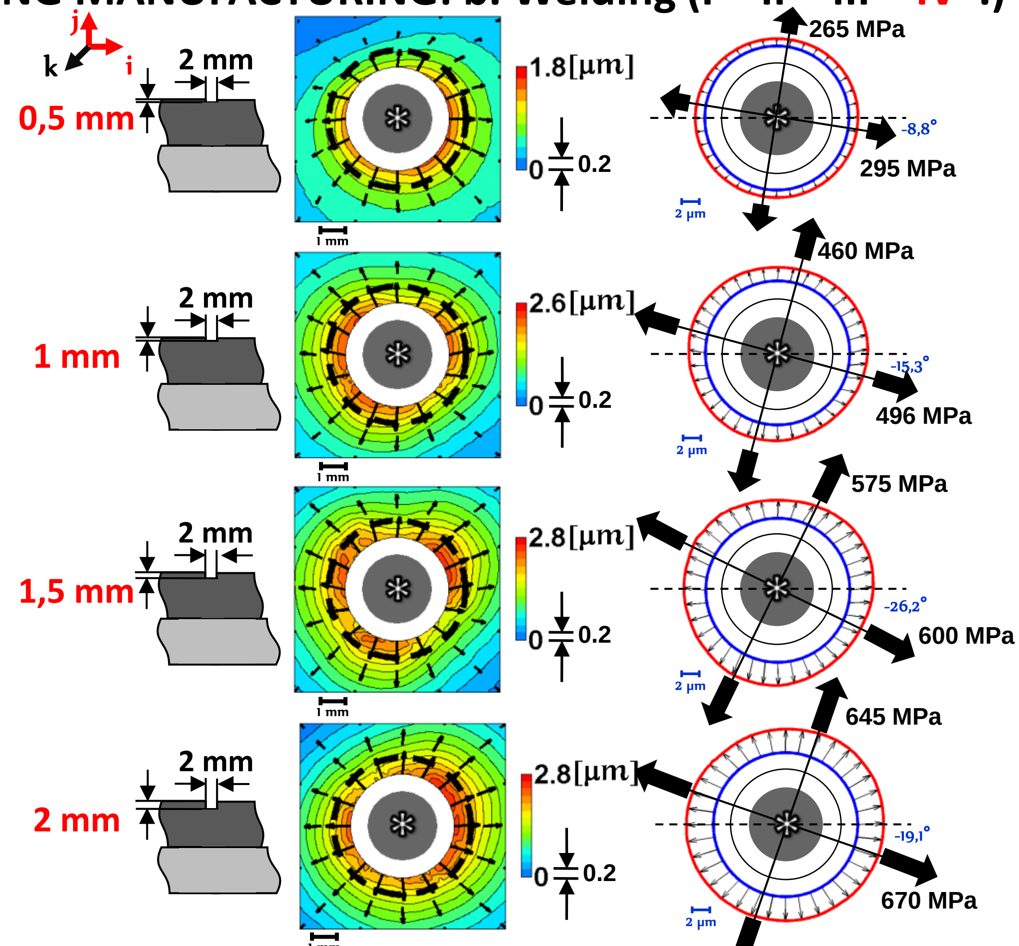
II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1. Actually formed stress

1.1. Without load (residual stress): SHAPE STABILITY and LOAD-CARRYING CAPACITY

1.1.3. DURING MANUFACTURING: b. Welding (I – II – III – IV''.)





Residual stress DOUBLES with drill-hole depth…

Stress distribution of the deposited layer of deposition welding and the substrate - for qualification of the welding technology (Ib.)

Specifically for qualification of weldings…

PRESSURE VESSEL - EXAMPLES

II/B. and II/C. ***Properties accessible from***

STRESS (DISTRIBUTION)

and its CHANGE

(measuring the deformation from stress-releasing at blind hole drilling)

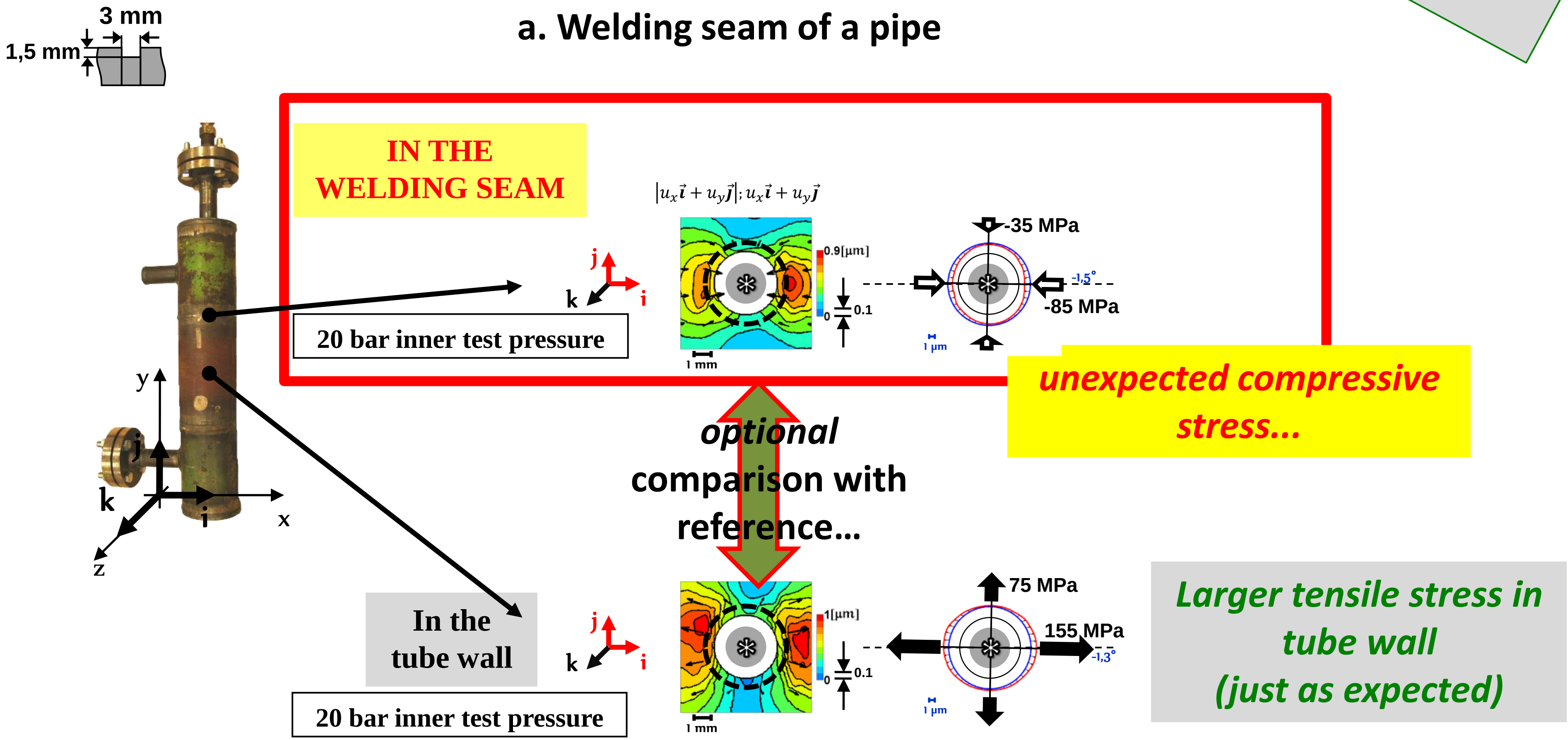
COMPARISON WITH REFERENCE

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

2. Applied stress – for diagnostic purposes

2.1 STRUCTURAL INTEGRITY (I-II-III.)

a. Welding seam of a pipe



Stress of welding seam (and pipe wall) at 20 bar test pressure – for qualification of structural integrity

II. *Applied* DEFORMATION – *for diagnostic purposes*

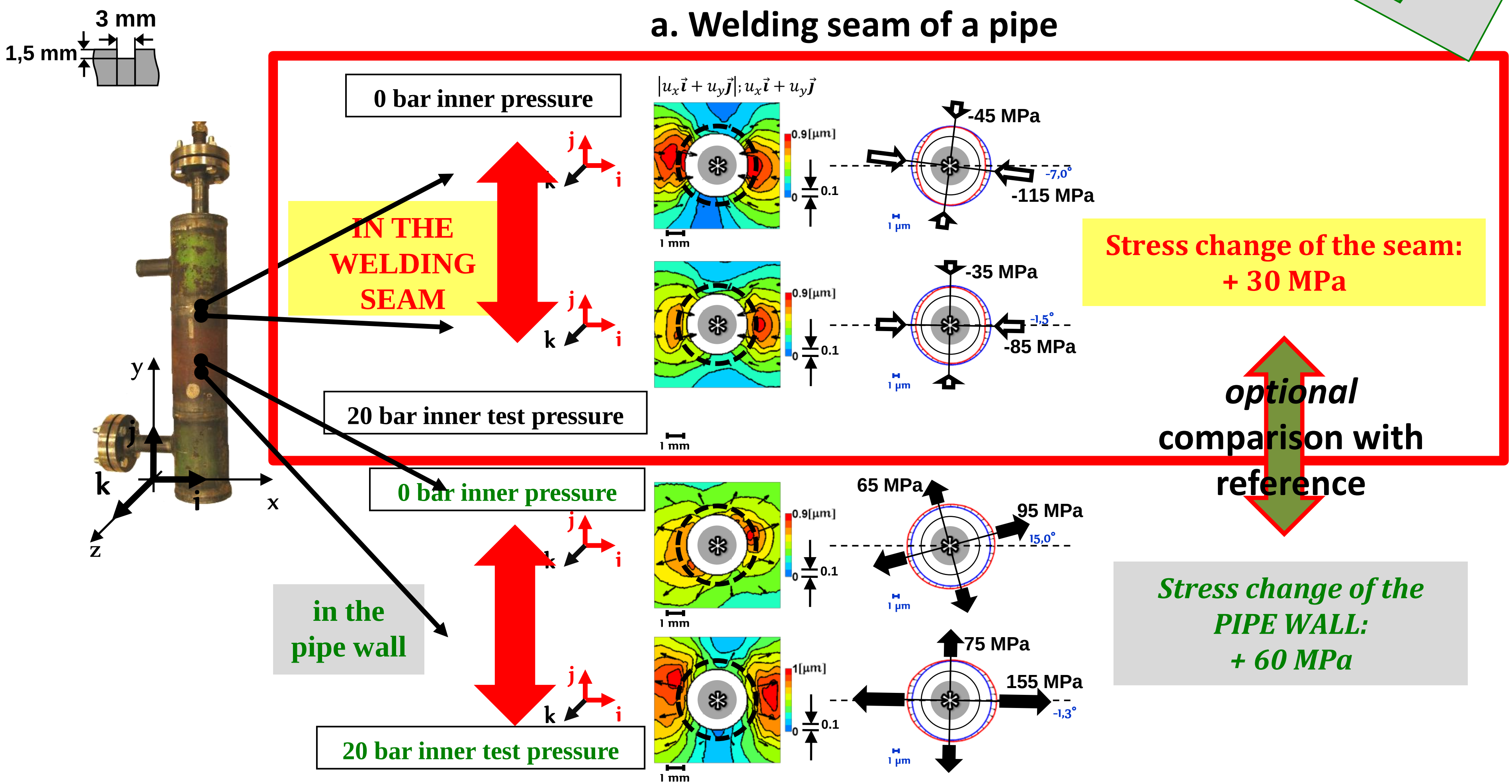
II/C. *Properties accessible from STRESS (DISTRIBUTION)*

2. Applied stresses for diagnostic purposes

2.1 STRUCTURAL INTEGRITY (I-II-III.)

COMPARISON WITH REFERENCE

a. Welding seam of a pipe



Stress *change* of the welding seam (and the pipe wall)

- for qualification of structural integrity

ADDENDUM

A COMPLEX STRESS EXAMPLE:
WELDED HOLLOW SECTION

Measurement of STRESS DISTRIBUTIONS
ON THE SURFACE
AND *IN DEPTH*, TOO…

STRESS DISTRIBUTION

ON THE SURFACE

by measuring the deformation

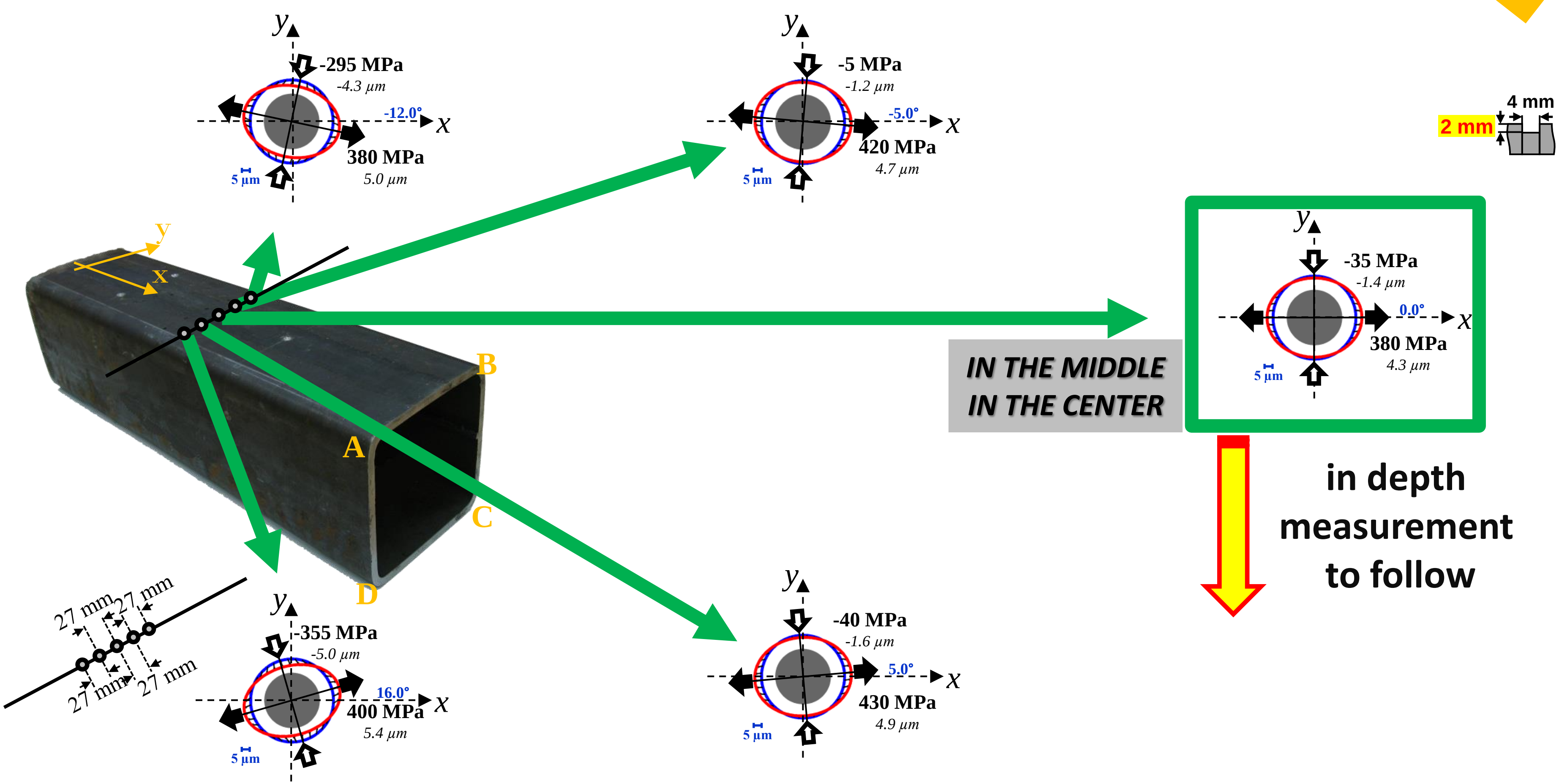
caused by (stress relieving) hole drilling

II. *Applied* DEFORMATION – *for diagnostic purpose*

Non-welded side

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II’/1 – III – IV.)

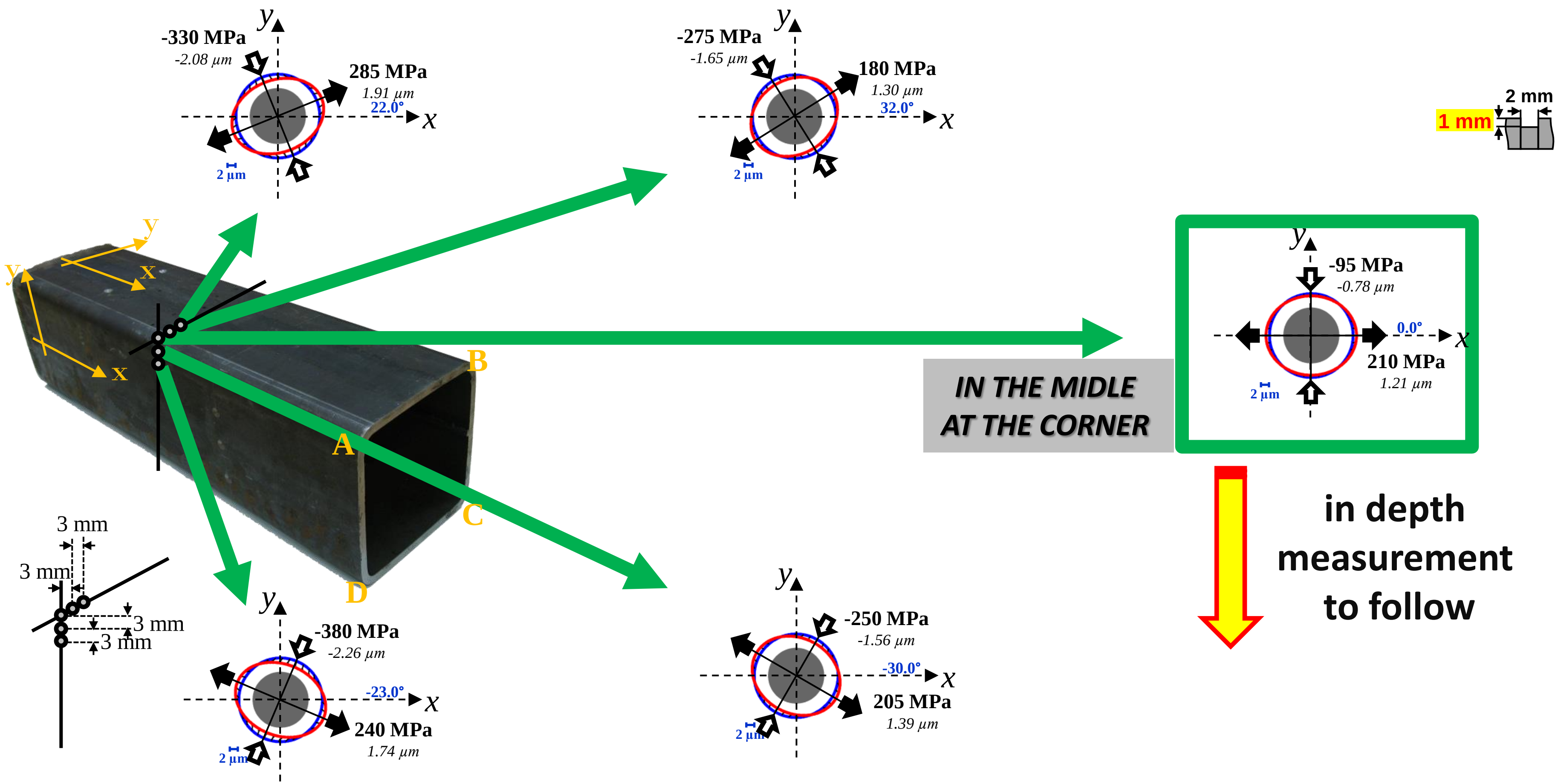


The surface distribution of residual stress - along a cross-line on the surface at the non-welded side

Around the corner

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)



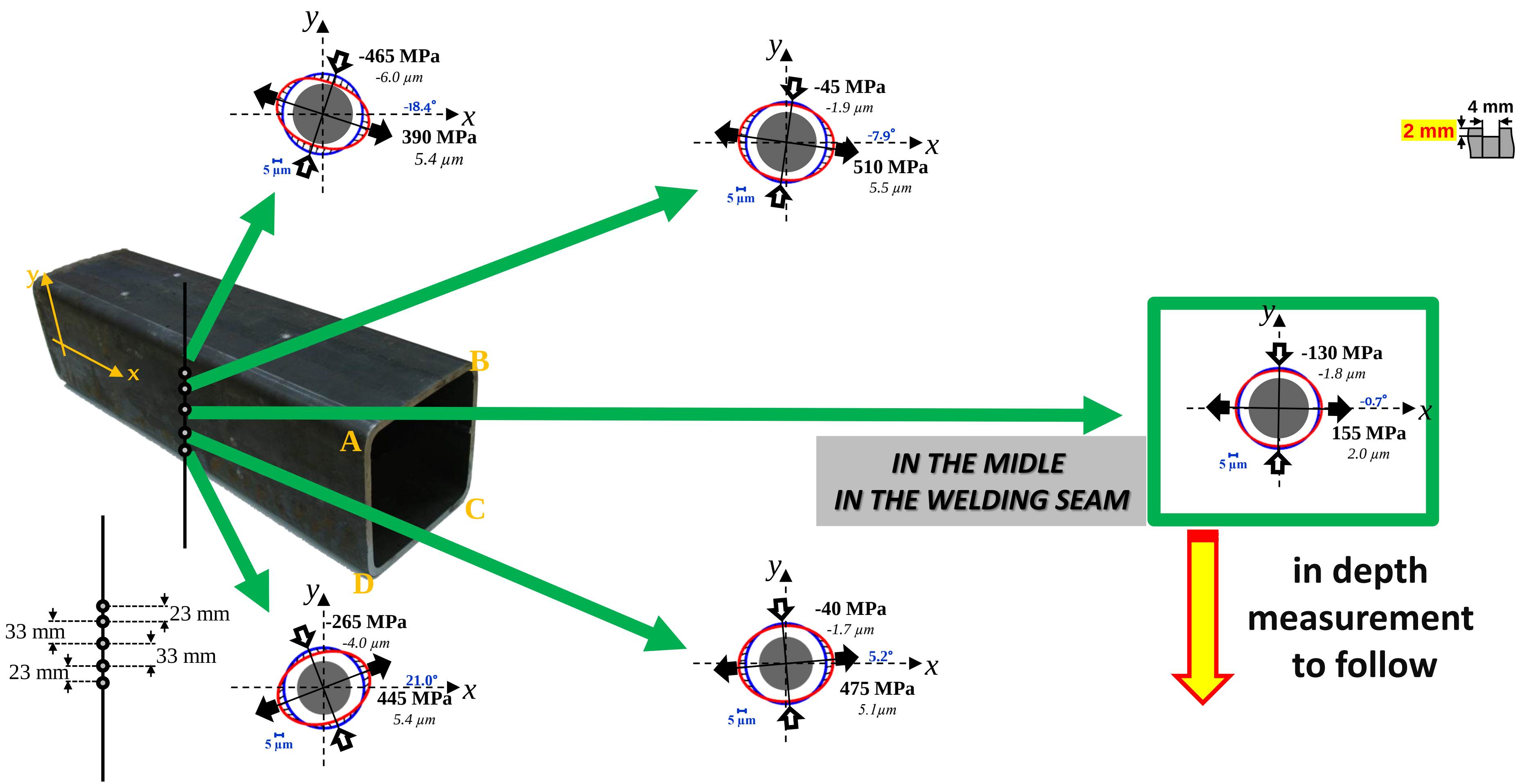
in depth measurement to follow

The surface distribution of residual stress - along a cross-line on the surface around the corner

Welded side

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)



in depth measurement to follow

The surface distribution of residual stress - along a cross-line on the surface at the welded side

STRESS DISTRIBUTION

IN DEPTH (I.)

by incremental hole drilling:

up to a limited depth...

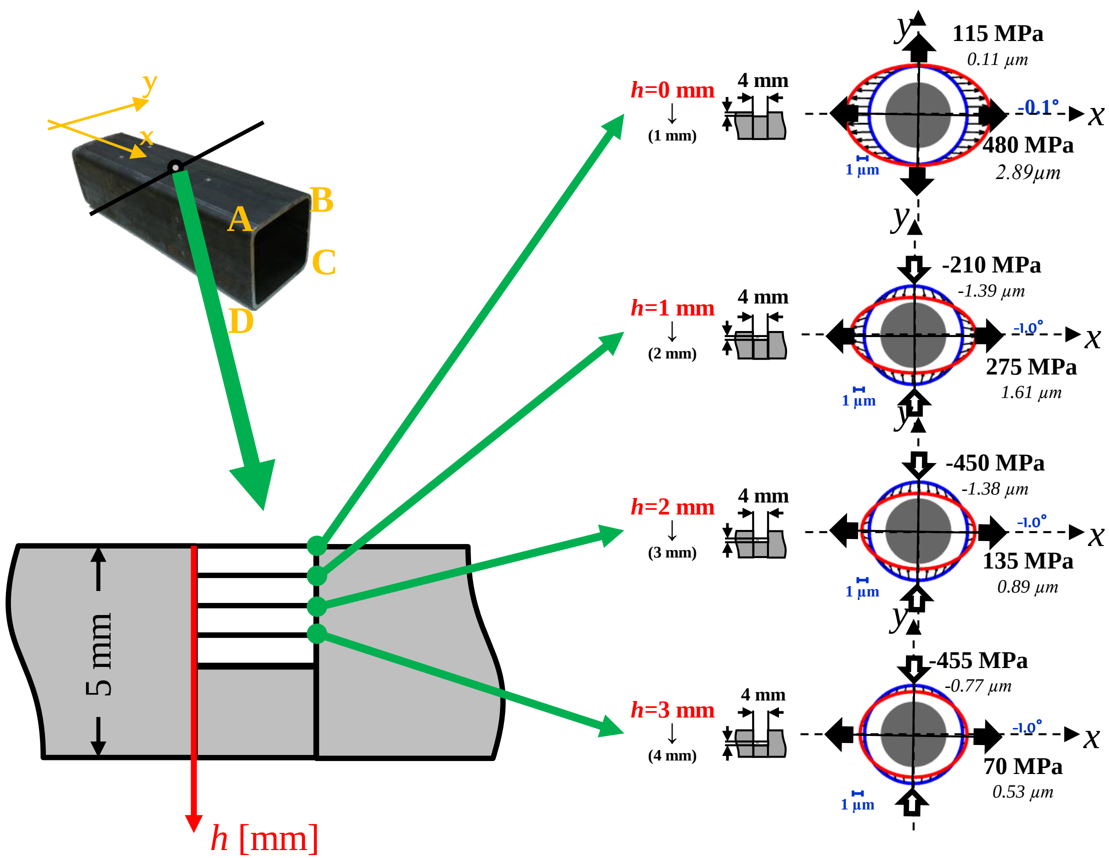
(approximately up to the hole diameter
and up to half wall thickness...)

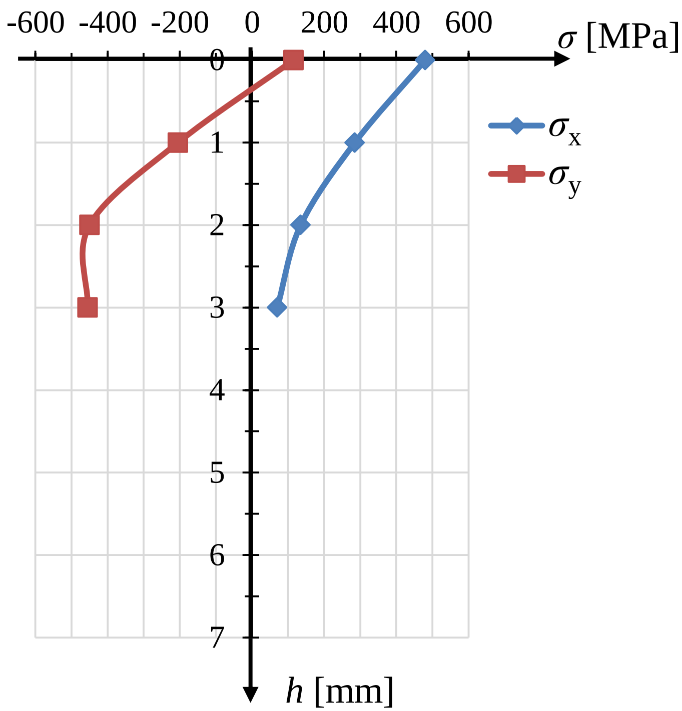
II. *Applied* DEFORMATION – *for diagnostic purposes*

Non-welded side

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)





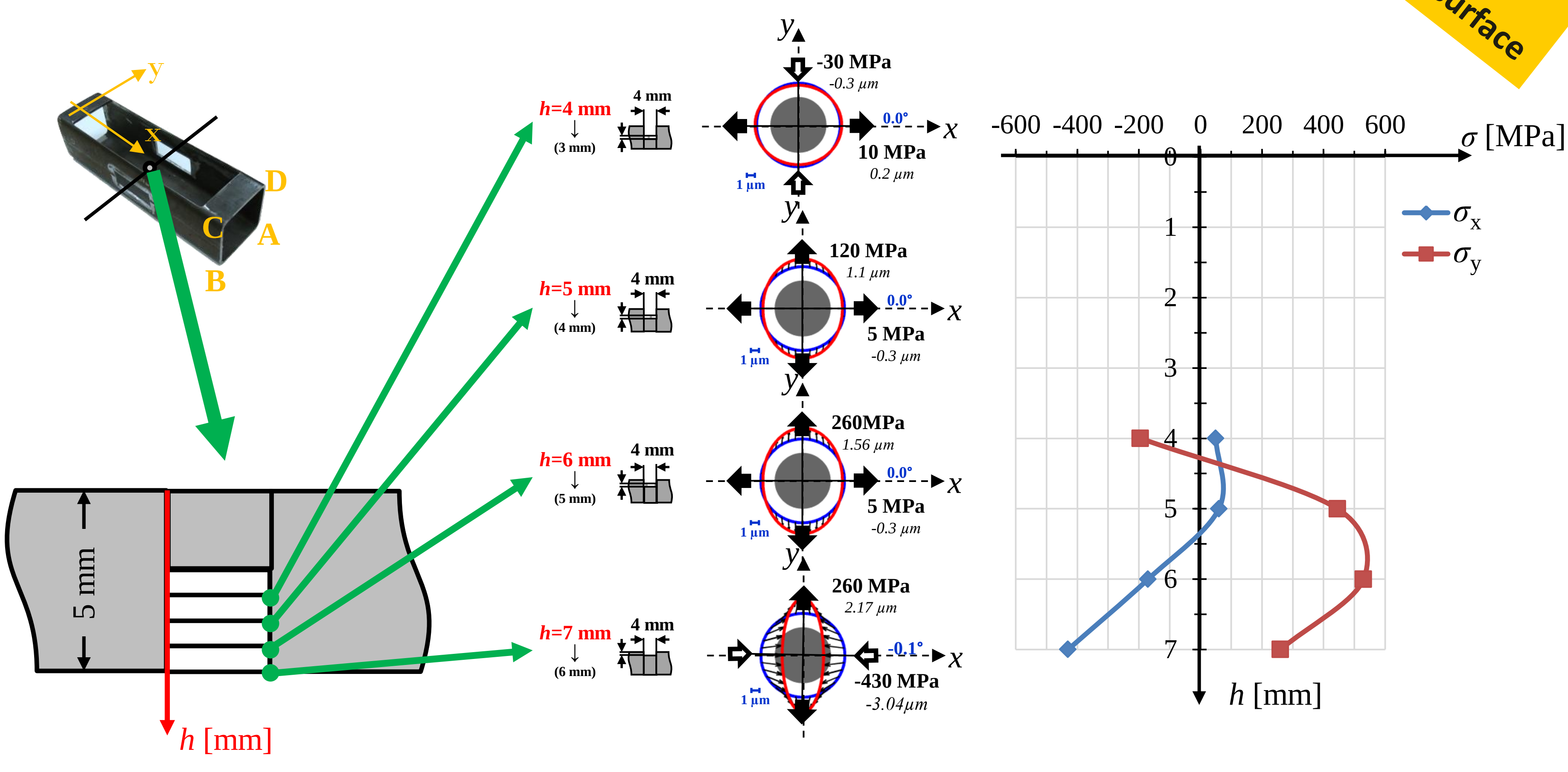
The in depth distribution of residual stress - in the wall at the non-welded side:

from above

Non-welded side
from inside surface

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)



The in depth distribution of residual stress - in the wall at the non-welded side:

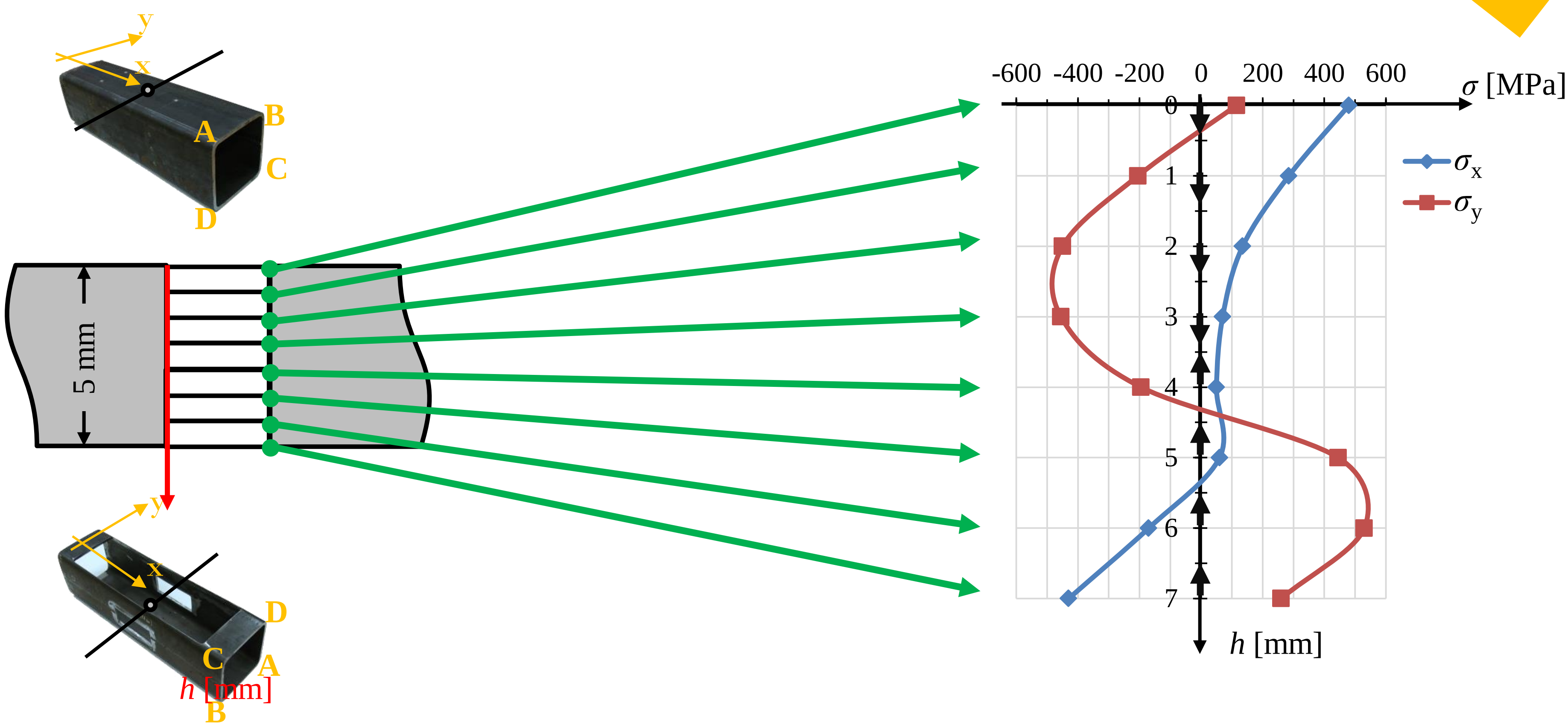
from below

II. *Applied* DEFORMATION – *for diagnostic purposes*

Non-welded side
from both sides

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)



The in depth distribution of residual stress - in the wall at the non-welded side

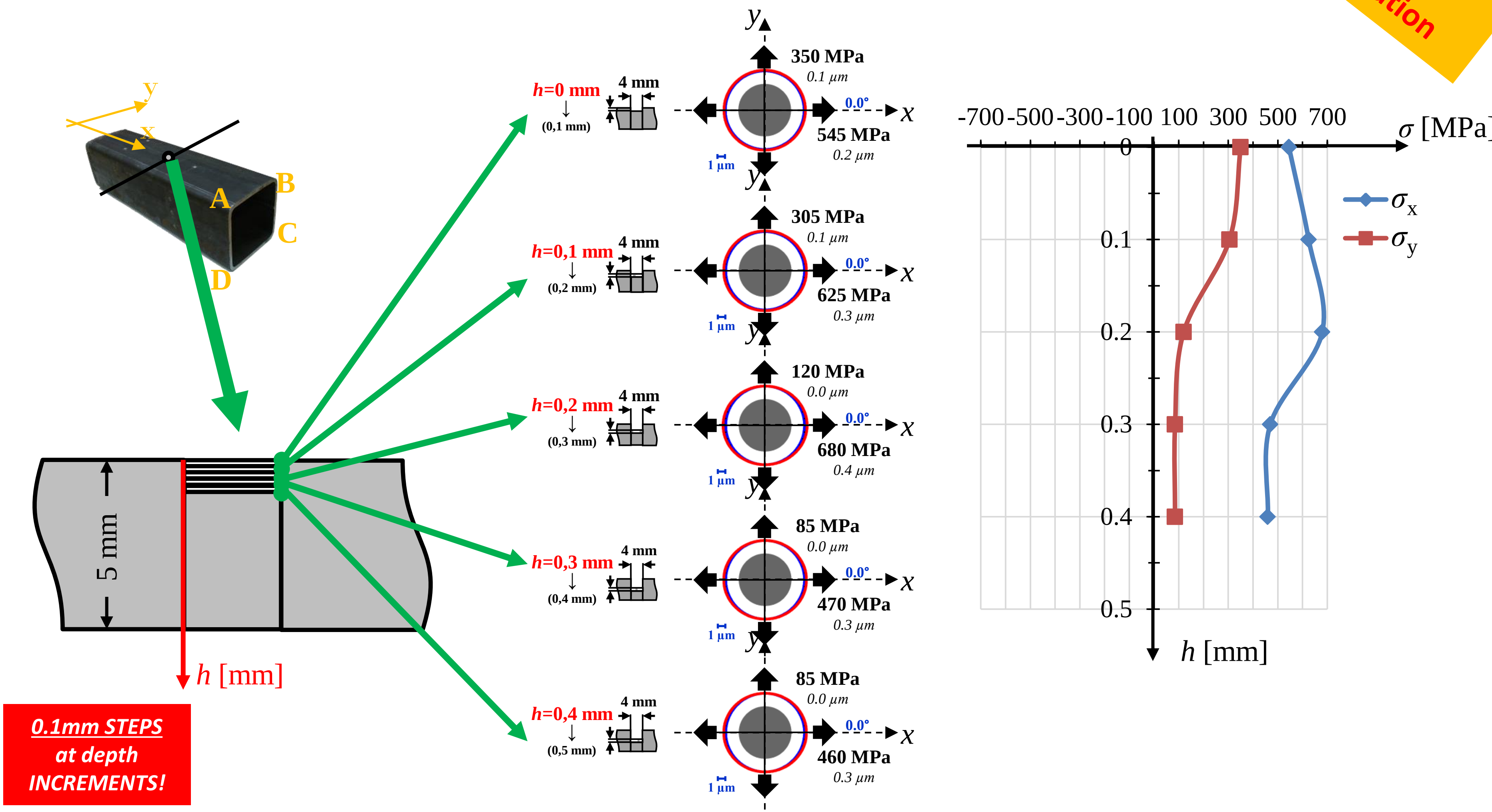
from above and from below together: COMPLETE DEPTH DISTRIBUTION

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)

Non-welded side

high resolution



***0.1mm STEPS* at depth INCREMENTS!**

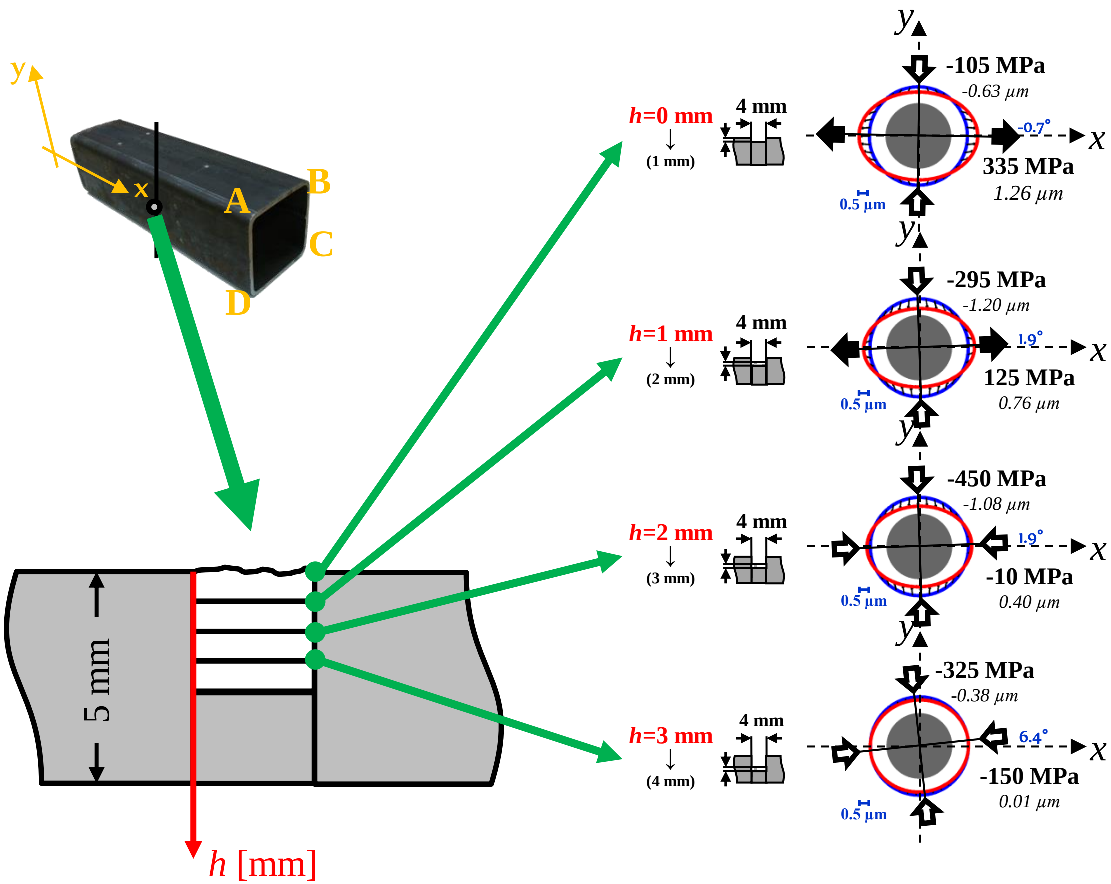
The in depth distribution of residual stress - in the wall at the non-welded side:

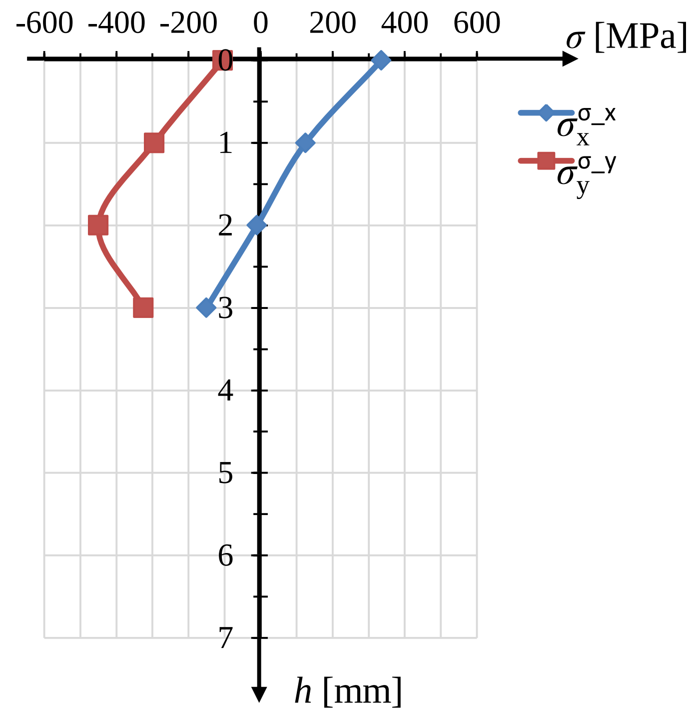
at very fine depth steps

Welded side

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)





The in depth distribution of residual stress – at extreme places:

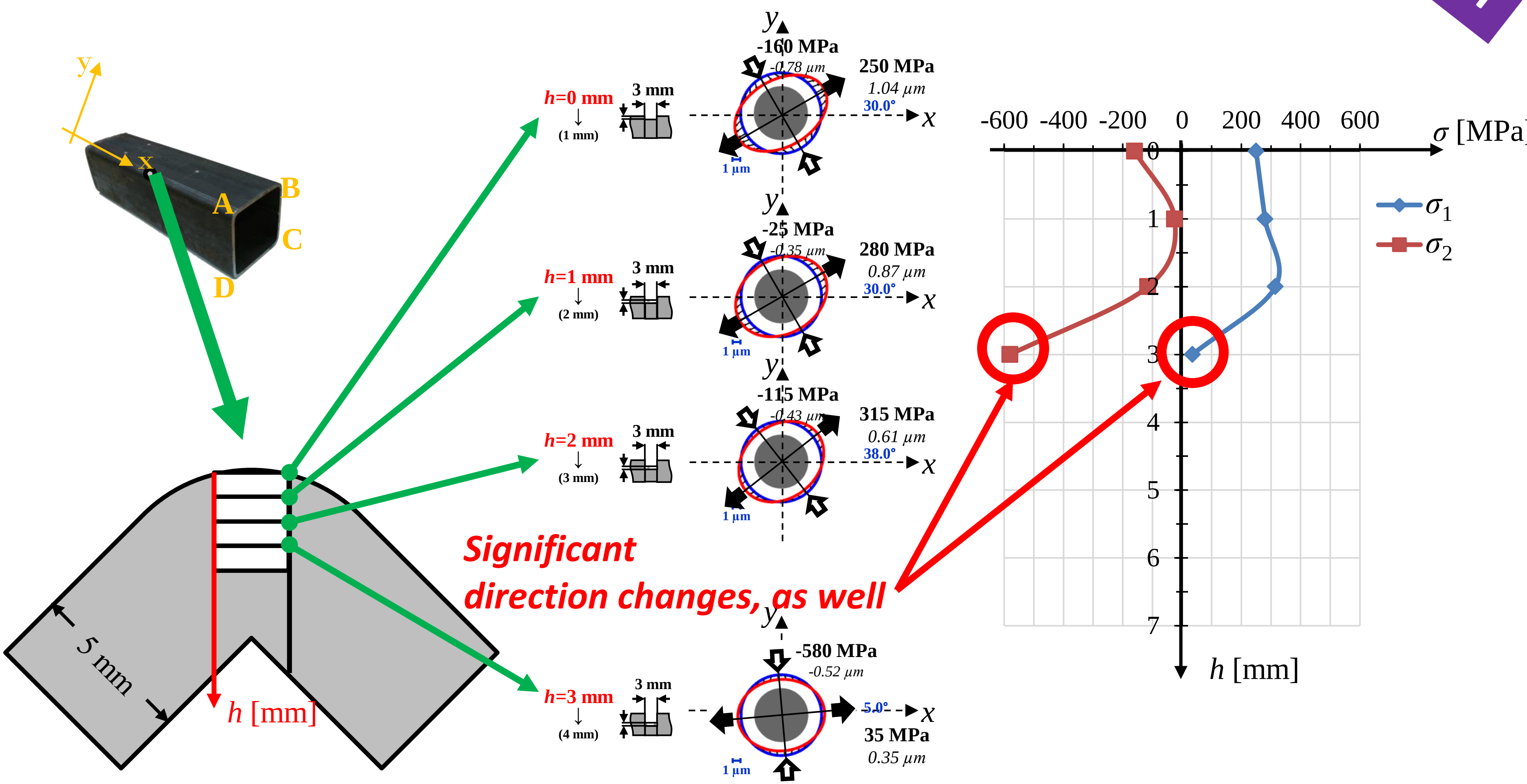
in the welding seam

II. *Applied* DEFORMATION – *for diagnostic purposes*

Around the corner

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)



The in depth distribution of residual stress – at extreme places:

at the corner

STRESS DISTRIBUTION

IN DEPTH (II.)

by (incremental) hole drilling:

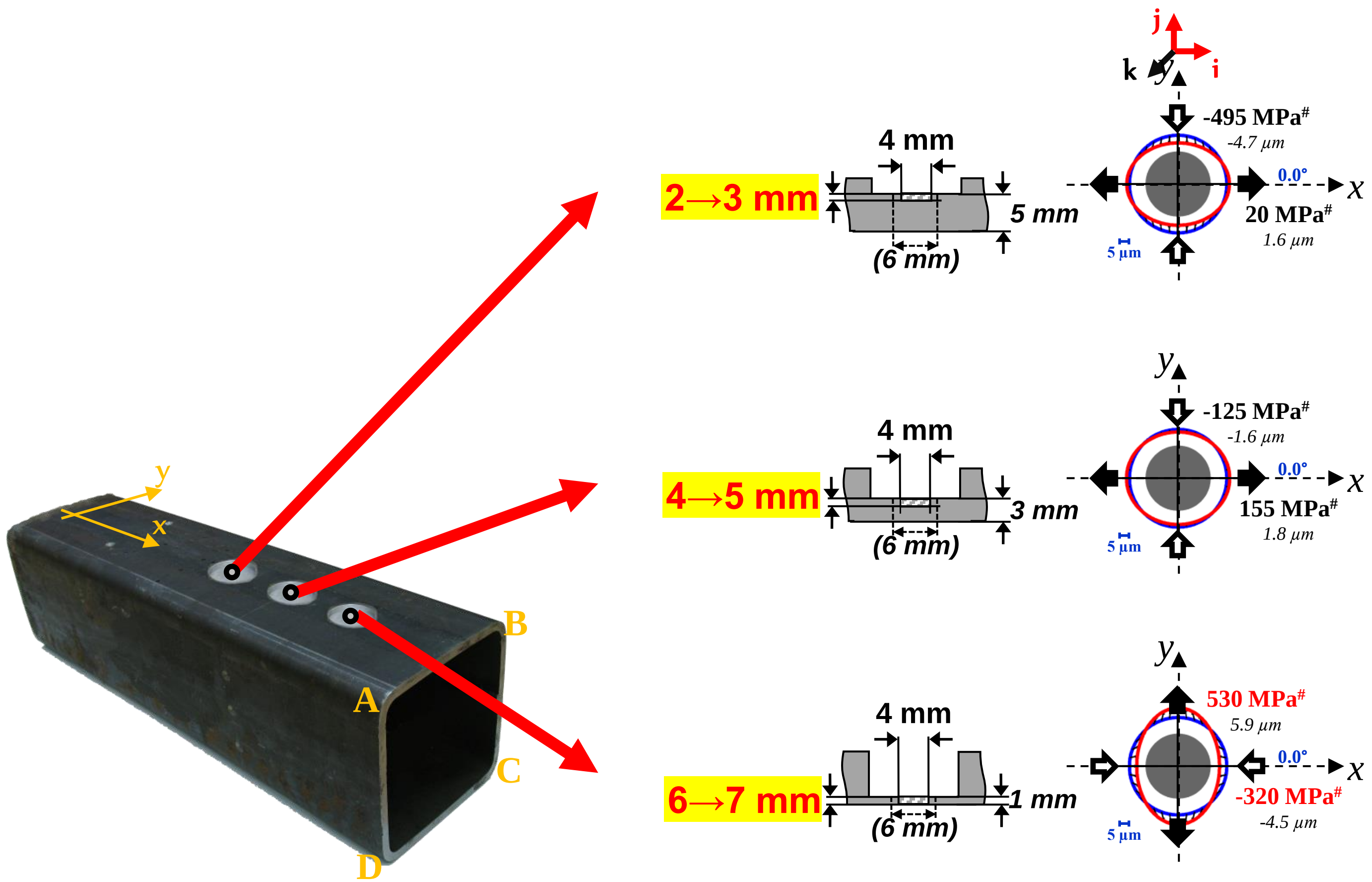
with upper layer removal
to a much less depth limitation...

(under current development,
limitations not quite definite yet...)

Non-welded side with layer removal

II/B. *Properties accessible from STRESS (DISTRIBUTION)*

1.1.3. DURING MANUFACTURING: b. Welding (I – II'/1 – III – IV.)



indicative values only
but not very far from reality!

The in depth distribution of residual stress - in the wall at the non-welded side:
with experimental upper layer removal...

Thank you for your attention!

Contact:

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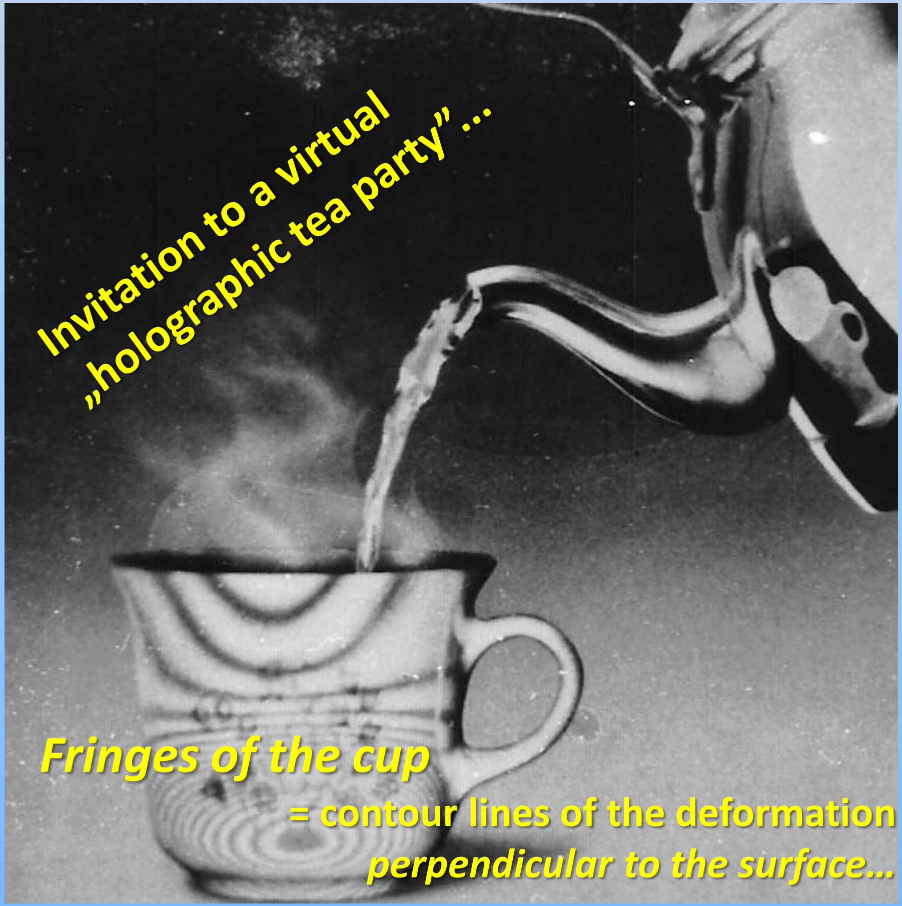

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