KISTLER
measure. analyze. innovate.

Weigh-In-Motion

Unique Quartz Sensor Technology: Now also for Railways

David Cornu,
Kistler Instrumente AG
Winterthur, Switzerland

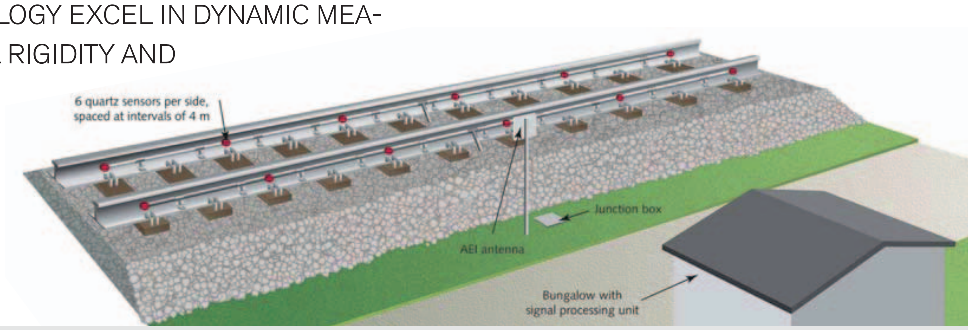
Special print from
EURAILmag Business &
Technology, Issue 18
September 2008

Special Print
920-365e-10.08

WEIGH-IN-MOTION

UNIQUE QUARTZ SENSOR TECHNOLOGY: NOW ALSO FOR RAILWAYS

SENSORS BASED ON QUARTZ TECHNOLOGY EXCEL IN DYNAMIC MEASURING TASKS DUE TO THEIR EXTREME RIGIDITY AND STABILITY. THANKS TO LATEST PRODUCT DEVELOPMENTS, ALSO IN-LINE WEIGHING SYSTEMS FOR RAIL CARS CAN NOW BENEFIT FROM THESE UNIQUE PROPERTIES.



Picture 1: Kistler in-line weighing system - standard layout

The need to monitor and control loading and weight of rail cars has increased since the train operators were separated from the companies owning and maintaining the railroads and since railroad pricing and train access charges were introduced. For weighing vehicles (or vehicle load respectively), weighing bridges were widely used in the past. In order to improve efficiency, in-line wheel load weighing systems have been deployed. Additionally, such in-line weighing systems are now used by railroad companies to check the operational safety and, consequently, to identify potentially unsafe vehicles. These systems detect:

- overloaded vehicles
- uneven load conditions of vehicles
- damaged wheels, flat spots

As the world's leading supplier of sensors and sensor electronics for measuring pressure, force, torque and acceleration, Kistler has in-depth knowledge of dynamic measuring technology. Motivated by the success achieved in monitoring heavy vehicles on the road thanks to unique weigh-in-motion (WIM) quartz sensors and also due to the fact that quartz technology excels in dynamic force measurement, Kistler developed a high-speed WIM system for railways called “Overload & Imbalance Detector”.

System Description

The Kistler WIM system for rail cars (see picture 1) uses quartz sensor technology to weigh freight cars en route over mainline tracks at high speed. The sensors are installed in holes drilled through the vertical rail web (see pict. 2 and 3). No other modifications have to be made to the rails or supporting structures (wood or concrete ties, ballast pebbles or earthen substructure). Consequently, the installation can be done very fast and easily without interrupting the traffic flow. Each sensor measures the compression of the rail and produces a physically correct result for the actual wheel force. The standard system is composed of twelve force sensors, six of which are mounted in each rail at intervals of approx. 4 m. Sensor signals are routed via cable to a trackside bungalow or electronic cabinet, where they are digitalized and converted into wheel loads by a signal processing unit. The wheel loads are summed to obtain the gross weight of each rail car and the total train weight. Furthermore, the load imbalance of each car (front/back and left/right imbalance) is calculated and wheel damage (e.g. flat spot) detected. The system also counts the cars and number of axles of each car, determines the driving direction and speed, the total number of cars and the train length. The system accepts Automatic Equipment Identification (AEI). Via an RFID antenna mounted at the track side, the cars’ IDs are collected and automatically correlated to the weight data output. All WIM data is stored on a local hard drive and downloaded continuously or on demand to any of a railroad company’s remote facilities.

System Performance

The following results originate from a rail WIM site (see pict. 4) installed in Ogallala, Nebraska (USA). Approximately 40 trains per day (fully loaded coal trains) coming out of a coal mine are continuously being monitored. The speed range is 50 to 90 km/h. Installation was completed in August 2006 within one day without interruption of the traffic flow. To evaluate the performance of the system, cars with known weights were considered. The results of the system evaluation presented below are based on the measurements of 5 trains, each consisting of 130 rail cars.

The individual rail car weights (measured on a static scale) were subtracted from the weights measured on the WIM site to generate an error population for each of the five trains. As these trains consisted of 130 rail cars, each of the five error sets was of that size. A calibration constant was set to bring the mean error to near zero for the entire set of rail cars of all five trains. Then the mean error and standard deviation were calculated for each train (see table 1).

It was expected that the mean error for each train would be near zero – however, this was not the case. The reason was that the trains did not originate from the same mining company; therefore, some deviations (offset) occurred between the static scales of the different companies. The standard deviation (σ) demonstrates the excellent performance of the system with an accuracy within ±2% for 95% of the measurements (2σ-confidence level). The system produces very

Picture 2: Kistler rail WIM sensor installation

Picture 3: Rail with installed sensor

Picture 4: Rail WIM site

Train number	1	2	3	4	5
Speed [km/h]	57.3	38.9	83.8	77.6	76.2
Mean error [%]	-0.37	0.85	-0.43	-0.58	0.47
Std. deviation σ [%]	**0.78**	**0.66**	**0.89**	**0.80**	**0.55**

Table 1: Results of rail WIM system evaluation

good results due to the fact that the sensors are specially designed for detecting only vertical wheel forces. They measure only the compression of the rail, without being influenced by other force components like shear force or bending moment. This measuring principle (compression) is the most accurate one as the results depend neither on vehicle position or geometry (distance between axles) nor on the track conditions (stiffness of the track bed). Additionally, thanks to multiple samples from the sensor array, the signal processing algorithm mitigates the effect of vehicle dynamics and extracts the static signal component representing the true weight of the car.

Rail WIM Applications and Benefits

In-line wheel weighing systems improve operational efficiency and safety.

Thanks to imbalance and overload detection as well as wheel damage detection, unsafe vehicles are identified. As a result, potential car derailments can be prevented. As regards commercial aspects, in-line weighing systems allow to detect overloaded vehicles and consequently reduce wear and tear of the infrastructure. Vehicle and track maintenance can be efficiently planned. Road pricing and shipping contracts (payload) can be implemented and verified.

The Kistler rail WIM system provides excellent benefits for these applications. It features technical advantages thanks to the unique sensor technology. The system is very stable and accurate, no fatigue or ageing occurs and it is independent of speed and temperature variations. There are also financial benefits as the system is maintenance free, easy to install and long-lasting ■

David Cornu, Product Manager

FOR MORE INFORMATION

Kistler Instrumente AG
Switzerland
Phone: +41 52 224 11 11
Email: info@kistler.com
Web: www.kistler.com

Kistler worldwide

Europe

Austria
Kistler GmbH
Lemböckgasse 49f
1230 Wien
Tel. +43 1 867 48 67 0
sales.at@kistler.com

Czech Republic/Slovakia
Kistler, s.r.o.
Zelený pruh 99/1560
140 00 Praha 4
Tel. +420 296 374 878
sales.cz@kistler.com

Denmark/Norway/Sweden
Kistler Nordic AB
Aminogatan 34
431 53 Mölndal
Tel. +46 31 871 566
info.se@kistler.com

Finland
Kistler Nordic AB
Särkiniementie 3
00210 Helsinki
Tel. +358 9 612 15 66
info.fi@kistler.com

France
Kistler France
ZA de Courtabœuf 1
15, avenue du Hoggar
91953 Les Ulis cedex
Tel. +33 1 69 18 81 81
info.fr@kistler.com

Germany
Kistler Instrumente GmbH
Daimlerstrasse 6
73760 Ostfildern
Tel. +49 711 34 07 0
info.de@kistler.com

Italy
Kistler Italia s.r.l.
Via Ruggero di Lauria, 12/B
20149 Milano
Tel. +39 02 481 27 51
sales.it@kistler.com

Netherlands
Kistler B.V. Nederland
Leeghwaterstraat 25
2811 DT Reeuwijk
Tel. +31 182 304 444
sales.nl@kistler.com

Switzerland/Liechtenstein
Kistler Instrumente AG
Verkauf Schweiz
Eulachstrasse 22
8408 Winterthur
Tel. +41 52 224 12 32
sales.ch@kistler.com

United Kingdom
Kistler Instruments Ltd.
13 Murrell Green Business Park
London Road
Hook, Hampshire RG27 9GR
Tel. +44 1256 74 15 50
sales.uk@kistler.com

Asia

China, People's Republic of
Kistler China Ltd.
Unit D, 24/F Seabright Plaza
9-23 Shell Street North Point
Hong Kong
Tel. +852 25 915 930
sales.cn@kistler.com

India
Kistler Instruments (Pte) Ltd.
India Liaison Office
2B Century Plaza
560/562 Anna Salai
Teynampet, Chennai 600 018
Tel. +91 44 4213 2089
sales.in@kistler.com

Japan
Kistler Japan Co., Ltd.
23rd floor, New Pier Takeshiba North Tower
1-11-1, Kaigan, Minato-ku
Tokyo 105-0022
Tel. +81 3 3578 0271
sales.jp@kistler.com

Korea, Republic of
Kistler Korea Co., Ltd.
Gyeonggi Venture Anyang
Technical College Center 801
572-5, Anyang-Dong, Manan-Gu,
Anyang-City, Gyeonggi-Do 430-731
Tel. +82 31 465 6013
sales.kr@kistler.com

Singapore
Kistler Instruments (Pte) Ltd.
50 Bukit Batok Street 23
#04-06 Midview Building
Singapore 659578
Tel. +65 6316 7331
sales.sg@kistler.com

Taiwan
Kistler Representative Office in Taiwan
Room 9, 8F, No. 6, Lane 180
Sec. 6, Mincyuan E. Road
Taipei 114
Tel. +886 2 7721 2121
sales.tw@kistler.com

Thailand
Kistler Instrument (Thailand) Co., Ltd.
26/56 TPI Tower, 20th Floor
Nanglingee Rd., (Chan Tat Mai Rd.)
Thungmahamek, Sathorn
Bangkok 10120
Tel. +66 2678 6779-80
sales.thai@kistler.com

America

USA/Canada/Mexico
Kistler Instrument Corp.
75 John Glenn Drive
Amherst, NY 14228-2171
Tel. +1 716 691 5100
sales.us@kistler.com

Australia

Australia
Kistler Instruments Australia Pty Ltd
G21 / 202 Jells Rd.
Wheelers Hill, Victoria 3150
Tel. +61 3 9560 5055
sales.au@kistler.com

Other countries

Kistler Instrumente AG
Export Sales
Eulachstrasse 22, 8408 Winterthur
Switzerland
Tel. +41 52 224 11 11
sales.export@kistler.com

Headquarters

Switzerland
Kistler Group
Eulachstrasse 22, 8408 Winterthur
Tel. +41 52 224 11 11
Fax +41 52 224 14 14
info@kistler.com

www.kistler.com

KISTLER
measure. analyze. innovate.