

“Non-intrusive temperature measurement for industrial process control”

Jacques-Olivier FAVREAU
Eric GEORGIN



Outline

1. Mise en pratique / State of the art / Theory
2. Sensors
 1. **“Classical”**
 2. **Clamp-on**
3. Effects of implementation
4. Uncertainties

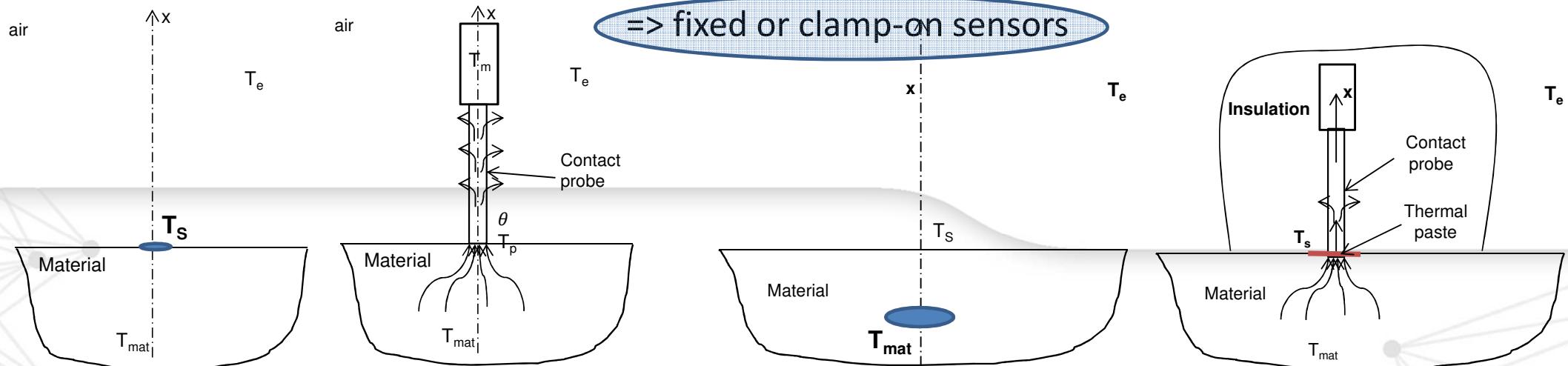
Mise en pratique / State of the art / Theory

- Fluid temperature measurement ?



Mise en pratique / State of the art / Theory

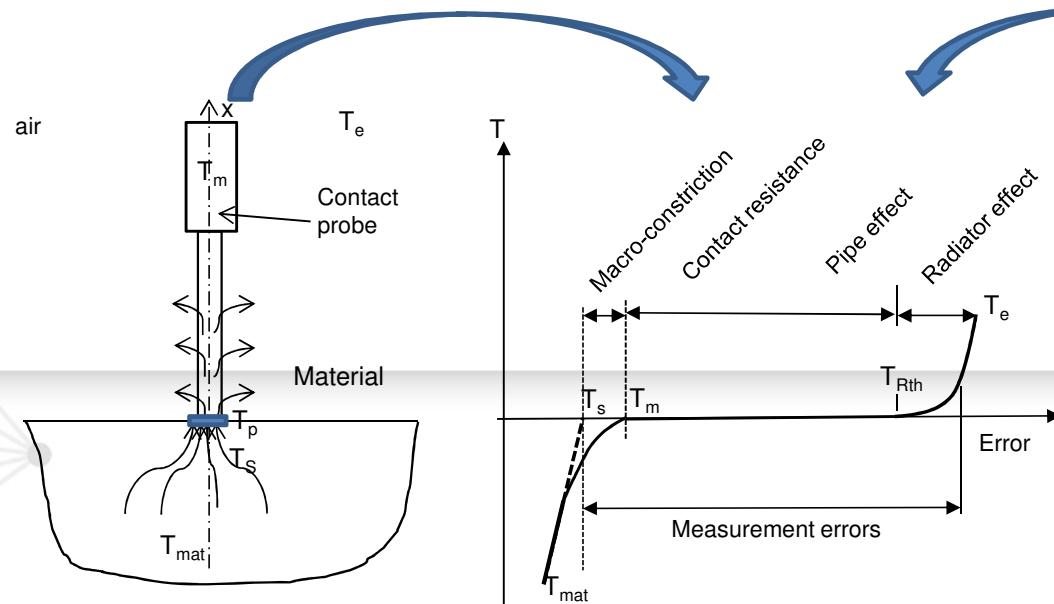
- Direct or indirect measurement ?
 - **Direct measurement => surface temperature**
=> hand type sensors
 - **Indirect measurement => temperature in the pipe / material**



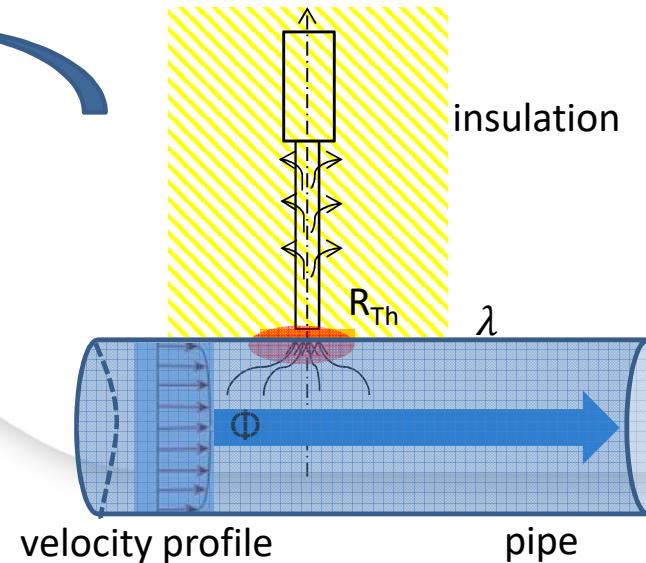
Mise en pratique / State of the art / Theory

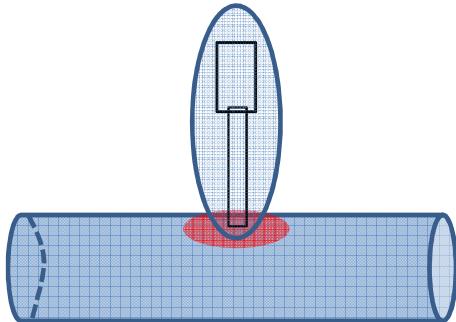
Measurement error theory

On reference surface



On pipe

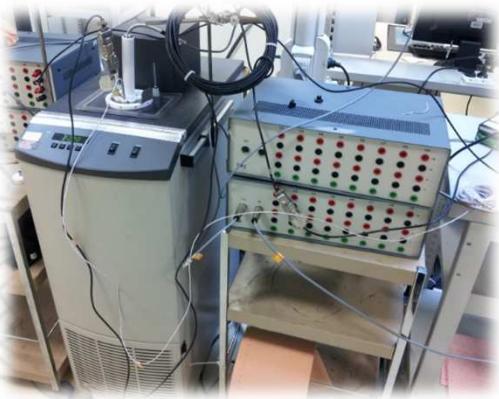




In bath

Uncertainties

$U_{k=2}(t)$ de 0,03 °C à 0,08 °C (RTD)
 $U_{k=2}(t)$ de 0,12 °C à 0,22 °C (TC)



On the surface

Uncertainties

$U_{k=2}(t)$ de 0,8 °C à 1,5 °C
(RTD, TC)



On pipe

Uncertainties

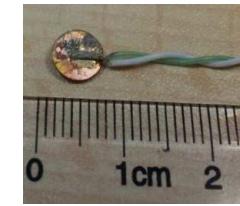
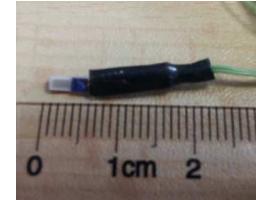
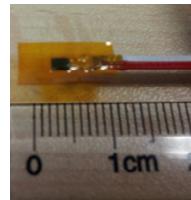
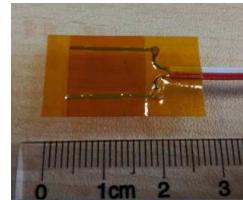
$U_{k=2}(t)$ de 1,0 °C à 1,8 °C
(RTD, TC)



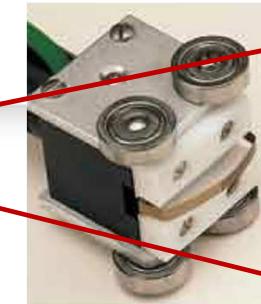
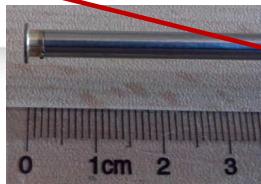
Sensors : classical surface sensors clamp-on sensors

“Classical” sensors

- Fixed sensors

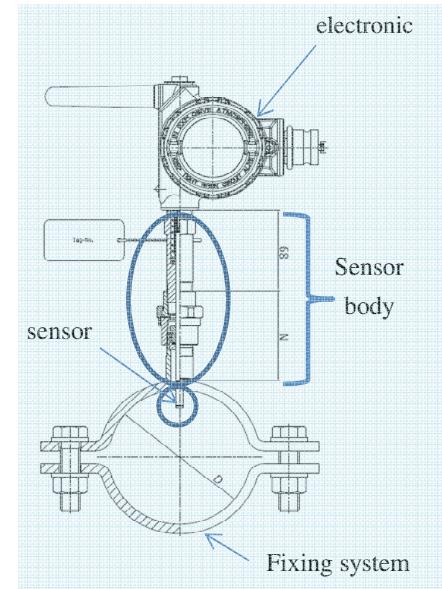
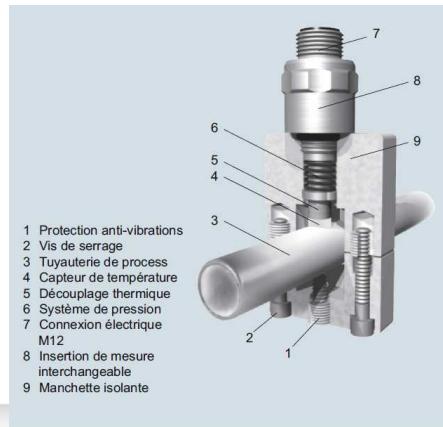


- Hand type sensors



Clamp-on sensors

- Siemens TS300 / Rosemount 085

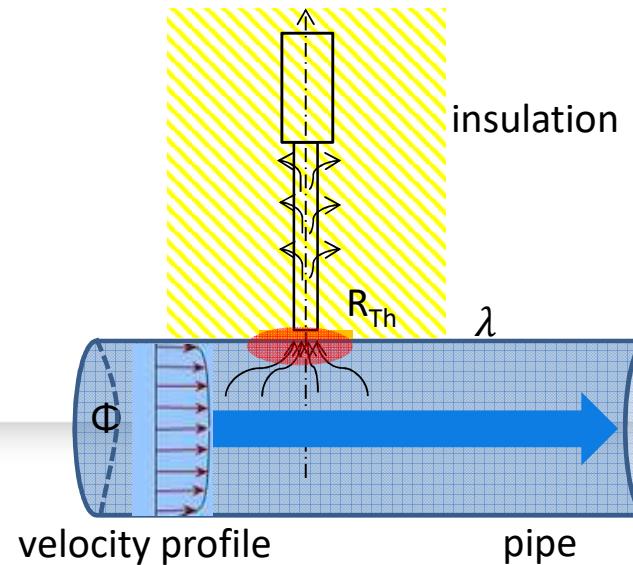


- Others ...



“Mise en pratique” / State of the art / Theory

Test facility at CETIAT



Testing facility :

- temperature and flow
- controlled and measured
- pipe's material (thermal conductivity)
- insulation

Mise en pratique

Sensors

Effects of implementation

Uncertainties

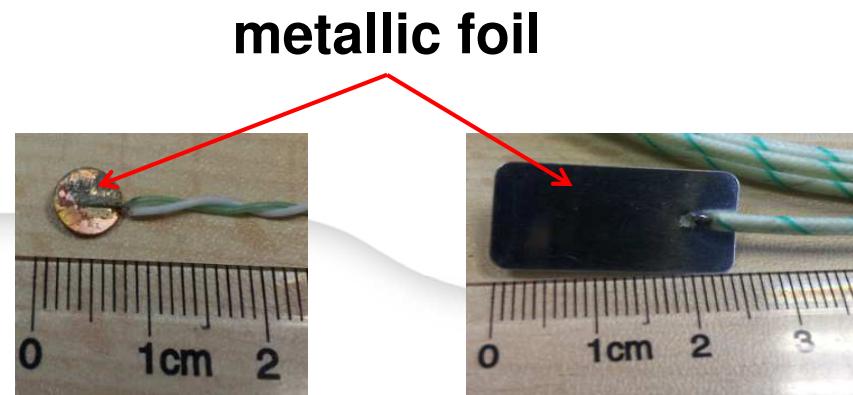
Results : “classical” sensors

“Classical” sensors

- Different sensors tested :
 - RTD

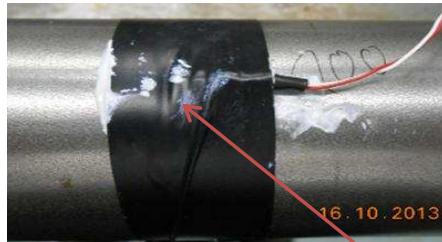


- Thermocouples



“Classical” sensors

- Thermal paste effect



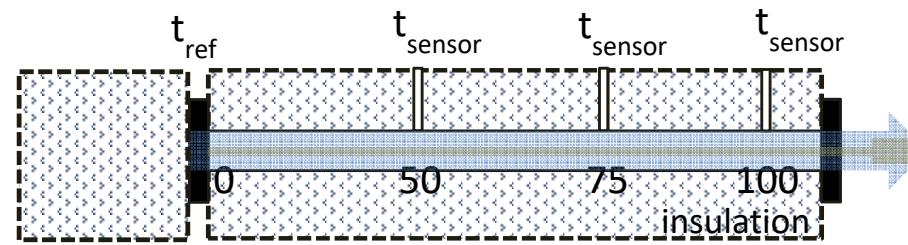
- Results
 - Impact of thermal paste**

$t_{ref} / ^\circ C$	Water flow 500 l/h	Accuracy ($t_{ref} - t_{DUT} / ^\circ C$)
79,75	RTD + thermal paste	0,5
	RTD	0,7
	TC + thermal paste	-1,7
	TC	-2,5
	TC+ thermal paste + metallic foil	-3,7



“Classical” sensors

- Insulation effect
- Results



Insulation	t_{ref} / °C	Probe's position / cm	Accuracy ($t_{ref} - t_{DUT}$) / °C
Without	79,9	50	0,1
		75	0,5
		100	0,9
With	79,9	50	0,0
		75	-0,1
		100	-0,2



Mise en pratique

Sensors

Effects of implementation

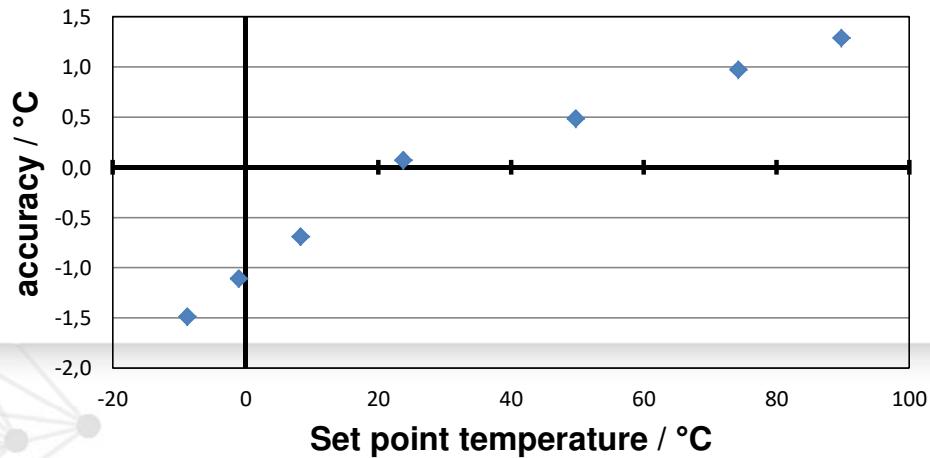
Uncertainties

Results : clamp-on sensors

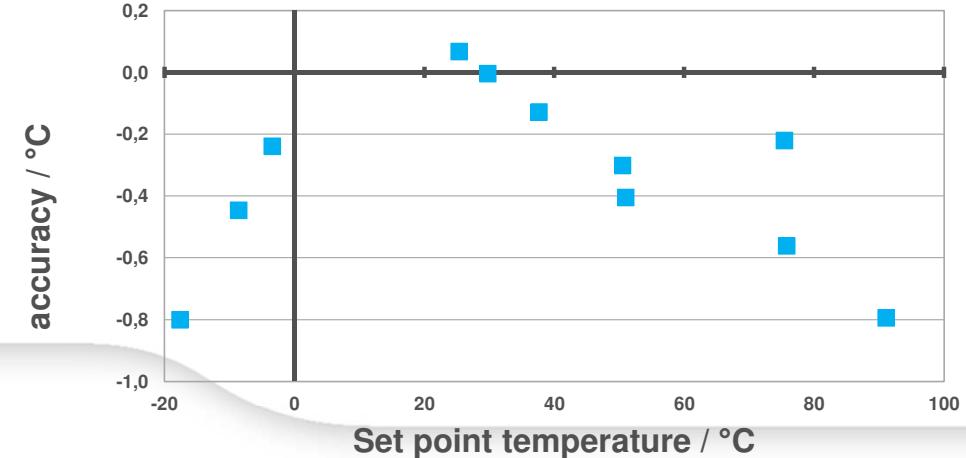
Clamp-on sensors

- Results on copper pipe

SIEMENS TS300 / Response on copper pipe

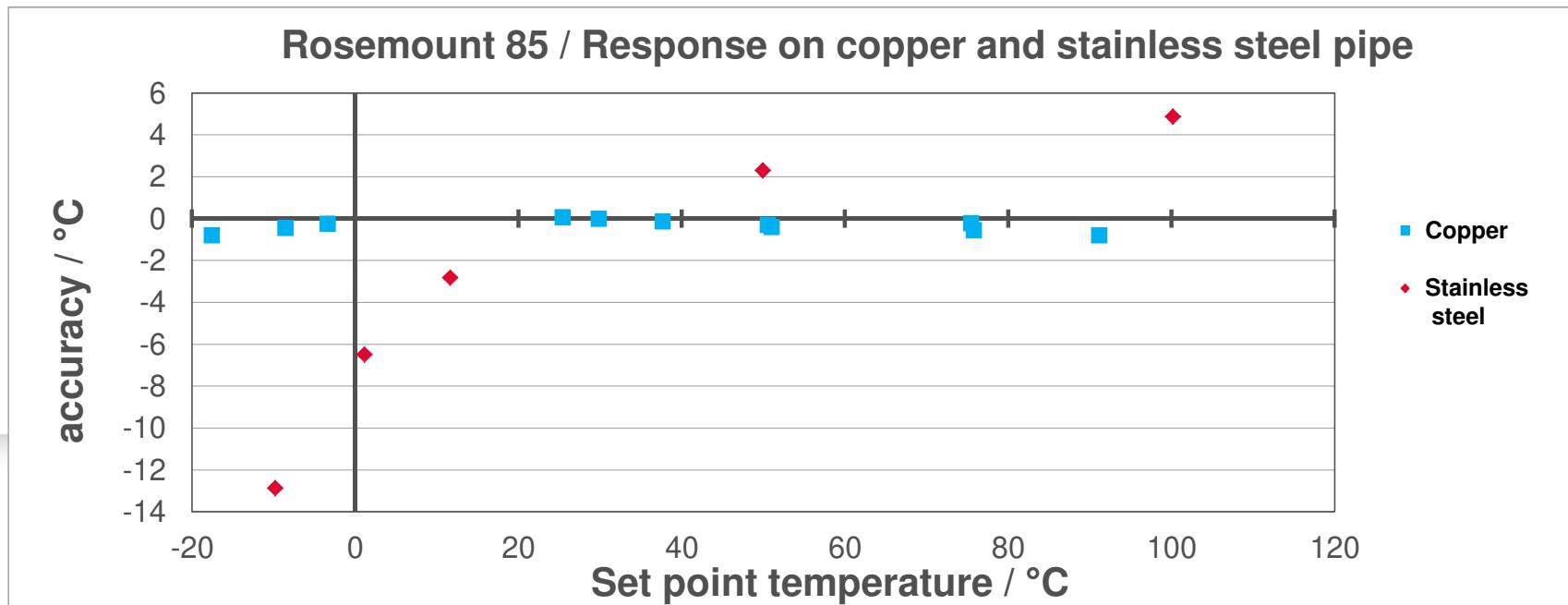


Rosemount 85 / Response on copper pipe



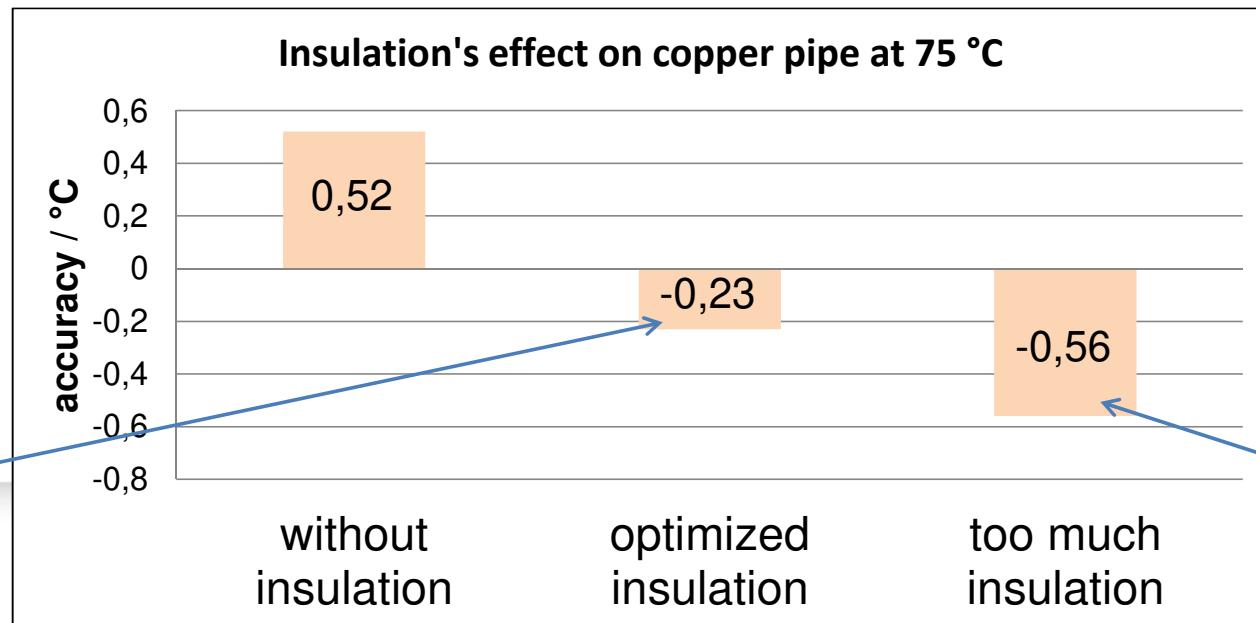
Clamp-on sensors

- Material effect



Clamp-on sensors

- Insulation effect



“Classical” sensor vs clamp-on sensors: conclusion

- To improve temperature measurement
 - **Indirect measurement : fixed sensors (all types)**
 - Use conductive thermal paste
 - Use an insulation
 - Make calibration
 - Calculate the heat losses (except Clamp-on)
 - **Direct measurement : hand type sensors**
 - Calibration on surface temperature generator
 - Preheat the sensor



Mise en pratique

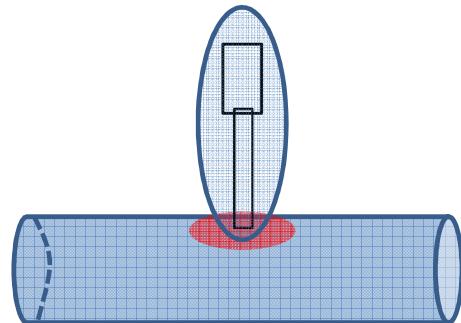
Sensors

Effects of implementation

Uncertainties

Uncertainties

Ensure a good measurement of surface temperature



On pipe	On surface generator	In thermostatic bath
 <p>Calibration + repeatability (S_{n-1})</p>	 <p>Calibration + repeatability (S_{n-1}) + Thermal Heat pipe error</p>	 <p>Calibration + repeatability (S_{n-1}) + Thermal Heat pipe error + Environment conditions</p>

Conclusion

- Guidelines / general thoughts about indirect measurements
 - “**Classical**” surface sensors:
 - good insulation
 - Thermal paste
 - calibration on pipe
 - **Clamp-on sensors**
 - good insulation,
 - Thermal paste
 - heat loss correction

Other



2013



Domaine scientifique de la Doua
25 avenue des Arts – BP 52042
69603 VILLEURBANNE CEDEX - FRANCE

Mail : information@cetiat.fr

Tél : 04 72 44 49 00

Fax : 04 72 44 49 49

DTI

