



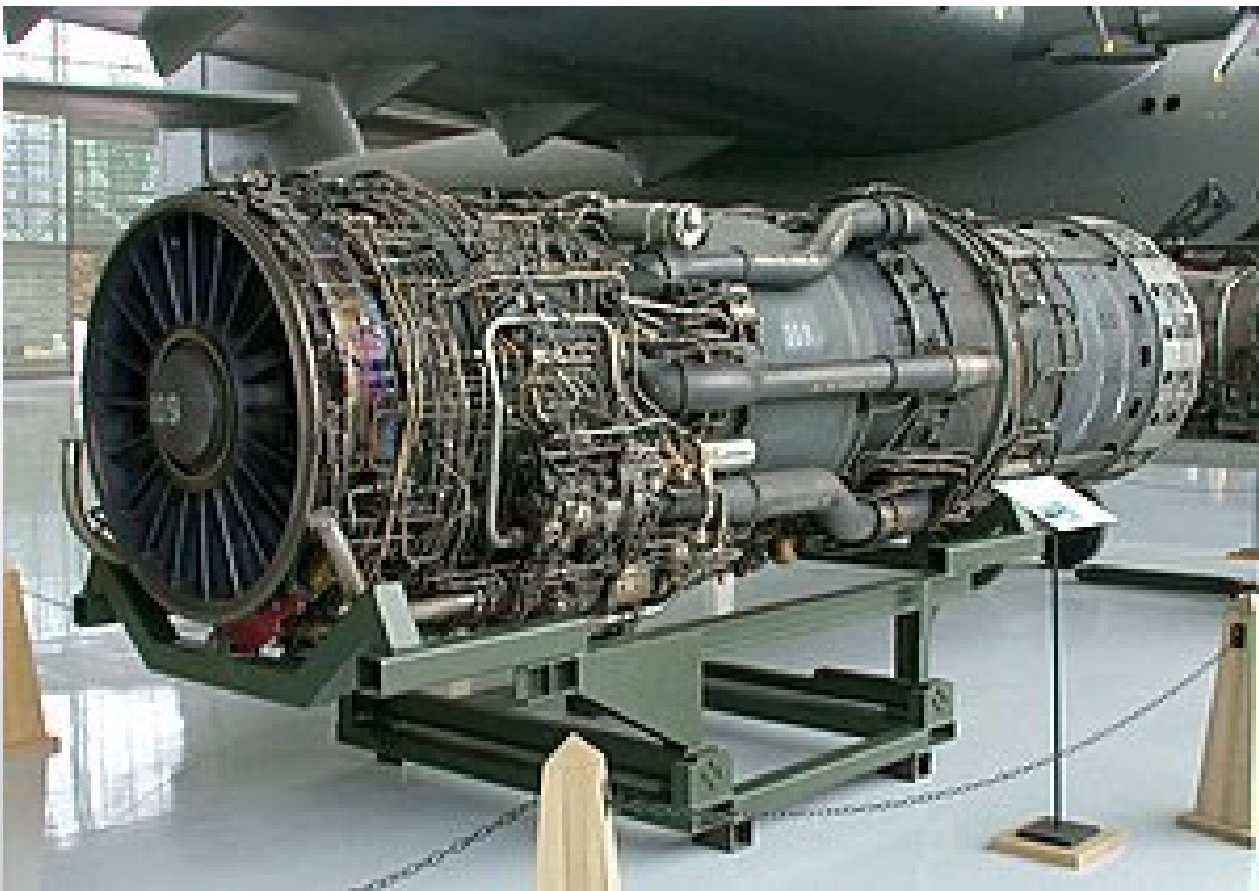
WELD DATA COLLECTING FOR USE IN WELDING SIMULATIONS AND DIGITAL TWINS



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Aerospace
Powerplants
Shipyards



Presenter



Why?

Introduction

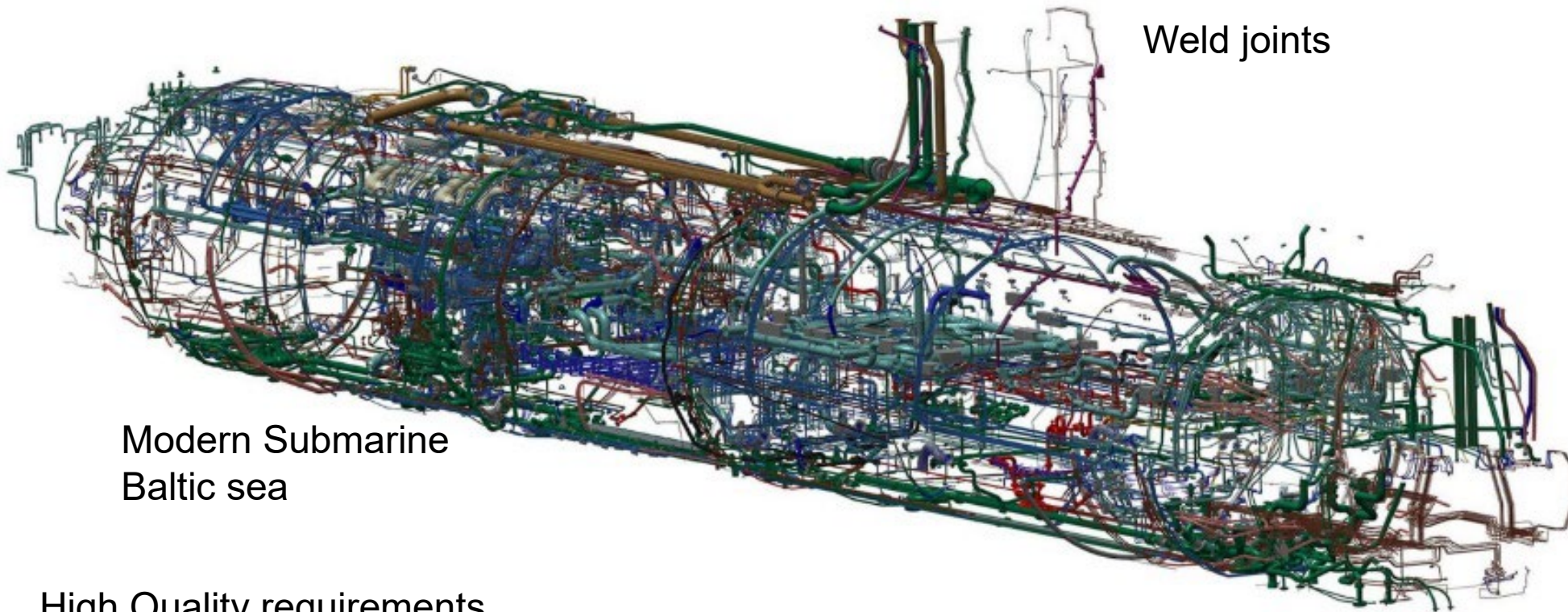
Ships

Powerplants

Aero Space

Prefabrication in workshop

Weld joints



Modern Submarine
Baltic sea

High Quality requirements

Small tolerances

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Referens 20240522: <https://www.saab.com/newsroom/stories/2020/july/a-submarine-in-space>

Welding – Joining method



Some problem with welding as a joining method

Shrinkage

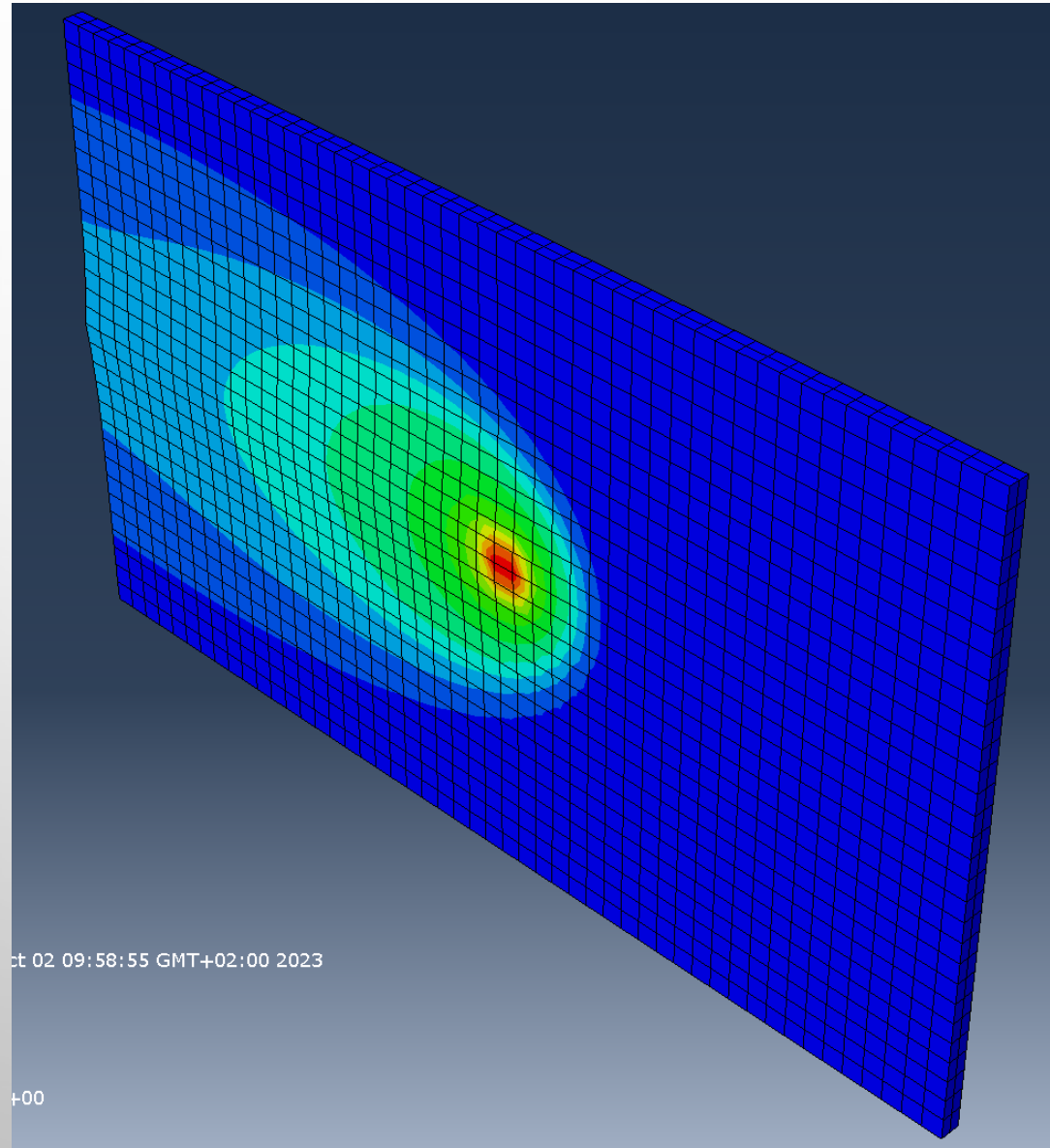
Bending

Distortion

Simulation of welding



- To predict and control the problems of welding before production.
- Collect data to compare with simulation data.



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How?

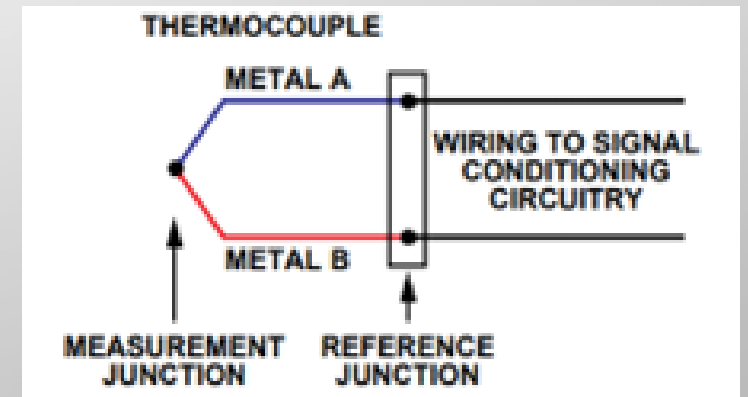
Equipment



Automatic orbital TIG-Welding

Welding machine: AMI MODEL 415A from ARC Machines Inc.

Thermocouple's type K



Material

Base material: Stainless steel 316L (1.4404).

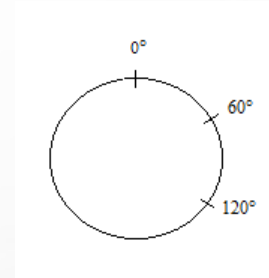
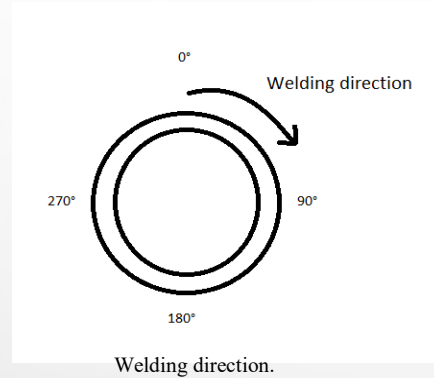
Pipe: Outer diameter 88.9 mm and a wall thickness of 2 mm.

Length of each pipe: 300 mm. Total 600 mm.

Seamless pipe for less interfering with the weld.

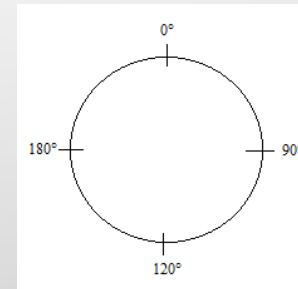


Weld direction and placement of thermocouple's



Placement of thermocouples. Test one.

10, 15 and 20 mm from weld



Placement of thermocouples. Test 2 and 3.

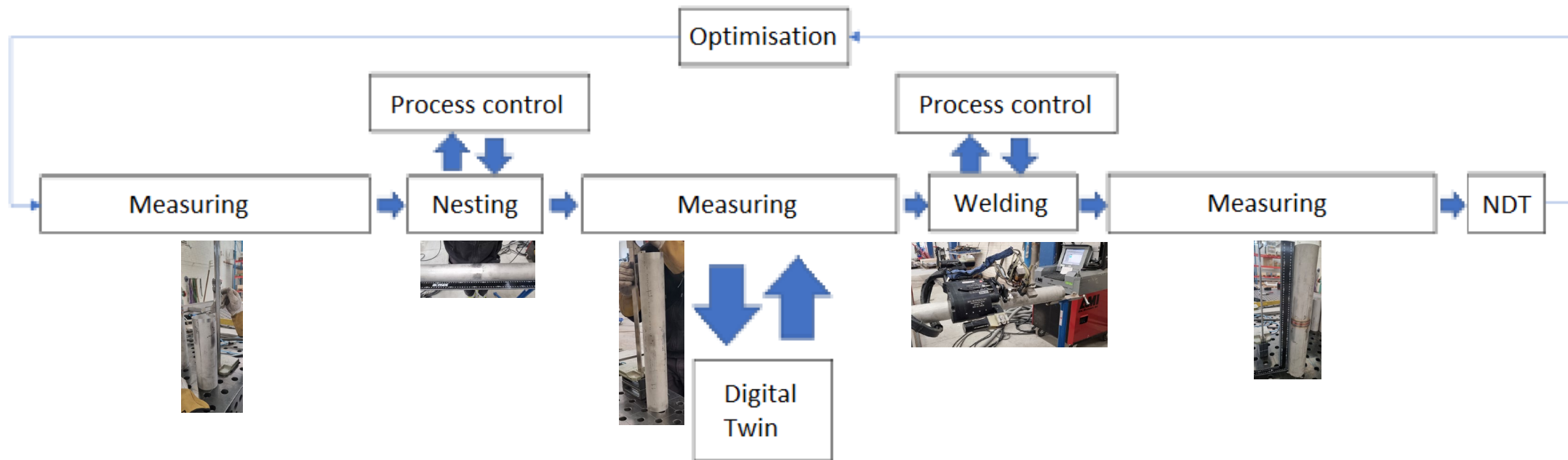
10, 15, 20 and 25 mm from weld

Research questions

RQ1: Will it be possible to collect temperature data from welding that later can be used for welding simulation in a digital twin?

RQ2: Will it be possible to measure longitudinal shrinkage on a thin wall stainless pipe after orbital welding so that the data can be used in welding simulation?

Process



Results



Measurement



Straightness after welding

Results

MEASUREMENTS SHRINKAGE

Test one						
(mm)	0°	90°	180°	270°	Mean value	Mean shrinkage
Measurement before welding	589,5	598,1	598,1	598,4	598,3	0,12%
Mesurment after welding	597,6	597,6	597,5	597,5	597,6	0,7 mm

Test two						
(mm)	0°	90°	180°	270°	Mean value	Mean shrinkage
Measurement before welding	604,5	604,6	604,2	604,6	604,6	0,15%
Mesurment after welding	603,8	603,3	603,3	604	603,6	0,9 mm

Test tree						
(mm)	0°	90°	180°	270°	Mean value	Mean shrinkage
Measurement before welding	598,1	598	598,2	598,5	598,2	0,18%
Mesurment after welding	597	596,6	597,1	597,6	597,1	1,1 mm

MEASUREMENT TEMPERATURE

Test 1			
Weld start 315°, this weld was visually OK			
Placement of thermocouple	0°	60°	120°
mm from center of weld	10	15	20
Temperature in Celsius lap 1	582	427	322
Temperature in Celsius lap 2	604	491	394

Test 2				
Weld start 0°, this weld was visually OK				
Placement of thermocouple	0°	90°	180°	270°
mm from center of weld	10	15	20	25
Temperature in Celsius lap 1	443	351	276	176
Temperature in Celsius lap 2	520	442	265	-

Test 3				
Weld start 0°, This weld was visually not OK				
Placement of thermocouple	0°	90°	180°	270°
mm from center of weld	10	15	20	25
Temperature in Celsius lap 1	493	487	330	284
Temperature in Celsius lap 2	639	392	304	-

Some possible errors

Air pockets between the thermocouples and the base material – Heat conducting past

Welding Equipment – Calibrated according to IEC 60974-14

Thermocouples – Calibrated

Future work

Simulation of welding in whole piping systems from start to end for ships, powerplants, aerospace etc.

