Road map for research concerning measuring and online control systems

Kersten Marx
VDEh-Betriebsforschungsinstitut GmbH
Sohnstraße 65
40237 Düsseldorf
Germany

Sensoring for improved process control

State of the art

- Thermal and fluid-mechanical conditions in continuous casting moulds are only roughly known although highly relevant for the product quality.
- Operational windows for lubrication, mould heat transfer and shell growth were developed but did not provide a real-time process control.
- Anomalous casting conditions were identified with innovative sensors but could not be implemented in real-time.
- It was found that insufficient mould powder coverage has a tremendous influence on the strand surface quality.
- Fibre Optical Temperature Sensors (FOTS) were successfully implemented in the mould copper.
- Continuous temperature measurement system with an optical fibre in the melt (DynTemp®) was developed but not tested in the mould until now.

Sensoring for improved process control

General Aim

Evolution of measuring instrumentation and control system tools to increase the performance of the continuous casting process in terms of:

- Safety
- Energy and raw material savings
- Reduction of defect occurence on the final product

Sensoring for improved process control

New tools to optimize process control

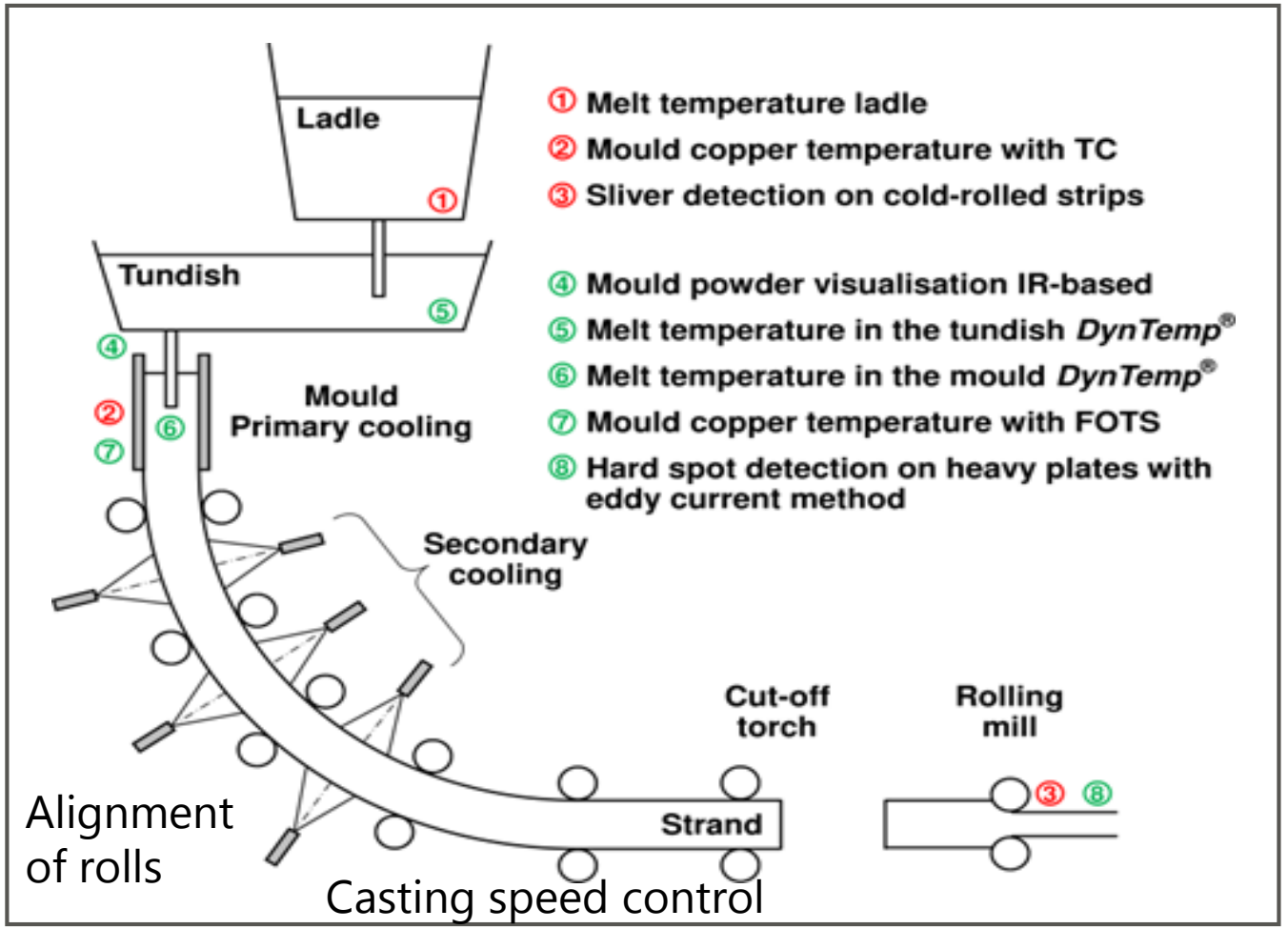
- Fibre optical temperature measurements in the mould copper and in the melt
- Continuous observation of the mould powder surface and derivation of its influence on melt temperature as well as lubrication and with it on surface quality
- Innovative measuring techniques for the detection of defects
- Enhanced data processing based on Big Data technologies to exploit various and heterogeneous existing and new data from ladles down to quality supervision in real-time

Sensoring for improved process control

Possible measuring locations and control parameters

Control of mould powder feeding

Cooling control



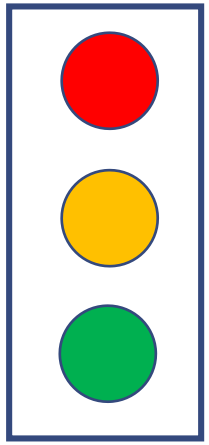
Alignment of rolls

Casting speed control

Plant data:

Meniscus level
Mould oscillation
Cooling water temperature
etc.

Surface inspection
Crack detection
Quality control



Sensoring for improved process control

Possible outcome of future work

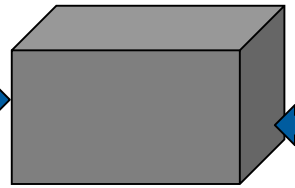
- Track the thermal field at top of the mould, mould steel level and mould powder layer thickness
- Effect of manual powder feeding and meniscus level oscillation on the mould temperature
- Identification of irregular casting conditions with particular reference to mould powder feeding, slag rim formation and irregularities in initial solidification
- Development and operation of a better control of the initial solidification at meniscus level to enhance surface quality of as-cast products

Mould powder monitoring

IR Camera Measurement of mould powder cover

Image analysis system

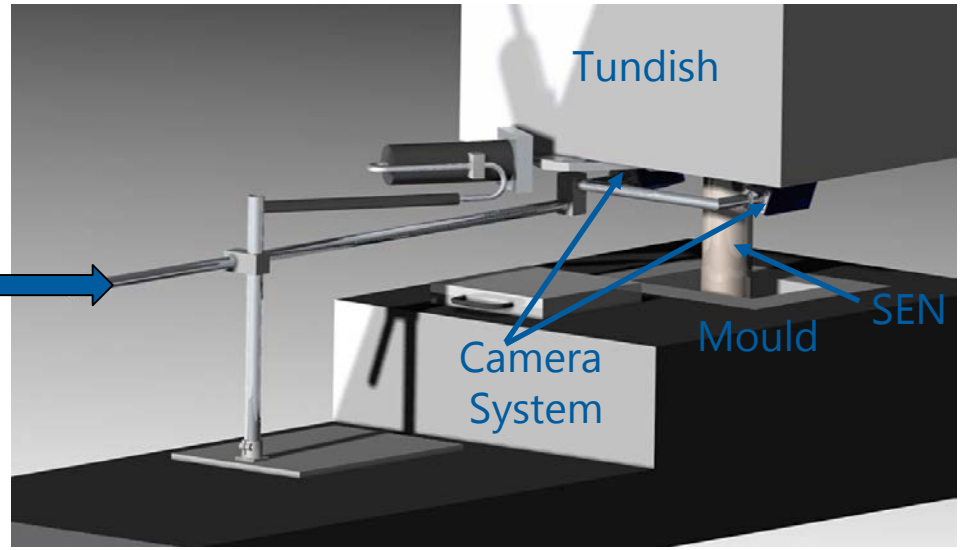
Supply box



- Image acquisition from camera
- Analysis of images
- Extraction of important information, e.g. starting point, frequency and intensity of mould powder break-up
- Display of results on screen
- Transfer of results to the project data base

› Supply of:
  - › Data transfer
  - › Power to cameras
  - › Cooling gas

Monitoring system for casting powder cover



- › Camera with IR sensor to monitor the thermal radiation of the mould powder surface
- › Protective housing to protect camera against harsh environment

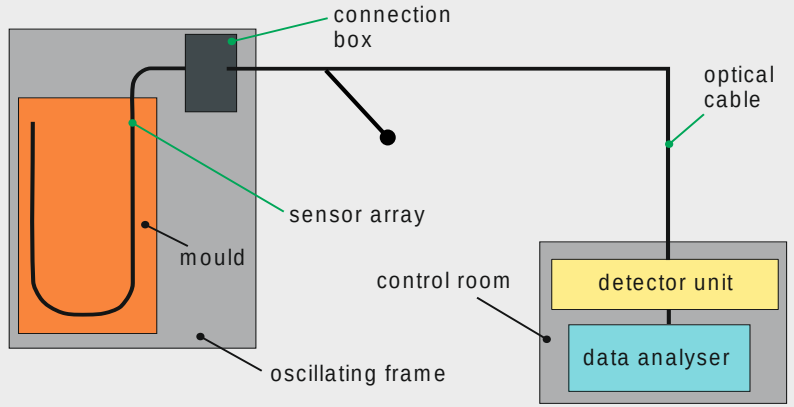
Monitoring the mould temperature by using fibre-optical-sensors

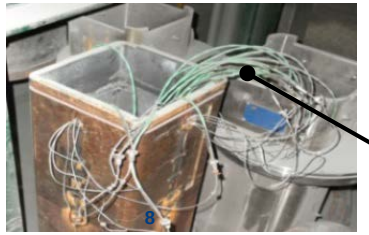
Advantages of Fibre-Optical-Temperature-Sensors (FOTS)

FOTS

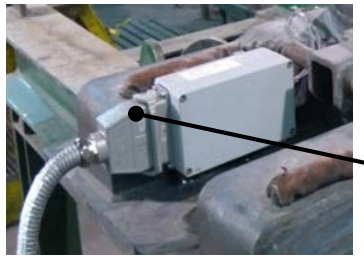
- No influences by electro-magnetic fields
- No or less influence of water flow
- Only one access point per mould plate
- Geometrically free positioning up to 20 temperature sensors in one fibre
- Multiple usage also possible

Principle structure and components of the used FOTS-system





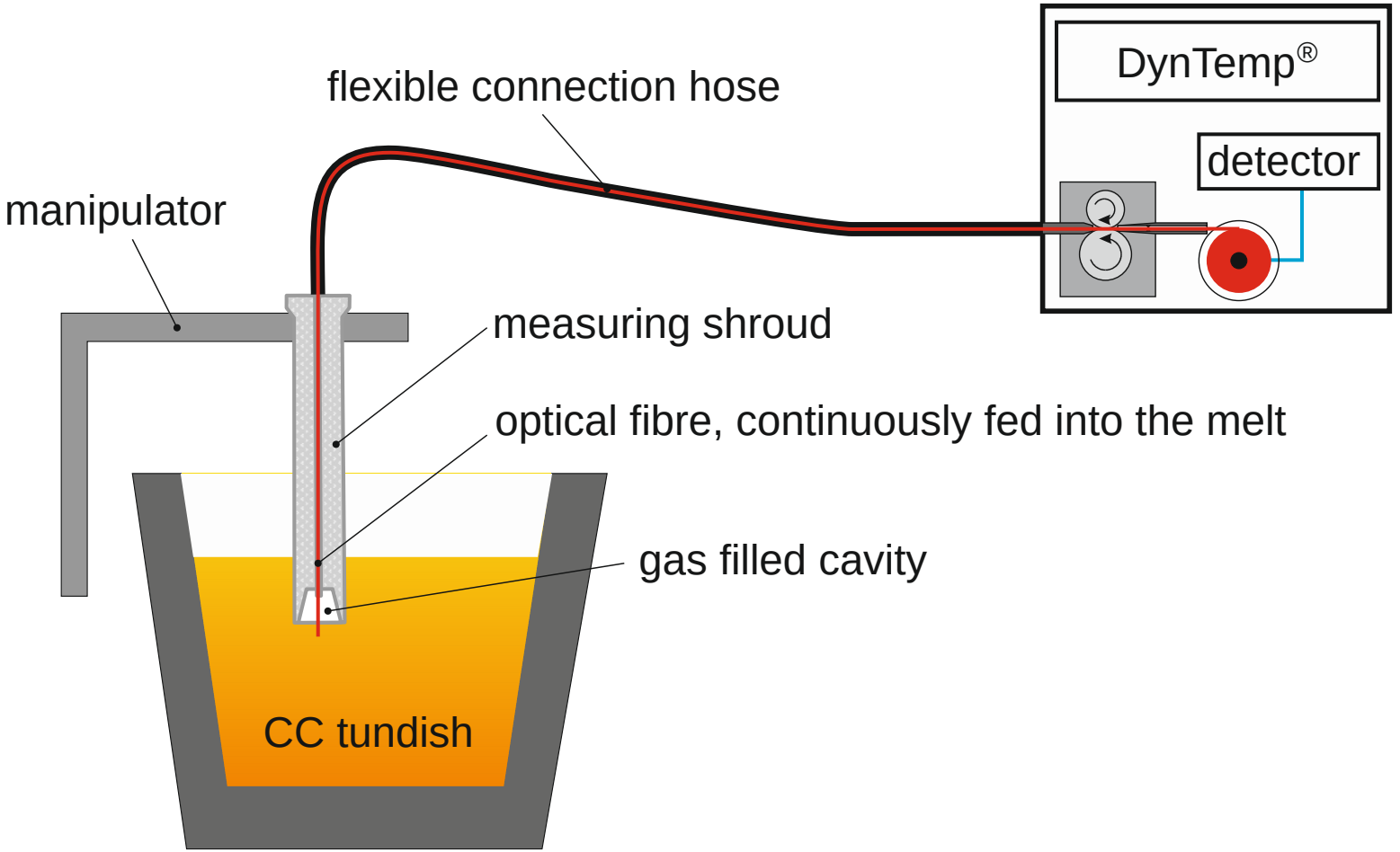
Cable bundle
15 thermocouple



FOTS cabling:
application with
40 measuring points

DynTemp®

Continuous Temperature Measurement in the Melt



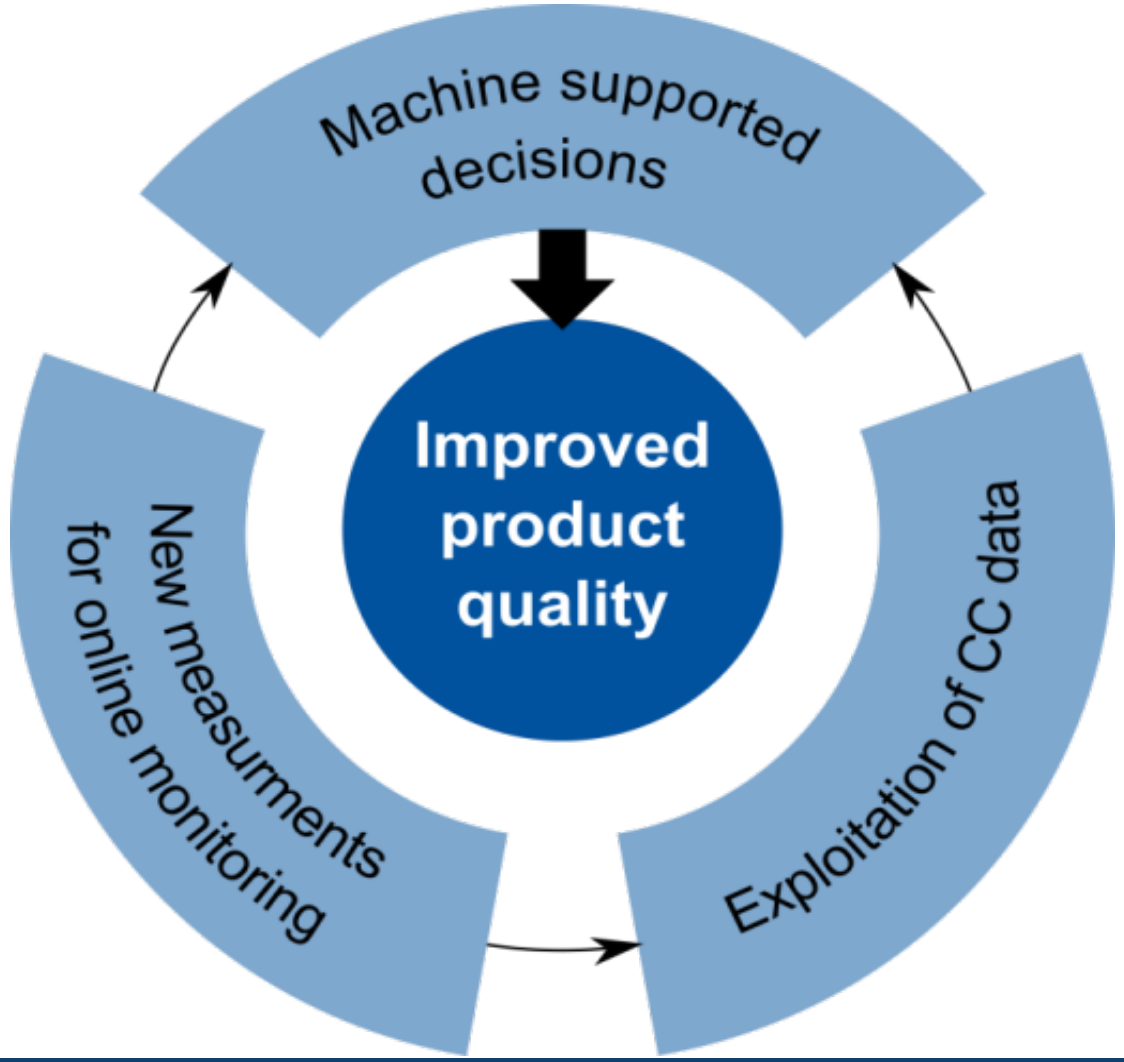
Detection of surface defects

- **EMAT-EMAT system** for generating and receiving ultrasound designed as Phased-Array-probes
- **Laser-EMAT** technology to inspect steel above the Curie point
- **Conoscopic Holography** (CH) system: Incoherent light interferometry, interference pattern is captured by a CCD camera

EMAT = **E**lectro**m**agnetic **A**coustic **T**ransducer

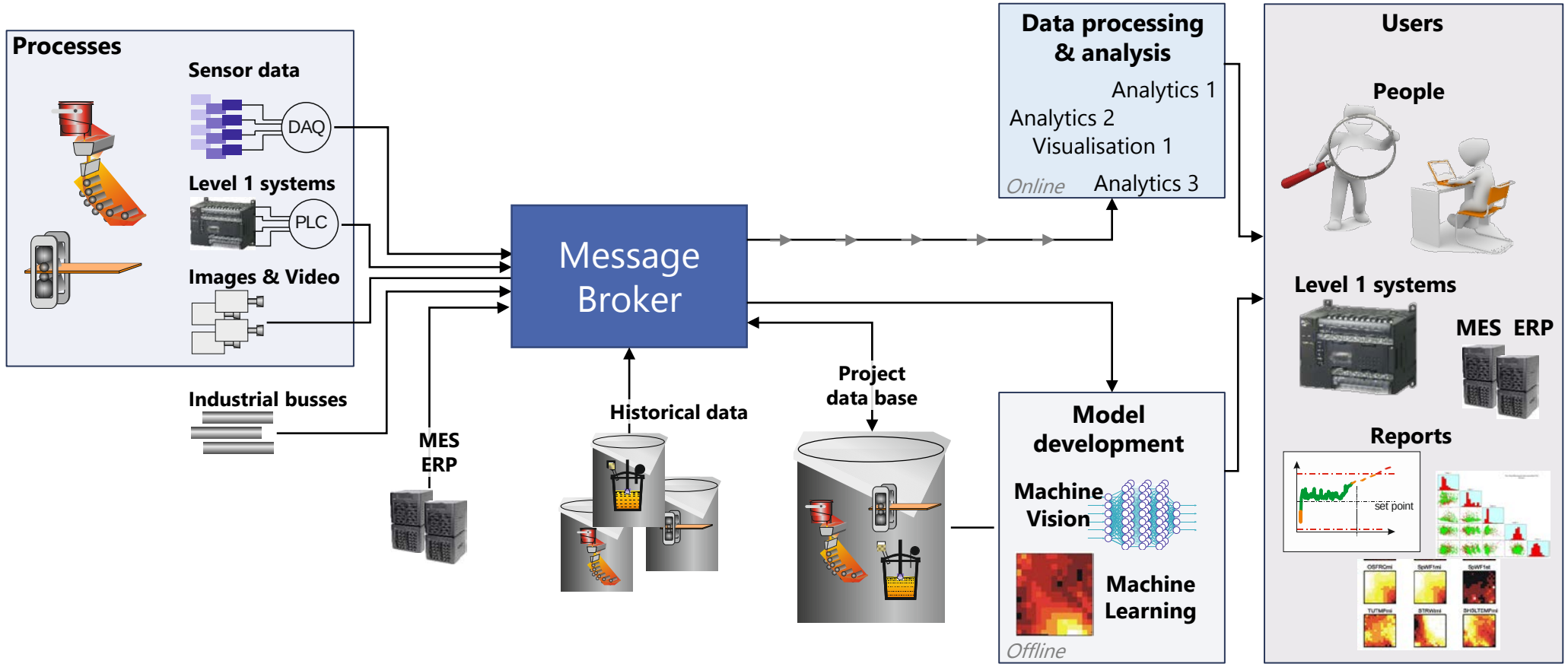
Online control systems

Proposed Measures



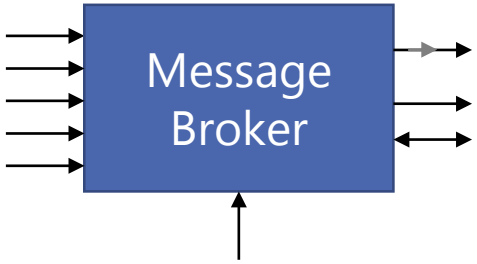
Online control systems

Possible concept of Big Data application

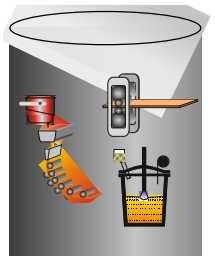


Online control systems

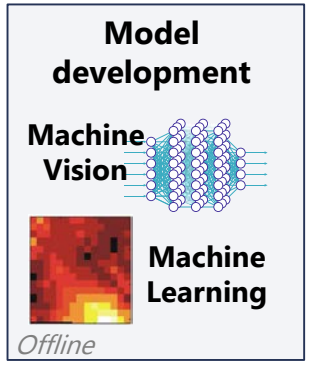
General description of Big Data applications



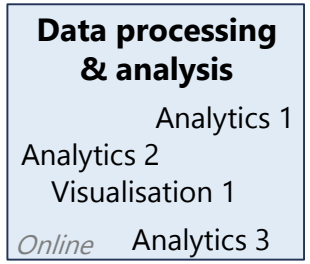
Message Brokers enable the communication between the nodes (sources and consumers of data). They are scalable in CPUs and memory. Examples are MQTT, AMQP or STOMP.



In the Project Data Base necessary data will be stored. To ease extension and to simplify the storage of different data types (numerical, images, …), NoSQL data bases are fast and powerful systems. Examples are MungoDB, CouchDB, …



For the modelling/estimation of defined target values, suitable methods must be selected and applied. These can range from simple statistical methods to more complex machine learning methods. The development of the models can only take place after sufficient data collection and is carried out offline.



Data processing and analysis modules can include

- simple statistics (thresholds, SPC,…)
- image analysis
- analysis and modelling by Machine Learning methods (clustering, Neural Nets, …)
- …

Thank you for your attention!

We would like to ask **you** some questions!

Contact: kersten.marx@bfi.de