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To ingest data in the Siemens Mindsphere platform the data is extracted from iba by an OPC-UA server from there to a Mindconnect box and finally to the Mindsphere platform. Another option is to use an interface which is provided by iba to connect to Mindsphere.

The first option was used to set up a connection for grinder 449 and to develop an OEE dashboard. The principle is shown in Fig. 3.

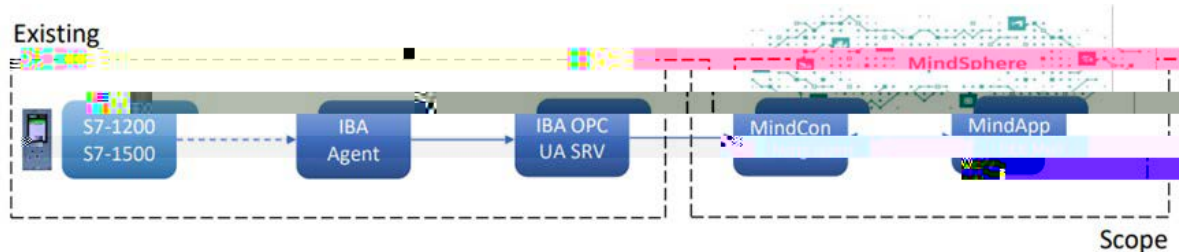


Fig.3 - Connectivity used present OEE-data on the Mindsphere platform.

OEE-DASHBOARD

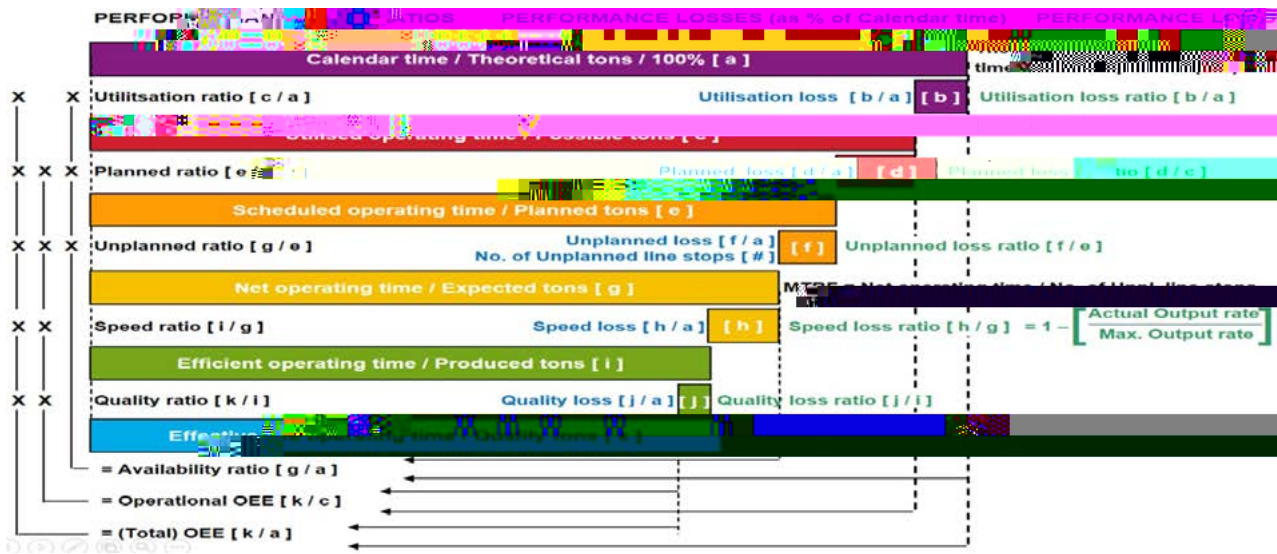


Fig.4 - OEE-breakdown according to World Steel Association.

The OEE-dashboard was based on the World Steel Association standard [1], which is elaborated in Fig. 4. It breaks down the calendar time in several pieces such as utilisation losses (overcapacity), planned losses (maintenance stops, tool changes), unplanned losses (installation issues, no rolls available), speed losses and quality losses. The last one is the most difficult to assign,

the others such as typical grinding time and definitions for unplanned and planned stops can be set in the OEE-app (Fig. 5).

2. Define error codes and name conventions.

Time Account	Category of the Time Account		
Productie	Net Production Time	Availability Losses	Planned Stops
Laden/lossen	Net Production Time	Availability Losses	Planned Stops
Omstellen	Net Production Time	Availability Losses	Planned Stops
Wachten	Net Production Time	Availability Losses	Planned Stops
Uitgeschakeld	Net Production Time	Availability Losses	Planned Stops
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The collected data was analyzed and categorized into categories such as the time account, which is an elaborate classification that could only be attributed to the



Build dashboard containing the following features:

- Status: Pie dia...
- Time per order per roll type: averages and single order;
- Time per step of the grinding process

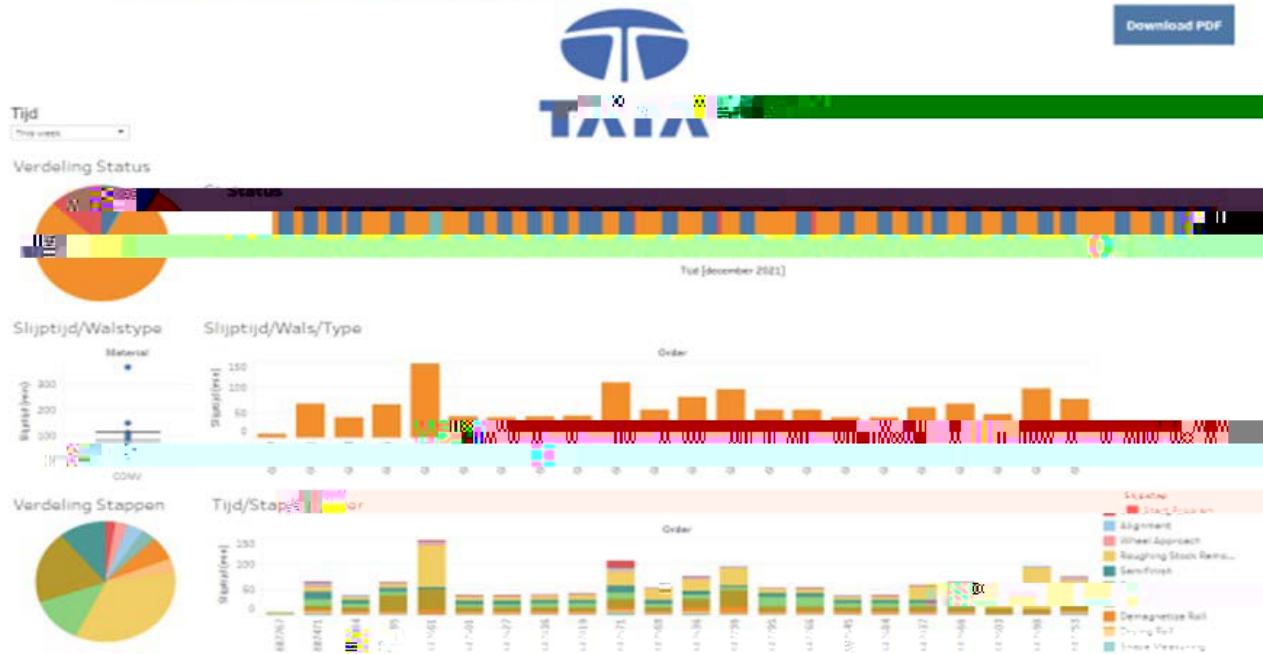


Fig.7 - Analysis of the grinding results based on historical data stored in the Cloud.

### CONDITION MONITORING

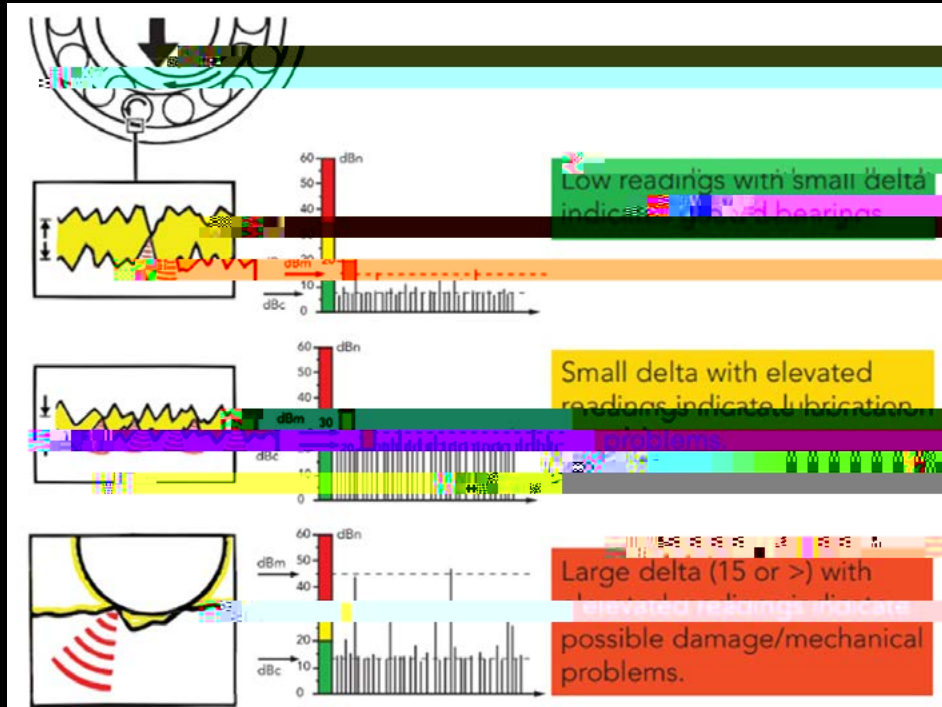
The same grinder 449 was equipped with Shock Pulse

Method [2, 3] sensors, which provide information on the condition of the machine.



Fig.8 - Shock Pulse Measurement sensor mounted on the fixed head of grinder 449.

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**Tab.1** - Part of the FMEA analysis of a grinder before SPM sensors were placed .

	Occurrence	Effect	Severity	Cause	Detection	Risk	Countermeasure
Failure of the main motor	1	No grinding possible	5	Electrical problems Misalignment	3	15	Check misalignment by vibration measurement
Failure of gear box	1	Work roll shape issues No grinding possible	7	Failing lubrication Misalignment Wear of wheels	7	49	Check lubrication vibration measurement Check misalignment by

**Tab.2** - After SPM sensors were placed the FMEA shows a considerable risk reduction.

	Occurrence	Effect	Severity	Cause	Detection	Old Risk	New Risk	Reduction
Failure of the main motor	1	No grinding possible	5	Electrical problems Misalignment	2	15	10	50%
Failure of gear box		shape issues No grinding possible		Misalignment Wear of wheels				

**DIGITAL MODEL OF ROLL SHOP**

Tata Steel in IJmuiden has set up sharp definitions on Digital Models, -Shadows and -Twins, based on the Digital Twin consortium [4]. The term Digital Twin will only be provided on systems which has direct connections both on the input and output with the real world. A Digital Shadow is only connected on the input side with the real world.

Digital Twins are the most complex of the three and a hard

coupled feedback loop to the real world is not trusted by most plant operators. Digital Shadows are sometimes used for testing new functionality. Digital Models could be simulation models: such a model was developed for the Roll Shop.

Since there is no direct input, an appropriate data set must be constructed. This was done by investigating all available roll data from the MES system and check these data whether pinches had occurred and to which severity.



**Fig.10** - Roll Shop at Cold Mill.





The Digital Model is another proof that all equipment in a roll shop, such as cranes and grinders must be in a good shape. It can also be used to test scenarios for maintenance stops, planned grinder revamps and others.

It might that in the future the Digital Model might be transformed in Digital Shadow providing up the up to date Roll Status ate every moment. A last step might be a change to a Digital Twin where the output is used to replan the Roll Shop. With new Cloud and Edge Technology, better data connectors to those platforms, this will come into sight in the coming decade and improved Artificial Intelligence Model this will come into sight in the next decade.

## CONCLUSIONS

The IT/OT landscape in the Cold Mill Roll Shop is modernized step by step. The introduction of a new data acquisition systems provides more insight in the operations, for instance to find the root cause of incidents. The date was connected to the IoT-platform Mindsphere, which also contains apps to unlock data. The OEE was set up for one grinder and provides additional insight in its performance and will also be rolled out for other grinders.

## REFERENCES

- [1] Tol K and Purvis A, Maintenance for the new Millennium, World Steel Association, 2008, ISBN: 978-930069-52-4  
 [2]

Additionally one grinder was equipped with vibration measurements to provide insight in its condition. Since the window of prediction is 3 to 9 months Predictive Maintenance can be introduced for the grinder.

The use of a Digital Model was introduced to obtain more insight in the constraints in the Roll Shop.

All these building blocks together fit in the Integrated Maintenance Model 4.0 (IMM4.0) as is described by Colla et. al. [5]

## ACKNOWLEDGMENTS

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**PAROLE CHIAVE:** ACCIAIO, LAMINAZIONE, TORNERIA CILINDRI, RETTIFICATRICE, MANUTENZIONE, MANUTENZIONE PREDITTIVA, OEE, MODELLO DIGITALE

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