Overhead & Gantry cranes: innovative solutions in predictive maintenance.

In Steel industry, as well as several other industries, overhead and gantry cranes are among the most critical production assets. Unexpected downtime often leads to huge financial losses. However, contrary to highly critical large rotating machinery and balance of plant equipment, predictive maintenance mostly remains an uncommon strategy for the main wheel bearings of these cranes. While vibration analysis is a widely accepted technique to implement a predictive strategy to prevent unexpected equipment failure, it is rarely applied to overhead and gantry cranes. The reason for this is obvious. The low speed, difficult access and most of all high background noise of the contact from the crane wheels with the rails, make an approach as applied to standard rotating machinery useless.

The customer’s journey: from curative to predictive maintenance

Since 2013, I-care is supporting a major player in Steel industry in its challenge to move from expensive and inefficient curative maintenance to a 4.0 maintenance program for its overhead and gantry cranes. The customer operates a total number of 227 overhead cranes, of which 55 are very critical to production.

A variety of mechanical defects can cause unexpected outages, but especially bearing failure of the crane wheels can result in important downtime and can cause severe safety issues. Early detection of inadequate lubrication and defects of the wheel bearings would allow a predictive maintenance approach, limiting downtime and increasing safety.

To meet the customer expectations, I-care has developed a successful monitoring program based on vibration analysis, infrared thermography, oil analysis and motor current analysis. Using customized data filtering to eliminate the noisy interference signals, and accurate analysis techniques allowed to deliver well-aimed maintenance and repair recommendations.
The monitoring challenge on cranes

Vibration measurements on gearboxes and drive motors allow a fairly standard approach, but monitoring of the crane wheels is more challenging. Indeed, several difficulties presented themselves:

- Low speed (20-50 RPM)
- Difficult to access
- Important background noise caused by the contact of the wheels with the rails

Our action took place in three phases:

- Phase 1 in 2013: First tests and development of measurement technique
- Phase 2 from 2014 till 2018: Periodic monitoring based on portable vibration measurements.
- Phase 3 (since 2019): Wireless crane monitoring

Phase 1: First tests and development of measurement technique

In 2013, a test was performed to determine the feasibility of vibration monitoring on the crane wheels using portable data collectors.

The following components are measured during the test:

- 16 crane wheel bearings (wheel diameter of 1m)
- 8 trolley wheel bearings
Because of the dimensions of the overhead crane to be measured (width 35m, height 20m, 447 tons), lifting the crane is not an efficient option.

For that:

- accelerometers are positioned as close as possible to the wheel bearings.
- Measurements are made with long cables, so the analysts can remain in a safe location on the crane, while it’s moving.

Standard vibration readings will not provide good results because of the background noise. A high pass filter is used to remove vibration caused by the contact of the wheels and the rails, while keeping the high frequency signals caused by the bearings defects. Classic high frequency techniques will calculate the spectrum based on the analog waveform obtained by enveloping the rectified signal.

More advanced techniques will use very high frequency sampling (>80kHz), to detect the stress waves caused by the bearing defect. This technique is available e.g. in CSI’s PeakVue or in Wi-care as I-DNA.
Test measurement results:

- HF measurement, filter 1
- HF measurement, filter 2
- HF measurement, filter 3
- Standard FFT, no filter

The standard reading (below) is distorted because of background noise. If the standard FFT measurement is removed, results are more clear:

- HF measurement with filter 1
- HF measurement with filter 2
- HF measurement with filter 3

Comparing the envelope readings with the selected filter on all 16 bearings shows one bearing with much higher amplitudes.
Analysis: defect frequency corresponds to the outer race defect frequency (BPFO) of the bearing SKF 23240.

<table>
<thead>
<tr>
<th>BRG ID</th>
<th>BEARING TYPE</th>
<th>RB/R</th>
<th>FTF</th>
<th>BSF</th>
<th>BPFO</th>
<th>BPI</th>
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<td>74903</td>
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<td>3.555</td>
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<td>10.778</td>
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</table>

As the measured amplitudes were very low, it was uncertain if the detected defect would be clearly visible on the bearing.

Few weeks later, the bearing indicated as the defective one reveals severe damage when the outer race was inspected.
Phase 2: Periodic monitoring based on portable vibration measurements

The second phase occurred from 2014 until 2018. Based on the results of the test campaign, a complete monitoring program was setup for 70 overhead cranes (±1500 bearings), based on periodic measurements.

- Between 2014 and 2016, 45 bearings were replaced based on the results of the monitoring program.
- In the same period, 13 unexpected bearing failures occurred (breakdown maintenance), mostly on cranes not yet implemented in the program.

For all 45 predictive bearing changes, the replaced bearings were closely examined and catalogued as:
- Necessary bearing replacement (crash avoided)
- Bearing replacement performed too early

![Number of changed wheelbearings chart]

- 28 avoided crashes
- 17 defect visible (too early)
Based on the feedback received, criteria for bearing replacement were adjusted and fine-tuned.

Measurements in November 2015 indicate the appearance of bearing defect frequencies on a wheel bearing of crane #121.

Based on the experience of previous cases, amplitudes are estimated too low for bearing replacement, and lubrication of the bearing is recommended.

After lubrication, a new measurement is performed and shows an important improvement of the vibration signature. Further follow up is recommended.
Conclusion: if measurements show early signs of bearing damage, but amplitudes are too low to expect important bearing damage, inadequate lubrication is determined as a possible cause and replacement of the bearings is not recommended.

Example of early signs of wear. Additional lubrication extends the remaining life of the bearing, without the need of replacement.

Periodic vibration measurements and detailed analysis allowed to set up a reliable condition monitoring program for the overhead and portal cranes.

However, there are some disadvantages of this approach...

- In average, measurement and analysis of an overhead crane represents 20 man-hours per crane.
- To perform the measurements, cranes need to be taken out of production, which for some cranes causes lost production time.
- As the analysts need to be on the crane, while it is moving, special safety measures are necessary.

Because of the aforementioned reasons (safety & lost production time), the company asks to investigate possibilities to perform online monitoring. Compared to most applications, online monitoring of the overhead cranes is quite challenging.

- Fault detection is only reliable if high speed sampling is available.
- Good measurements are only possible if the crane runs at a stable speed for 20+ seconds, while operation conditions are very erratic.
- Wireless data transmission is preferred to limit cabling costs and improve reliability.
Although many wireless vibration systems are available, none of the existing systems investigated, could provide an answer to all of the requirements.

Phase 3: Wireless crane monitoring

The last step started early 2019: from preventive to predictive 4.0 maintenance. Wi-care wireless systems are an I-care internal development, and the specific requirements for crane monitoring were implemented from the start. The Wi-care 200 wireless system, unlike other wireless systems on the market, offers:

- bearing fault detection using high speed sampling
- smart’ data capturing on external trigger (speed)
- local power supply for continuous operation

Wi-care 200 series

- Multi CBM technology
- Intelligently capture data (trigger)
- Flexible communication
Tests performed on an overhead crane with a known bearing defect confirmed that the high sampling technique in Wi-care 200 allows defect detection.

The spectrum, measured during normal production, clearly shows the defect pattern, matching the theoretical bearing defect frequencies.
System architecture:
Wi-care 200’s flexible two-way communication also allows easy integration of other technologies and sensors: temperature, online oil analysis, thickness,...

The complete wireless system...

97 sensors installed
- 50 vibration sensors
- 21 online oil sensors (oil quality, oil wear, oil level)
- 26 ultrasonic distance sensors (thickness of brake liner, hoist cable, carbon brushes)

Thickness measurements are transmitted with the same wireless system and results are available in the same analysis software.
Conclusion

the wireless Wi-care 200 system allows to further increase the reliability of the crane monitoring program, while eliminating the disadvantages of the existing (successful) periodic program.

Based on the knowledge and by now years of experience in the field, I-care was able to meet the challenge of automating condition monitoring on cranes, developing a highly performant wireless monitoring system, that defies the tough challenges proper to the application. Wi-care 200 series manages to produce reliable measurements in conditions previously deemed virtually impossible, while wireless communication allows an acceptable level of investment.

Moreover, the elimination of the rather labour intensive portable measurements, often also disturbing production, yield a highly lucrative rate of return.

The Wi-Care technology allows the customer to overcome the problems and find the best solution to optimize the maintenance of its machines. This path is part of the maintenance 4.0, an automated maintenance to minimize costs.

More information

Would you like to know more about how I-care can help you reduce your downtime? Visit our website www.icareweb.com or contact us +32 (0)65 45 72 14 or by email via marketing@icareweb.com.