MODERN WEIGHING SYSTEMS FOR STEEL PRODUCTION: HIGHLY ACCURATE AND RELIABLE WITH A MAXIMUM EASE OF MAINTENANCE [1]

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Abstract
This article aims at providing to production and maintenance departments of steel plants and to plant designers a brief overview over modern process weighing systems, used for example for liquid steel or scrap**,** that offer high accuracy and reliability combined withsignificantly reduced time and money effort for maintenance. Considering especially the trends of reducing maintenance staff going on in parallel with the steadily increasing requirements on productivity, improving reliability and at the same time reducing maintenance of weighing systems under the harsh environmental conditions of steel production has proven to contain a high economical potential. Over the last years the following features with a focus on reliability and maintenance have been developed and successfully executed in various steel plant weighing applications: design of special strain gauge based Loadcells conceived for the specific environment, the so-called Direct Weighing Technologies**;** definition of optimally suited installation locations for the scale mechanics, thus representing the fundamental condition for long term stable operation and reduced maintenance work; utilisation of the advanced capabilities of modern evaluation electronics and field bus communication; continuous exploitation of field experience with the various successfully installed weighing systems worldwide as technical reference for new projects. Especially the close cooperation between steel plant operators, plant designers and weighing specialists has ensured a continuous technological progress regarding those process weighing systems. In-house development, design and production of Direct Weighing Technologies enables Schenck Process to meet ever growing customer requirements, assuring to all partners involved a continuous benefit also in future.
Key words: Weighing system; Direct Weighing Technologies; Maintenance.

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1 INTRODUCTION

More than ever before today's worldwide consolidation of steel industry entails the need for constant improvement of all internal processes.
Weighing systems have always played an important role in all stages of production: from the receipt of raw materials over the processing of liquid pig iron and steel to the sales of coils or sections. With masses to be weighed between a few kilos and several thousand tons and depending on their installation place, the numerous in-process weighing systems differ significantly from each other and from conventional legal-for-trade scales.
Ever stricter requirements to quality and availability result in a steady need of improved performances for all kinds of weighing systems. Besides the specific conditions imposed by the harsh operating environment and the on going reduction of service staff and intervals explain, why a high ease of maintenance today is of the utmost importance.
With this in mind, the present article provides an overview of some advanced weighing systems used inside steel production. It describes in particular the state of the art of different design features crucially optimising all kinds of maintenance tasks.

2 CENTRAL FUNCTIONS OF WEIGHING SYSTEMS IN STEEL PRODUCTION

The main function of weighing systems used in steel production is their contribution towards safety, profitability and environmental protection.

Safety:

Where large amounts of liquid pig iron and steel have to be transported between various processing steps, weighing equipment has an essential, safety-critical function in order to avoid spillages or accidents, for example during the weight controlled filling of ladles. This also applies to blast furnace burden hopper scales, contributing essentially towards safeguarding process safety by precisely mixing sinter, coke and additives.

Profitability:

Precise weighing systems improve the profitability allowing to feed the exact amounts of raw materials and alloys, ensuring that the material consumed represents the minimum needed in order to achieve the desired steel quality respecting the chemical tolerances.
Besides the total information about the exact masses of all materials involved is key for a better management of the entire process enabling the establishment of material balances assisting to identify improvement potentials.

Environmental protection:

Optimum feeding of all resources helps to reduce the consumption of material and energy and to prevent excessive emission of dust and production of wastes. Particularly considering current industrial efforts to minimise pollution levels including the associated evidence the significance of advanced weighing in combination with environmental considerations becomes more and more obvious.

3 CONVENTIONAL SOLUTIONS FOR LEGAL-FOR-TRADE WEIGHING SYSTEMS

Looking at the huge variety of weighing systems in steel plants, first it has to be distinguished, if an application is subject to verification requirements for legal-for-trade systems. Those applications usually are located at the beginning of the process (for the purchase of raw materials) as well as at the end of production (for the sale of coils, bundles or sections).
In these areas the ambient conditions usually are such, that they do not pose major problems to conventional weighing solutions.
The systems therefore are designed as usual hopper scales, road weighbridges, platform or double frame scales with a weighing range between 1t and 100 t.
The weight to be determined is transmitted through a weighbridge for load application and several legal-for-trade approved Loadcells to the foundation.

The installation example in Figure 2 shows a typical coil scale arrangement for a weighing range of 40 t and an increment of 10 kg, executed with 4 **Loadcells RTN 33 t C5**. This conventional solution for the weighing mechanics, based on standard strain gauge Loadcells RTN, Elastomer Mounts VEN (Figure 1) and external bumpers has proven to work extremely reliable in many steel plants worldwide. It is cost-efficient, highly accurate and requires only a minimum of maintenance. As all legal-for-trade weighing systems need periodic re-certification at any rate, this will ensure, that the operating status of the weighing system is routinely checked at regular intervals.

Figure 1. Schenck Loadcells with RTN Elastomer Mounts VEN

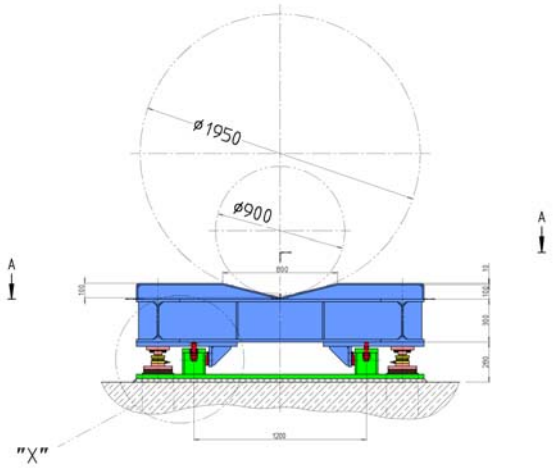

Figure 2. Basic structure of a legal-for-trade coil scale 40 t

Industrial practice has shown over the last years, that it makes special sense to distinguish with regard to maintenance requirements the various in-plant process scales from the legal-for-trade weighing systems shown above used for sales purposes.

4 REQUIREMENTS FOR IN-PLANT PROCESS SCALES

In-plant process weighing systems are working under entirely different conditions than legal-for-trade scales. Unlike weighing systems requiring trade use certification, there are no prescribed verification intervals for in-plant scales. Therefore significant cost savings can be achieved in a steel plant, if attention is focussed on an optimum ease of maintenance. This applies especially taking into account the operation conditions significantly more severe compared with systems for trade use. The following essential conditions have to be considered for a proper design and dimensioning of steel in-plant process scales:

Forces

- **huge forces in the measuring direction from 1 t up to 1000 t**
- additional dynamic loads with unknown peaks applied in operation
- high disturbing forces in both horizontal directions
- high lift-off forces opposite to the measuring direction

Temperatures

- exposure to high thermal loading in the liquid sector and at the input of the hot rolling mill, extreme temperature peaks arising in case of accidents

Contamination

- high contamination by dust, dirt and slag deposits on the mechanical structure

Operation

- difficult access to the mechanical components of the weighing systems
- on going production dictates minimum time windows for maintenance, inspection and repair

Under these specific conditions conventional weighing solutions as presented in chapter 3 often do not fulfil requirements with regard to accuracy, reliability and ease of maintenance sufficiently because of the following problems experienced in practice:

- mechanical destruction by overloading of Loadcells in the measuring direction
- weighing error / destruction resulting from missing or no more functional mounting elements damaged by excessive horizontal loads
- overheating of Loadcells and connection cable
- weighing error resulting from shunt forces
  - on mounting elements such as tie rods or shock absorbers
  - between other areas of the weighed and the non-weighed structure

These fundamentally different operating conditions in mind, **Schenck Process** started already twenty years ago to develop special strain gauge based Loadcells and applications, the so called **Direct Weighing Technologies,** optimally suited to design state of the art in-plant process scales.

5 APPLICATION EXAMPLES FOR IN-PLANT PROCESS SCALES

In this chapter we present some typical application examples for advanced in-process weighing systems using Direct Weighing Technologies.

5.1 Weighing Inside the Ladle Supports of Turrets or Transfer Cars

Ladle turrets are used for tapping liquid steel in the continuous casting machine.

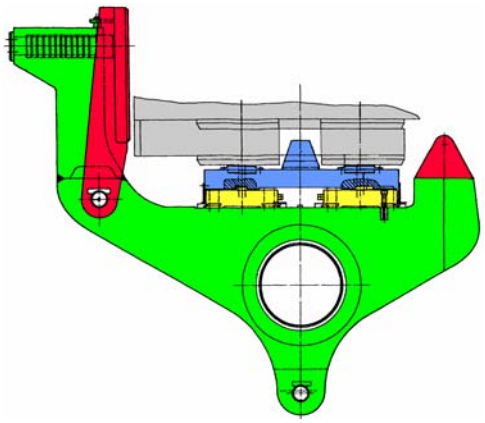

Figure 3. Basic structure of a **ladle turret scale**

Figure 4. Schenck Weighbeam DWB

Figure 3 shows a typical mechanical integration of a weighing system inside a ladle turret: two **Weighbeams DWB** (Figure 4) are directly screwed below each supporting area of the ladle. Weighbridge (in blue) and foundation structure (in green) are distinctly separated from each other. Specific load directing plates adapted to the geometry of the ladle allow the transmission of all dynamic impacts.
Concerning maintenance the extremely small dimensions of the weighing arrangement reduce the risk of shunt forces under the unavoidable contamination to a minimum. Besides temperature heating of the weighing equipment is limited, because the ladle suspension itself provides protection from heat radiation. It is also an advantage, that, if necessary, the installation place of the weighing components allows easy access.Additionally to those benefits resulting from the suited installation position the following features of the installed Weighbeams as components represent the second main condition for high accuracy, reliability and ease of maintenance:

- simple fixed bolting without any mounting elements such as tie-rods, limit stops and hold-downs, resulting in an eliminated risk of shunt forces
- no mechanical adjustment, minimum number of installed parts
- no moving parts, hence no wear, simple design and assembly
- operating temperature range up to 150 °C
- free of electrical destruction up to peak temperatures of 180 °C
- special connector to avoid cable damages
- integrated PT 100 sensor for continuous temperature monitoring room

This weighing solution achieves an accuracy of up to + - 0,1 % of Full Scale, requiring no regular maintenance. Only an accuracy checking interval of about 6 month is recommended.

5.2 Casting and Ladle Transport Crane Scales

Cranes are the most important transport devices for lades up to 600 t filled with liquid pig iron or steel. From the maintenance point of view the installation of a weighing system offers the maximum degree of safety and ease of maintenance in the area of the crane trolley for the following reasons:

- unlike in the case of weighing systems integrated in the crane spreader beam or in the crane hook, there is no endangered moving cable connection, which is likely to fail in operation by flames or mechanical movement
- the elasticity of the crane cables significantly reduces dynamic loads
- the big distance from the ladle significantly reduces thermal loads

As the available headroom usually rules out the option of weighing the entire crane trolley of existing cranes with a double frame, please find two different possibilities of modern crane trolley weighing systems.

5.2.1 Weighing of the crane trolley in the area of the wheelbase

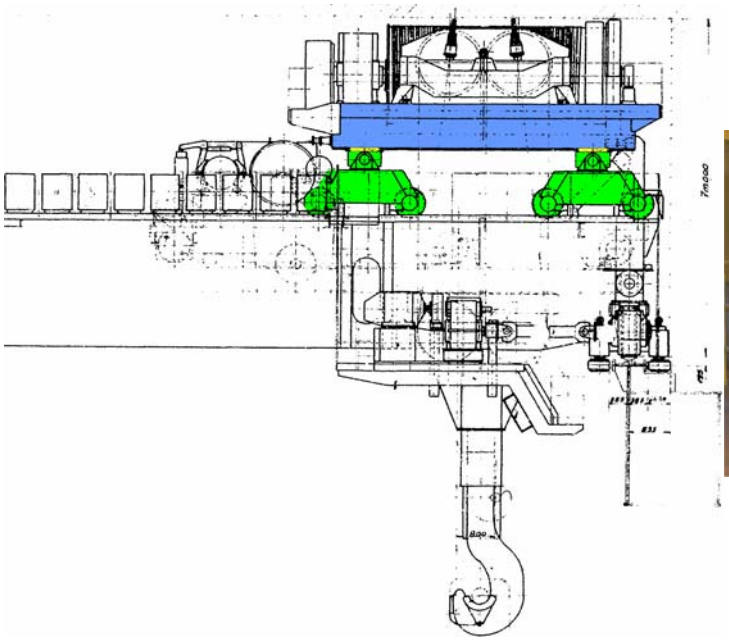

Figure 5. Basic structure of a scale at the trolley wheelbase (courtesy of SIDMAR)

Figure 6. Weighing unit of a 380 t casting crane courtesy of Siemens VAI)

The principle of this solution shown in Figures 5 and 6 consists of the integration of four weighing units at the interface between the trolley frame and the wheelbase. The design has to be capable to transmit all dynamic driving forces. Each weighing unit is composed by several **Weighbeams DWB** as described in chapter 5.1.
The extremely low installation height makes this arrangement particularly suitable for retrofitting. The main advantage of this solution in regard of maintenance is the installation place inside the trolley, that contains no critical cable passages different from all spreader beam installations.
Casting crane scales designed according to this principle usually achieve accuracies up to + - 0.1 % of Full Scale.

5.2.2 Weighing at the crane trolley in the area of the upper sheave block

The variety of crane types forces designers of weighing equipment to keep an open eye for several possible variants at all times, finally to arrive at a suitable solution concerning

- accuracy demands,
- costs of equipment and installation,
- downtime necessary for the weighing modification,
- installation height and
- ease of maintenance.

During the design of weighing systems for those heavy casting cranes especially the required time for modification and maintenance has to be taken into account, as these cranes usually operate around the clock and minimum maintenance shifts will leave virtually no time for works on weighing equipment for months at a time. The second application example for crane weighing presented here is suited in cases, where weighing equipment at the wheelbase (see chapter 5.2.1) cannot be realised.

Figures 7 and 8 show as alternative solution a very easy weighing installation inside the upper sheave blocks of the crane hoist.

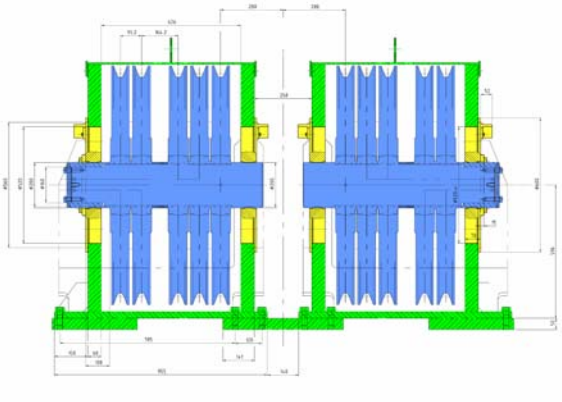

Figure 7. Basic structure of a 350 t upper sheave block scale

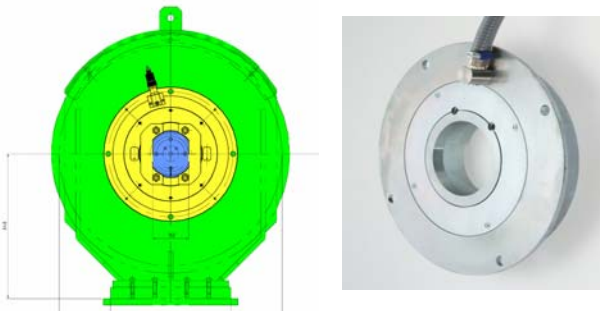

Figure 8. Schenck Radial Force Transducer DRA

Special ring shaped Loadcells, the so-called **Radial Force Transducers DRA** are directly mounted inside the bearing shields of the upper sheave block. These sensors measure and transmit the radial forces introduced by the crane cables. The DRA sensors transform the supporting structure to a weighing system.
Main design advantages of this solution are:

- no modification of the crane static's, of connecting and sheave dimensions
- no additional headroom required for the weighing equipment

Concerning maintenance matters, this solution is essentially equivalent to weighing equipment installed at the wheelbase with regard to the safe cable ways. The access to the mechanical structure and the temperature protection must even be judged superior. The installation accuracy of such an upper sheave block weighing system measuring about 80 % of the ladle weight achieves up to + - 0,2 % of Full Scale. As for the first solution presented in chapter 5.2.1 regular maintenance is not required, we only recommend accuracy checks with a test ladle from time to time.

6 PREVENTIVE MAINTENANCE AND EASY TROUBLE-SHOOTING WITH MODERN ELECTRONICS

Additionally to the modern mechanical solutions advanced features of today´s weighing electronics also contribute to increasing operational reliability and ease of maintenance for in-process scales. As a first example Figure 11 shows the **Disobox**, an advanced multi-channel analogue-to-digital converter. Installed in a field housing it is suited for an installation in the vicinity of the weighing mechanics. Inside the Disobox all single Loadcell signals are digitized, transformed into weight values by 8 independent A/D converters and then added to the total weight by software. The central output cable transmits all single and the total weight to the customer control system. The major advantage of this new weighing electronics lies in that the weights measured by all individual Loadcells are available at the control room at any time. This enables maintenance staff to detect the failure of a Loadcell, for example as result of a cable damage, and to shut down this Loadcell electronically without costly and time consuming intervention on the weighing mechanics, until repair or exchange

are possible. During this time the influence of the damaged Loadcell on the total weight can be compensated (with reduced scale accuracy).
Over and above this possibility of a manual intervention by the maintenance staff, the Disobox also features monitoring functions such as continuous automatic zero checking. This enables to recognise gradually growing damages of one of the Loadcells, for example caused by penetration of moisture through a damaged cable or increasing shunt forces automatically at a very early stage of time. With a warning signal either transmitted through a contact or as part of the field bus telegram that auto-verification increases the operational reliability and overall accuracy of the weighing systems significantly. Also, early recognition of potential future failures reduces the total maintenance effort and the risk of sudden failures with the associated serious impacts on production and control.

Figure 11. Schenck A/D Converter Disobox

Figure 12. Schenck Weighing Terminal Disomat Bplus

A second weighing electronics used for static weighing systems in steel plants is the **Disomat Bplus** (Figure 12). Its major contribution in terms of increased availability and maintenance support is made by advanced visualisation capabilities through the new Ethernet interface. In Web Server operation mode all essential data of the weighing system can be displayed through an Internet Browser simply by selecting the associated IP address. With the appropriate authorisation weighing data can be viewed throughout a company's Intranet or even from outside through the Internet. This provides in-time information about the proper performances of the most important process scales to the workshop responsible for maintenance, a feature useful for example to confirm more easily the success of a recent scale repair.