Coriolis Flow Mater (Mass Flow)

Topics (หัวข้อการอบรม)

- Theory
- Basic Setup/ Commissioning
- Basic Installation
- Basic Repair
- Basic Maintenance
- Basic Calibration
- Case Study

Theory

- ทฤษฎีและลักษณะการทำงานของ Mass Flow Meter

Gaspard Gustave de Coriolis

- Born May 21st, 1792 in Paris, France
- Died September 19th, 1843 in Paris
- Mathematician, mechanical engineer and scientist
- Best known for his work on the Coriolis effect
- Coriolis' papers deal with the transfer of energy in rotating systems like waterwheels

http://en.wikipedia.org/wiki/Gaspard-Gustave_Coriolis

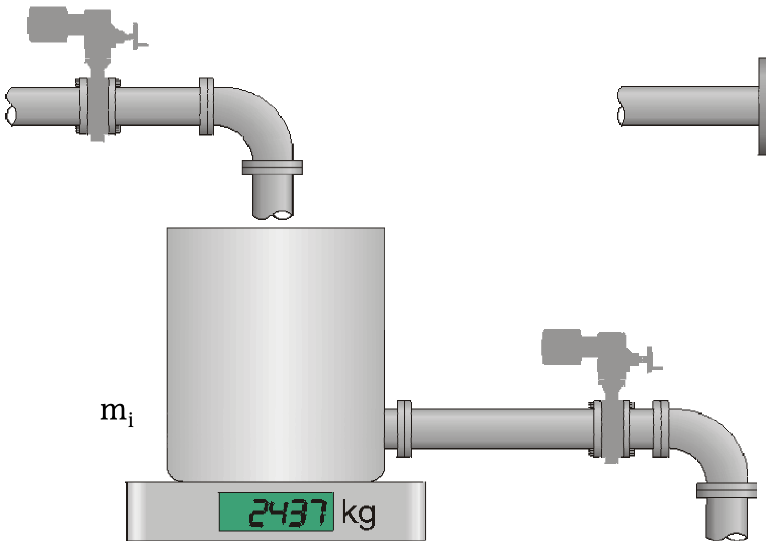
Coriolis sensor (general remarks)

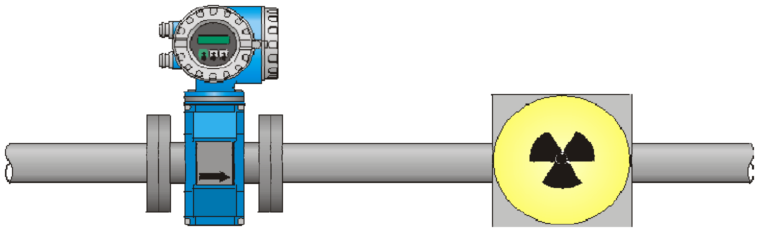
Some general remarks concerning all Coriolis sensors:

- Dual-tube design / single-tube design
  - Dual-tube instruments are intrinsically balanced against external disturbances because the tube movements compensate each other.
  - Endress+Hauser puts extra effort into the design of single-tube instruments. With competitor's single-tube instruments, vibration immunity is often a weak point.
- Material choice
  - Stainless steel has a relatively large thermal expansion coefficient (= reacts to temperature raise with high expansion). If a steel meter is specified above
    100 °C, it has to feature bent tubes in order to avoid material damage due to thermal expansion stress.
    The same applies to most alloy materials (Hastelloy C).
  - Titanium has a lower thermal expansion coefficient. All straight
    tube meters specified above 100 °C are made of titanium.

Traditional Mass Flow Measurement

Discontinuous, direct	Continuous, indirect



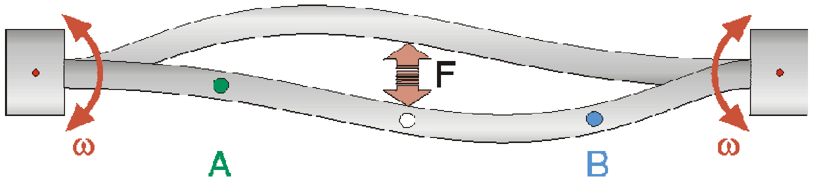


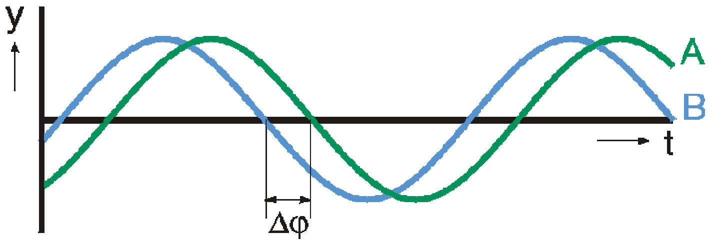
- V = Volume flow
  r = Density
- m = Mass flow

$$m = \Sigma m_i$$

$$\dot{m} = \dot{V} \cdot \rho$$

Measurement Signal





$$\Delta\varphi \sim F_c \sim \dot{m}$$

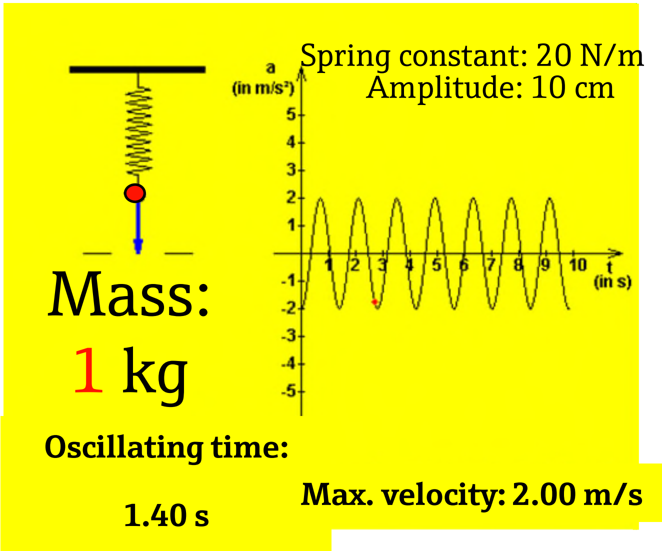
If fluid is flowing, the Coriolis Force introduces a time shift of the swinging points A and B. Point B passes zero before point A . The bigger the flow the bigger the shift.

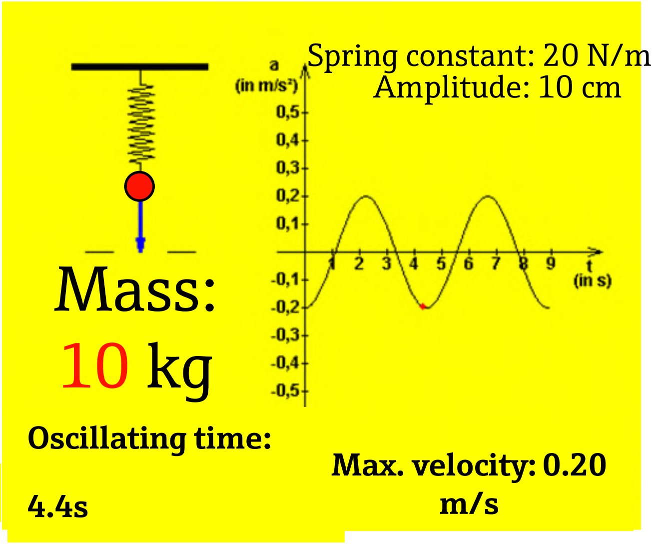
- w=Angular velocity
- Fc=Coriolis force
- Δφ=time shift
- A,B=Sensors
- y=Amplitude
- t=Time
-

Frequency-shift by Mass-shift

The resonance frequency of a swinging system is dependent on the stiffness c and the mass m.

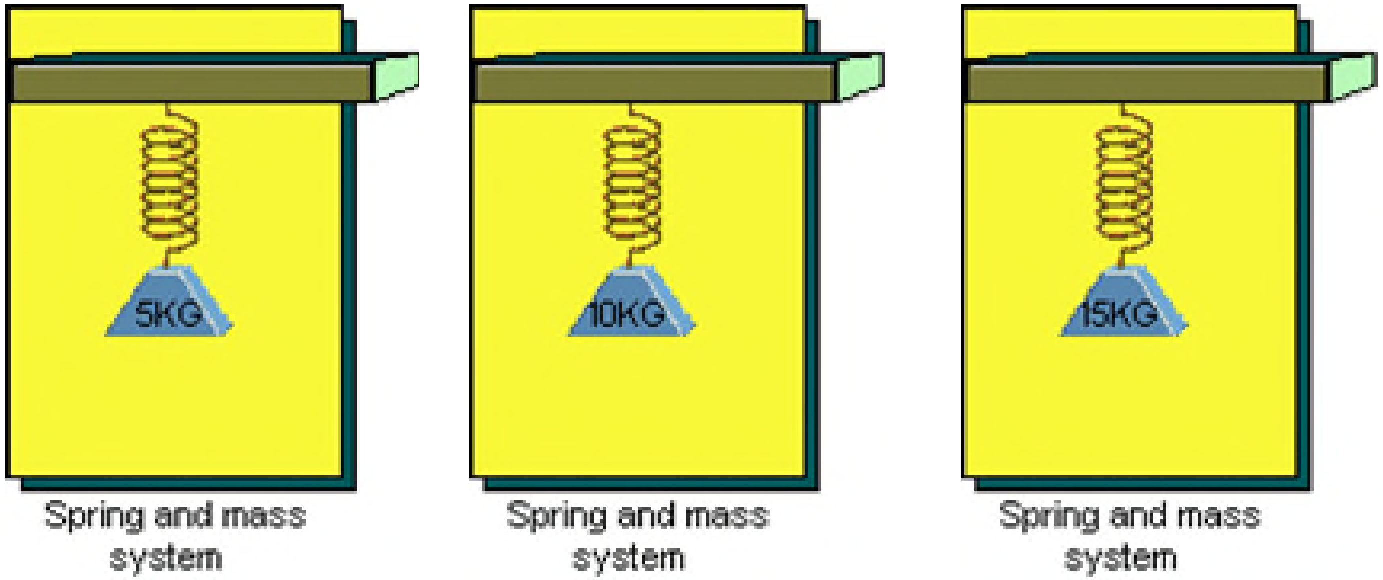
The bigger the mass at constant stiffness, the lower the resonance frequency





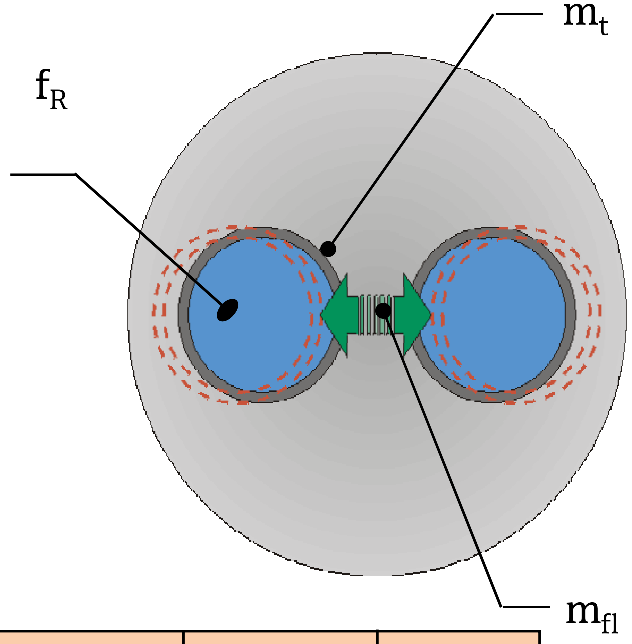
$$f_R = \frac{1}{2\pi} \cdot \sqrt{\frac{c}{m}}$$

Frequency-shift by Mass-shift



- The higher the mass the slower the frequency!
- The smaller the mass the higher the frequency!

The higher the density the bigger the mass



$$f_R = \frac{1}{2\pi} \cdot \sqrt{\frac{c}{m_{fl} + m_t}}$$
$$m_{fl} = V \cdot \rho_{fl}$$

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$$m_{fl} = V \cdot \rho_{fl}$$

f_R = Resonant frequency

m_t = Tube mass

m_{fl} = Fluid mass

ρ_{fl} = Fluid density

c = Constant

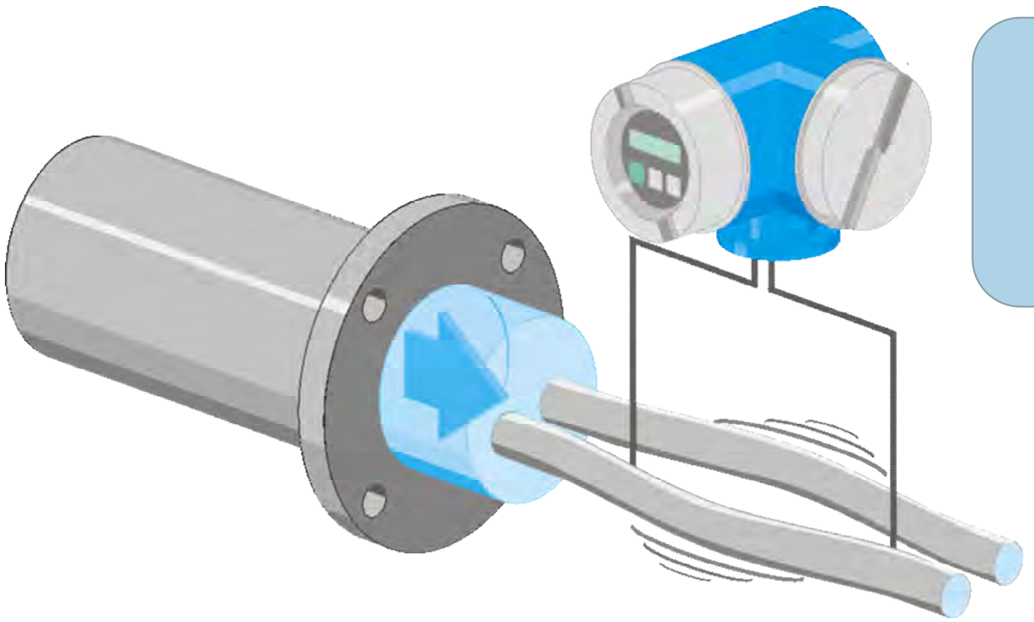
	DN 25	Density
Air	950 Hz	1,3 $\frac{kg}{m^3}$
Water	740 Hz	1000 $\frac{kg}{m^3}$

$$f_R = f(\rho_{fl})$$

The higher the density, the lower the resonance frequency

Overview of direct measuring variables

- Dφ=Phase shift
- m=Mass flow
- fR=Resonance frequency
- r=Density
- W= Resistance (PT1000)
- T=Temperature



$\Delta\varphi \sim \mathbf{m}$

$\mathbf{f_R} \sim \rho$

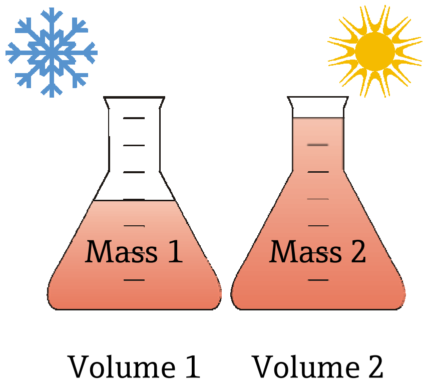
$\Omega \sim \mathbf{T}$

Overview of calculated values

- V=Volume flow
  V=m/r
- VN=Normvolume flow = Volume flow at fixed p and T
  VN= m/rN (note: rN is a fixed value for each fluid)
- c=Concentration
  Concentration can be calculated from density
  → see specific training (advanced module)
- n=Viscosity
  Viscosity can be calculated from oscillation damping. Viscosity measurement is only available with the Promass I sensor

Advantages of Coriolis Mass Flowmeter

- Measurement of Conductive and Non-Conductive Liquids
  - Standardisation on single flow technology
- Mass measurement independent of Temperature
  - Improved process control and stability due to eliminating of temperature influence
- High accuracy / High repeatability
  - Improved process control due to reduction in fluctuation of measured value
- Measurement independent of viscosity and density changes
  - High process stability with changing fluid properties
- High Operating Range
  - Improved process control also at low flow condition
- No moving parts
  - Reduced maintenance cost due to reduced wear and tear and improved operating time



Volume 1 ≠ Volume 2
Mass 1 = Mass 2

Endress+Hauser

Proline transmitter overview

100

- Ultra compact
- Full performance

150

- Thermal Flowmeters for gases and liquids

200

- Compact field transmitter for process industries
- Two-wire transmitter with reduced installation cost and easy to integrate

300

- Compact field transmitter for process industries
- Also suitable for harsh process environment

Proline transmitter overview

400

- Dedicated to water applications
- Polycarbonate housing

500

Remote

- Specialist for applications where electronics at sensor is not feasible
- All Ex approvals

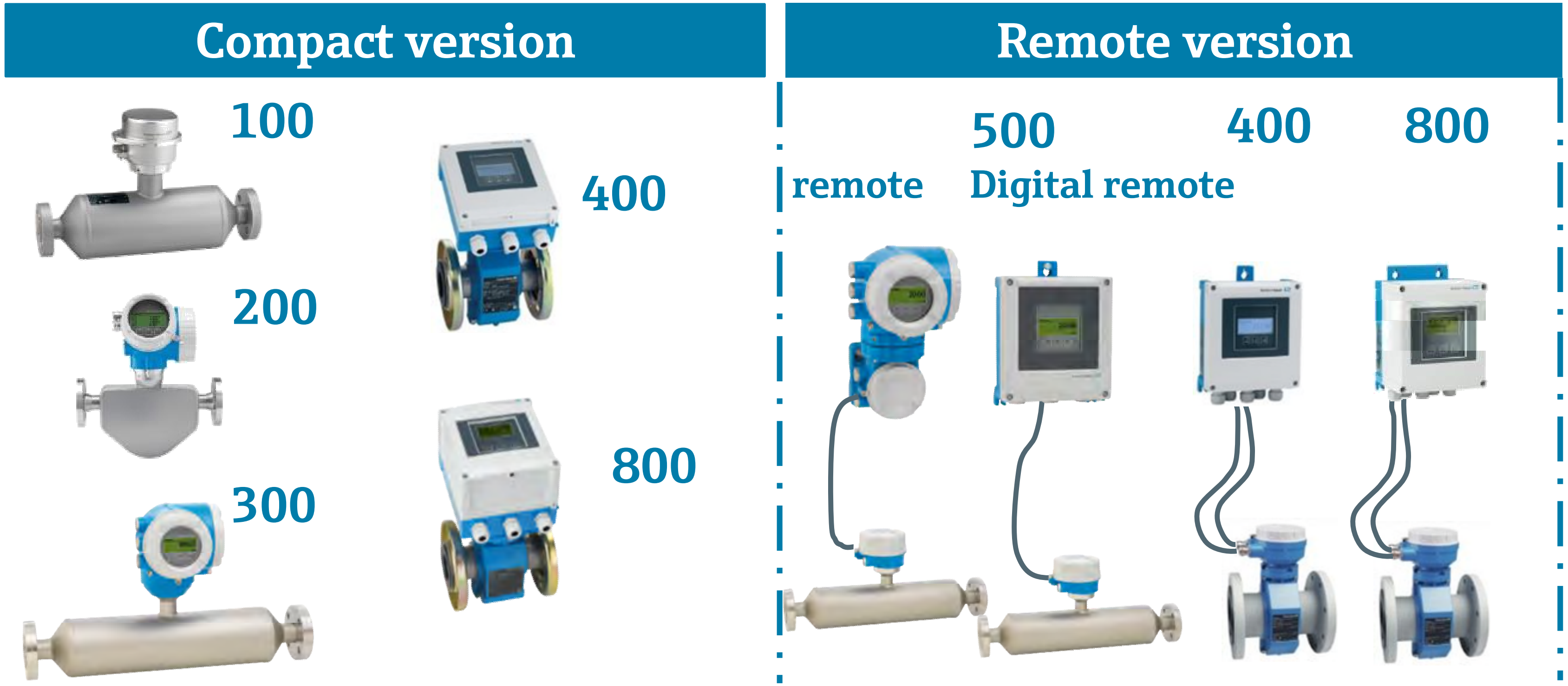
Digital Remote

- With up to 4 IOs
- For mixed ex installations

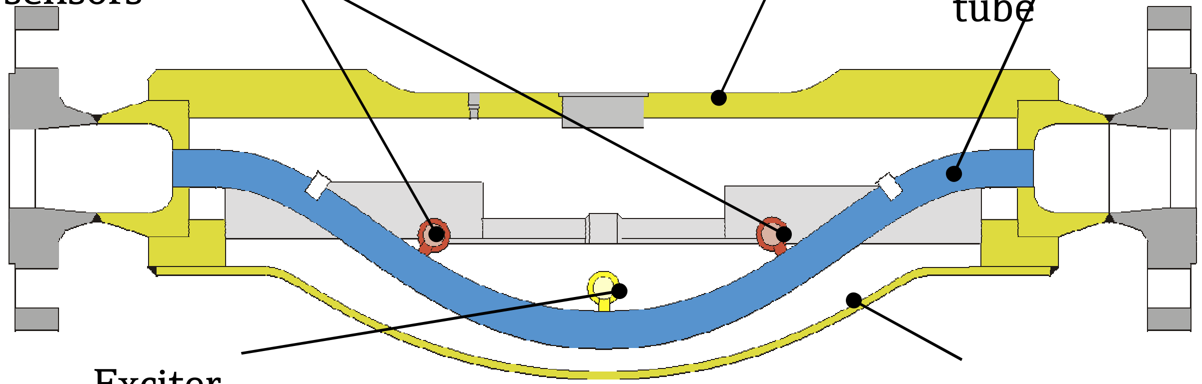
- 800
  - Battery operated for remote locations
  - With data logging and GSM/GPRS communication

✗ Not covered

Proline transmitter overview



Sensor Design



The rigid carrier tube withstands all loads in a piping system, allowing for true "Fit and Forget".

No extra measures like pipe line support needed.

No restrictions on pipe mismatch.

Questions