Developing a Report Generator for the Automatic Analysis of Rolling Data in Heavy Plate Mills

Dipl.-Ing. Christian Schaaf, Aachen University

Dr.-Ing. Robert Krumbach, Ilsenburger Grobblech GmbH

Dipl.-Ing. Jürgen Korth, Ilsenburger Grobblech GmbH

Dr.-Ing. Jerry Mackel, ACIDA-TorqControl GmbH

1 Introduction

The recording and monitoring of process data is nowadays state of the art in rolling mills. But even high investment in measuring and data acquisition equipment is mostly not used in an efficient way. In general lack of time and the huge amount of raw data is the reason for unused analysis options.

The *ACIDA-TorqControl GmbH* and the *Institute of Mining and Metallurgical Machine Engineering of Aachen University* have developed the *REPORT GENERATOR*, a tool for automatic data analysis, in cooperation with the *Ilsenburger Grobblech GmbH* (Member of the Salzgitter Group).

The *REPORT GENERATOR* is a software module of the online machine monitoring system OMM. OMM records sensor and plant signals online, i.e. main drive torque, rolling force, rotational speed etc. and produces header information. This data is stored in a long-term database.

Periodically and *automatically* the *REPORT GENERATOR* scans the data base and generates a set of customised reports. During the development of the *REPORT GENERATOR* a special focus had been set on the ergonomics, i.e. the layout of the single reports. The layout is important to inform the production, maintenance and management staff with concentrated, but easy-to-read information of the plant and process conditions regularly .

2 Initial Situation

In the year 2000 the main drive spindles of the Ilsenburg 4-high rolling stand were equipped with a permanent torque measuring system. The actual torsional loads and additional process data like motor speed, rolling temperature, plate dimension or steel grade are stored in a database permanently and simultaneously. This database is the starting point for the data analysis.

In a first step the manual analysis focussed on the load history of the main drive spindles was done to determine the load distribution during production. Subsequently more sophisticated investigations were carried out, for example ski compensation and bite impact.

To relieve the production team, which carried out the data analysis and to close gaps in the analysis history the analysis had been sourced out. Predefined reports were generated as a tele-service on a monthly basis.

After six reports the content and the layout of the report had been brought to it's final version.

In the next step the software module to generate single reports was developed. Thereby the reduction of tele-servicing costs in terms of engineering time and communication charges should be achieved and a long-term documentation of the monitoring results should be ensured.

In the following the technological content of the reports and the functionality of the software module are described.

3 Technological content of a REPORT

Each report has a fixed formatting. The frame includes a header with the reporting period, the name of the plant, the rolling mill stand and the report ID. The footer displays the report date and got the signing space. All technological report elements are placed within the frame for a unified layout.

3.1 Performance index for rolling mills

The SUR value (*S*tand *U*tilisation *R*atio), is a newly developed performance index for rating of rolling mills. This characteristic value is tripartite. The first part shows the ratio of the real contact time between work roll and rolled piece per day. The second part shows the rolled tons per day for different types of plates and the third part shows the loading rate per day.

The loading rate is proportional to a virtual ultimate load, e.g. the extrapolated load collective per year. Fig. 1 shows the SUR diagram of one month. Very productive days can be found by combining the maximum time ratio with a high tonnage and low loading rate. The SUR value provides thus a quick overall information to the management, but also a maintenance and production rating.

3.2 Fatigue monitoring of the main drive

The torque load of the main drive is a significant information, which has to be analysed continuously. Therefore, the LCC-collective (Level-Cross-Counting method) of the torque signal is included in the reports and diagrammed (Fig. 2).

The analysis includes:

- the load collective recorded during the period of the report,
- the accumulated or extrapolated yearly collective and
- the expected maximum torque for the extrapolated period.

The load collectives are classified for all components affected by fatigue: spindles, work rolls, coupling sleeves etc. Thus, the load collectives are the basis for fatigue calculations and part of the condition-based maintenance.

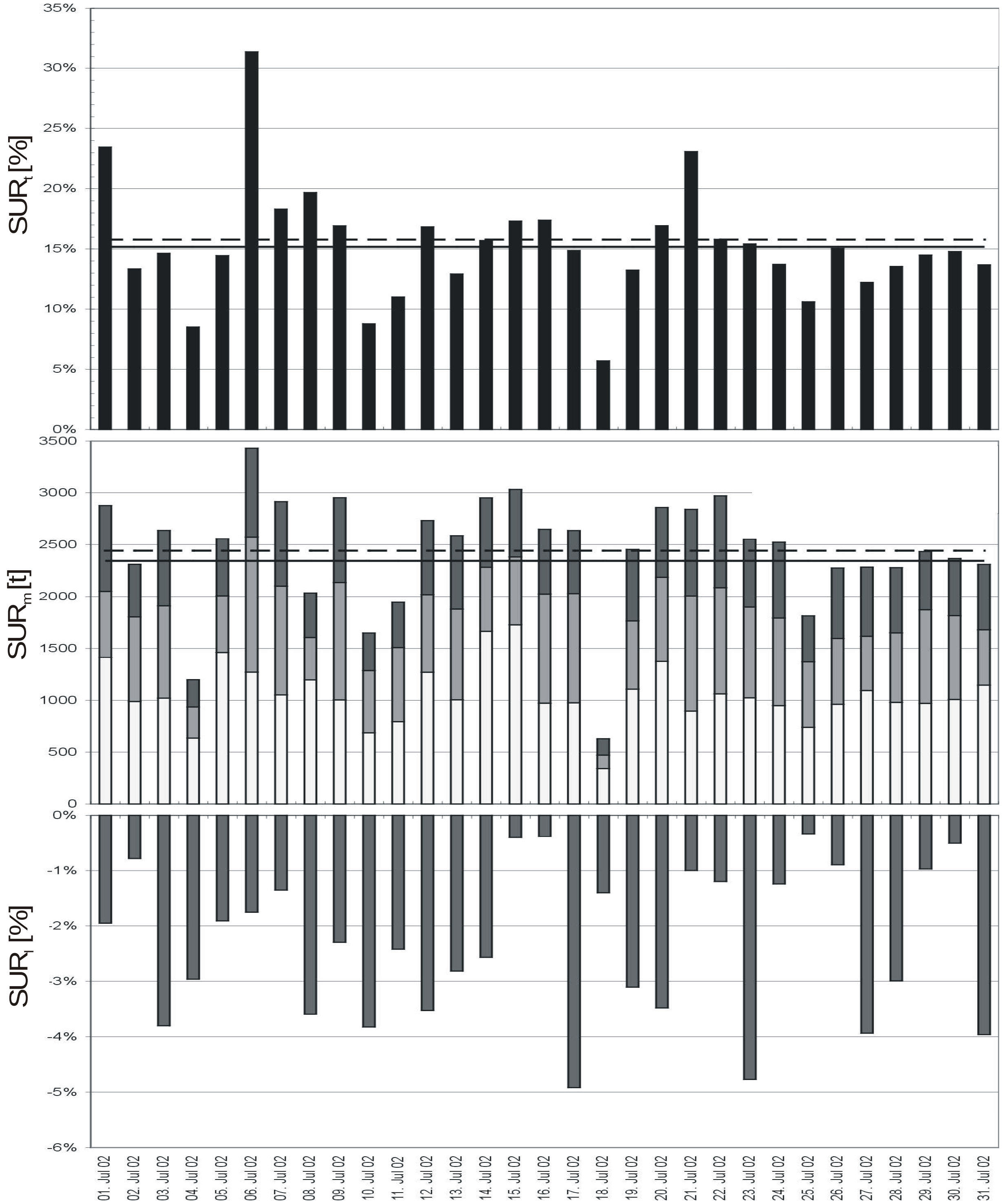

Fig. 1 - SUR (Stand Utilisation Ration)

In addition to the individual load collectives, the so called box-plot presentation was create. This tool allows to get a quick overview of the operating state of all selected machine components, i.e. work rolls and coupling sleeves (Fig. 3). Besides the load collective additional information are displayed: the number of grindings and rolled tons as well as the number of overloads occurred in operation. So, the residual life-time can be predicted .It is shown as a coloured bar in the box-plot. The life-time prediction is an important part. The estimation is based on occurred load cycles, the s-n-curve (Wöhler-curve) of the components and the detailed evaluation of damage events occurred before. By the clearly arranged prediction a maximum utilisation of all monitored components at a minimum risk of failure can be achieved.

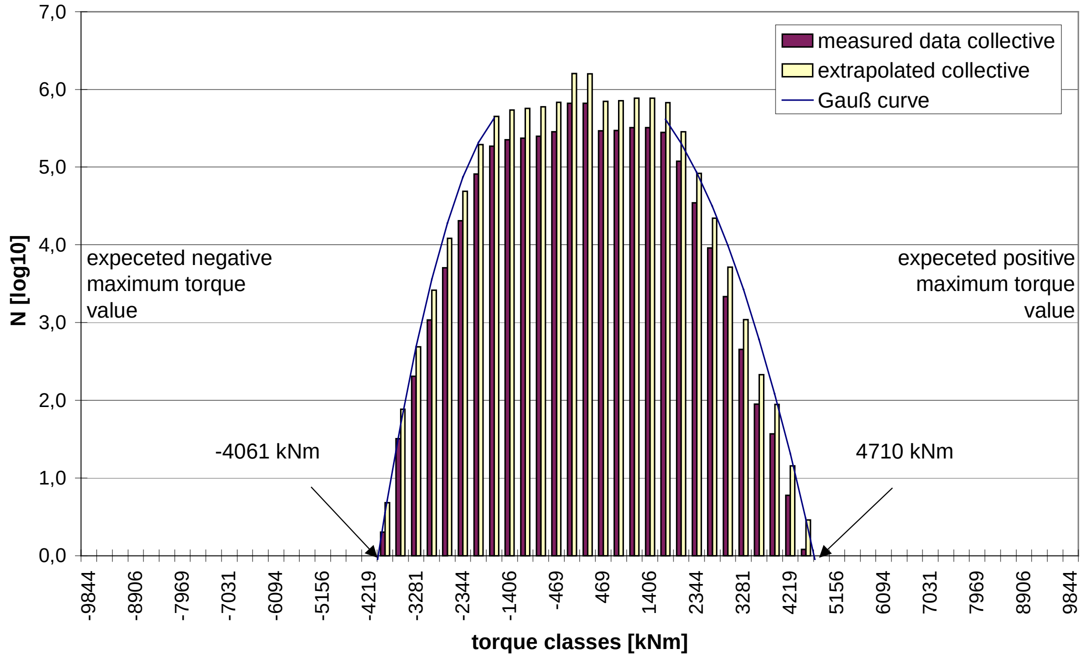

Fig. 2 - LCC collective of the load distribution of the main drive

3.3 Overload events

Overload alarms recorded during the reporting period are listed in alarm tables. For each signal threshold values (alarm limits) are specified. In general the foci are the two torque signals. Each rolling pass with an overload event is listed with additional process data like: time, rolling type, pass number, maximum torque, mean torque, rolling temperature etc. A colour code is showing when overloads on the top or on the bottom drive train occur.

The user of the REPORT GENERATOR can define the number of signal time-curves which should be annexed to the report for further analysis (Fig. 4).

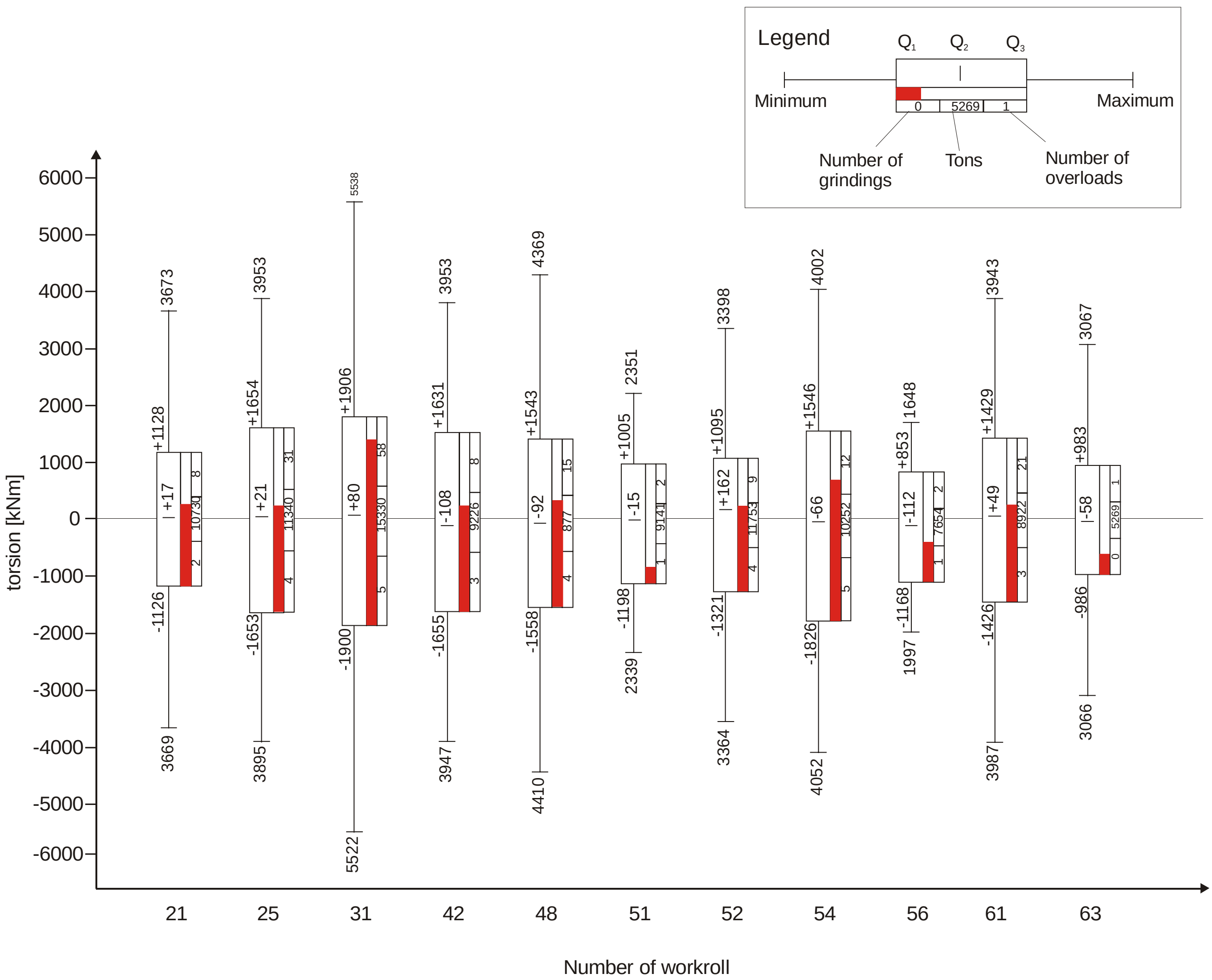

Fig. 3 - LCC box-plots of the work rolls with the fatigue and utilisation ratio

3.4 Documentation of the bite impact

The torsional behaviour of the bite impact is displayed for each pass in the TAF diagram (*T*orque *A*mplification *F*actorFig. 5. The TAF is the ratio of the torque peak value at the bite impact and the mean torque load during static rolling. The TAF is moreover an important index for classifying the impact behaviour of different steel grades, slab dimensions or the input of the ski compensation.

The constricting curves are the threshold alarm levels. The number of overloads for each rolling direction is displayed in the diagram (Fig. 5).

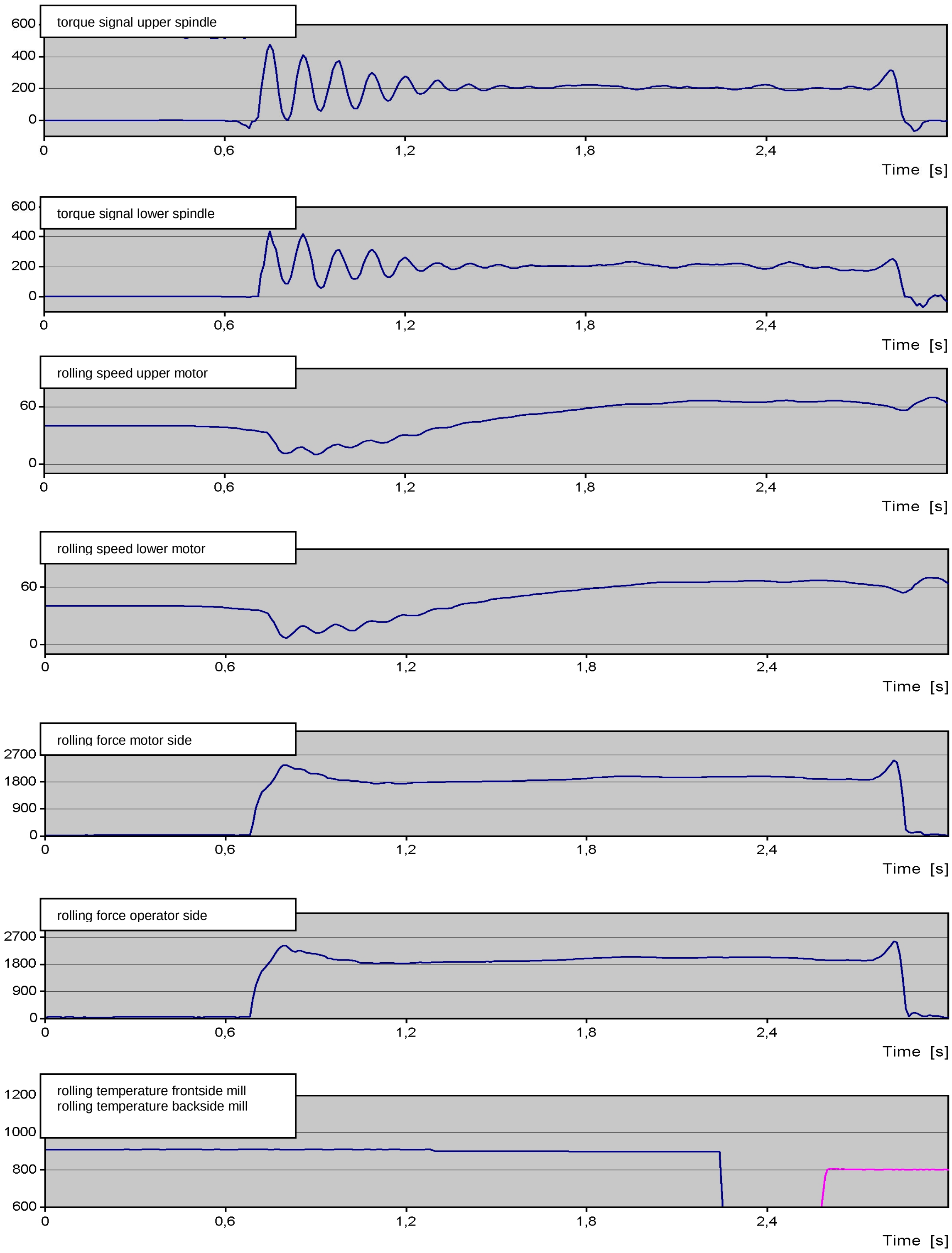

Fig. 4 - Signal curves of an alarm event

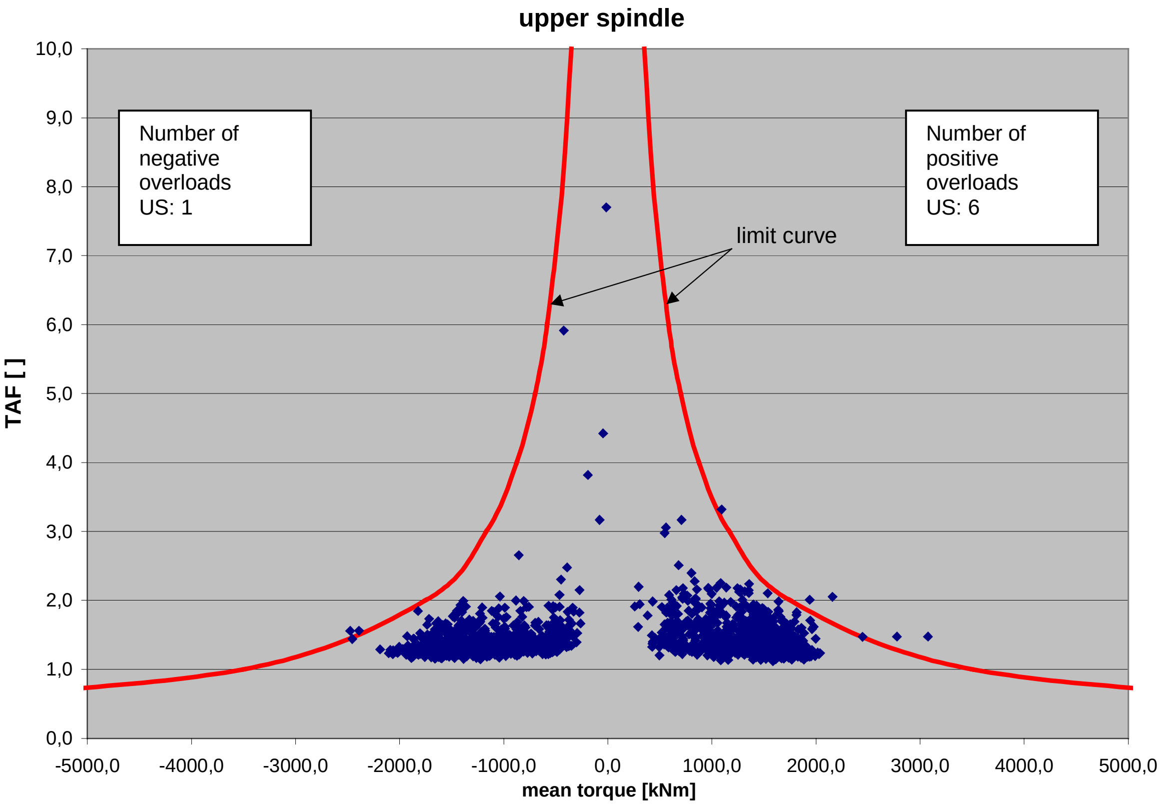

Fig. 5 – Control of the bite impact by using the Torque Amplification Factor (TAF)

4 Software design

The software design of the REPORT GENERATOR is divided into five parts, shown in Fig. 6. The main part is the analysis module. Therein, all analysis elements are consolidated separately. The modular structure allows a facile extension with new analysis elements. Each analysis element observed obtains information from the process and the result database to run the analysis function.

The analysis results are stored in an intermediate result database, which provides the information for the graphic or transport module. Furthermore the result database allows a long-term storage of the report content in addition to the file, paper or e-paper archive of the reports.

The user can also request for reports over different periods of time independent of the regularly generated reports. These documents will be generated from the intermediate database.

The transport module is the communication centre of the REPORT GENERATOR. It is able to distribute the analysis results to a printer of tele-fax, or send as a re-workable data file or in an e-paper format.

Within the graphical user interface (GUI) the user administration, the distribution of reports, the time triggers for the creation of reports and the report contents are configured.

Reportgenerator

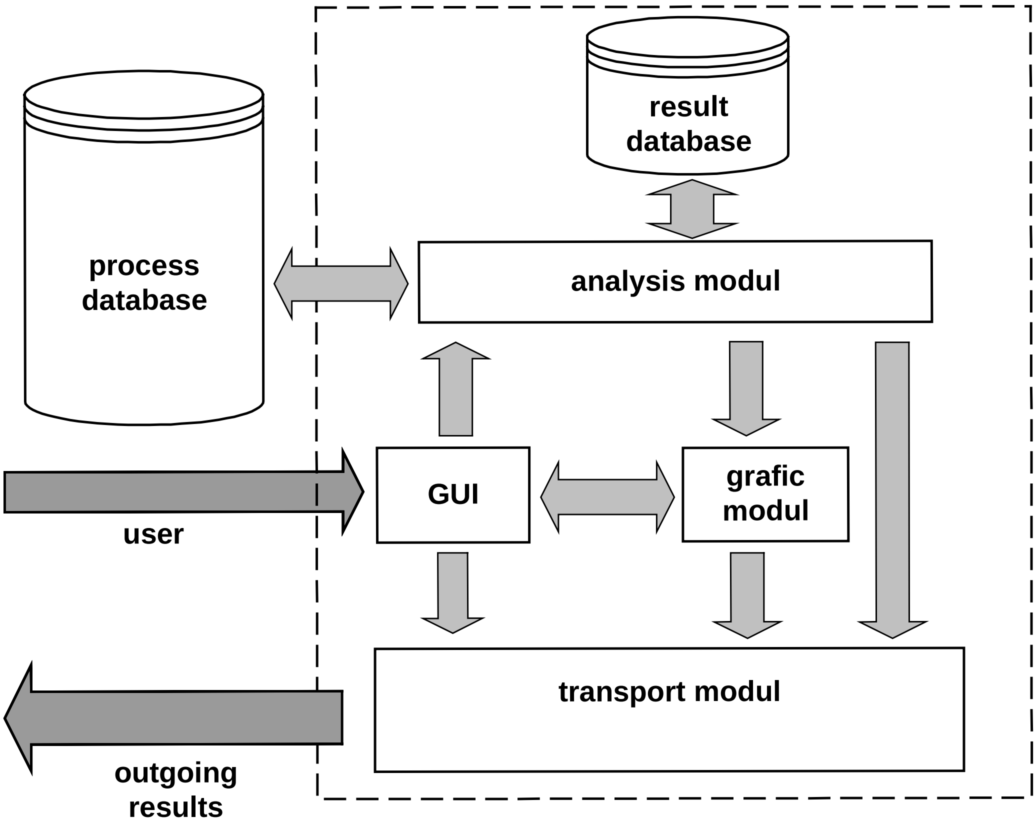

Fig. 6 - Software modules of the REPORT GENERATOR

5 Conclusions

The development of the *REPORT GENERATOR* allows a substantial exploitation of the recorded sensor, plant and process signals. The engineering costs and the response time for monitored data had been reduced. The availability of production and maintenance information for the management and the field staff could be improved. In addition positive side-effects occurred when the first reports were generated by tele-service. The availability of load collectives makes the dimensioning of new components for rolling mills safer and simpler.

The new introduced rolling mill performance index SUR offers an overview of the total mill performance for the report period and long-term trending.

The fatigue and wear monitoring for the condition-based maintenance had been improved by presenting the load collectives as box-plots. Furthermore, the level of utilisation of the monitored machine components could be compared directly and the parameters of fatigue implication could be displayed.

The product quality and the rolling process at the bite impact is monitored by using the TAF value at the bite impact.

Special events, for example torsional vibrations, stick-slips, cobble stops or torque overloads are monitored and listed in an alarm table in conjunction with the product ID's,. whereby an improved quality control system arose

All described features have been newly developed. They will help to provide more detailed information of the condition of the rolling mill and the rolling process. However the essential qualities of the *REPORT GENERATOR* are the *automatic* and *periodical* compilation of the reports with customised and easy-to-read information and data packages.

6 References

[AlRa/95] Al-Radhi, M.; Heuer, J.: Total Productive Maintenance: Konzept, Umsetzung, Erfahrung.
C.Hanser Verlag, München, Wien, 1995

[Brun/91] Brune, M.: Erstellung eines Beanspruchungsstandards für Walzwerksantriebe und experimentelle Überprüfung der Lebensdauerabschätzungsmethoden.
Dissertation, Technische Universität Clausthal, 1991

[Geor/99] Georges, D.: Konzeption, Entwicklung und Einsatz eines Überwachungssystems zur Erkennung und Vermeidung von qualtätsmindernden Störschwingungen an Kaltwalzgerüsten.
Dissertation, RWTH Aachen, Aachener Beiträge zur Angewandten Rechnertechnik 34, Verlag Mainz, Aachen, 1999

[Hart/00] Hartmann, E.H.: TPM Effiziente Instandhaltung und Maschinenmanagement.
Verlag Moderne Industrie AG & Co.KG, Landsberg, 2000

[Hopp/02] Hoppe, H.: Konzeption und Entwicklung eines technischen Berichtssystems zur weltweiten Anlagenüberwachung am Beispiel von Gutbett-Walzenmühlen.
Dissertation, RWTH Aachen, 2002

[Klum/90] Klumpp, S.; Eifler, D.: Verbesserung der Lebensdauerabschätzung für Bauteile in Walzwerksantrieben – Ermüdungsverhalten von normali-siertem und vergütetem 42CrMo4 unter Torsionsbeanspruchung.
VDEh-Forschungsbericht Nr. ABF 40.2, Düsseldorf, 1990

[Sach/99] Sachs, L.: Angewandte Statistik.
Neunte überarbeitete Auflage, Springer Verlag, Berlin, Heidelberg, New York, 1999

[Shne/98] Shneiderman, B.: Designing the User Interface.
Addison-Wesley Verlag, München, 1998