B-TRONIC visualisation and documentation of drilling processes

B-TRONIC visualisation et documentation des procédures de forage

E.Stötzer – *Bauer Maschinen GmbH, Schrobenhausen, Germany*

ABSTRACT: Powerful industrial systems for data acqusition and processing are now available for use in specialist foundation equipment, even during strenous operations in extremely diverse climatic conditions. Besides the actual acqusition of data and their visualisation on screen, the rig operator is actively supported by process visualisation and equipment monitoring. Quality assurance for operating processes, such as the installation of continuous flight auger piles or displacement piles, is supplemented by monitoring and documenting the entire production process, including production faults, and by providing a comprehensive product documentation protocol.

RÉSUMÉ: De nombreux systèmes industriels performants sont maintenant disponible pour l'enregistrement et l'analyse des données destinés aux équipements de fondations spéciales ceci même durant des opérations difficiles et dans les conditions climatiques très diverses.En plus de l'enregistrement et de la visualisation sur ècran, l'opérateur de la machine est aidé par le procédé de visualisation en temps réel de contrôle de l'équipement.L'assurance de qualité des travaux effectués telle que le forage de pieux à la tarière continue, le procédé mixed-in-place ou les pieux moulés dans le sol, est complétée par l'enregistrement complet de la production, y comprix les anomalies, grâce à l'impression d'un rapport du travail réalisé.

1 INTRODUCTION

Over recent decades, the performance of specialist foundation equipment improved markedly due to the deployment of hydraulic systems. This has made it possible for new processes and techniques to be developed.
As a result, rotary drilling rigs are now capable of putting down boreholes in a very short time to depths in excess of 100 m and with diameters of up to 3 m.
It has also become possible to construct deep trenches with the help of diaphragm walling cutters.

Operation of this equipment, which initially relied entirely on hydraulically operated controls, was simplified with the use of stored program control modules.
The rig operator is, however, still facing the same old problem of not being able to physically see the results of his hard labour - e.g. the completed pile - and that additional information, such as the verticality of the bore under construction, ought to be displayed.

The ever increasing demands by equipment operators and maintenance personnel for greater support in their operations has led to the development of the B-TRONIC System.

Figure 1. Drilling rig BG 18H

Figure 2. Diaphragm walling cutter BC 40

2 B-TRONIC SYSTEM

2.1 *System Description*

The B-TRONIC monitoring, control and visualisation system developed by BAUER Spezialtiefbau combines four essential tasks and integrates these in one system:

- Optimum visual aid for the rig operator during rig operation. (Example: visualisation of telescopic kelly bar positions inside borehole)
- Process-specific quality assurance by collecting, evaluating and printing-out production data. (Example: continuity of concrete shaft during concreting of CFA pile)
- Collection and evaluation of site-specific data relating to construction processes (Example: automatic collection of standing time periods during pile production)
- Collection and evaluation of plant-specific operating data. (Example: equipment develops fault, fault message)

The modular B-TRONIC system can be fitted into different types of specialist foundation equipment and used in connection with different foundation construction processes. Uniform hardware components, such as a processor unit, a touch-sensitive screen and numerous sensors, are controlled by software modules which are programmed for specific process applications.

2.2 *Sensors*

Sensors built into a drilling rig measure the following operating conditions independently from any construction process the rig may be engaged in:

Hydraulic pressures:	on winches
	on rotary drive
	on crowd system
Depth:	on main winch
	on crowd system
Speed:	on rotary drive
	on winches
Load:	on main winch

Further process-specific data can be collected by additional sensors, such as:

- measurement of vertical deviations of tools
- concrete pressures and concrete volume measurement during CFA process
- grout volume and grouting pressure measurement during Mixed-In-Place (MIP) process

3 APPLICATIONS OF THE B-TRONIC SYSTEM FOR ROTARY DRILLING RIGS

3.1 *Visual Aid for Rig Operator*

During drilling, the rig operator is aided by a continuous display of all process-specific operating data in both digital and graphic (sliding bars) format. These operating data include:

- Hydraulic pressures generated by the hydraulic pumps (indicated in bar)
- Rope force on main winch (indicated in tonnes)
- Spooled-off length of rope, i.e. actual drilling depth (indicated in m)
- Mast inclination (indicated in degrees)
- Speed of rotary drive
- Torque of rotary drive (indicated in kNm)

As part of an effort to increase safety at work, the bar colour changes as soon as a pre-determined limit value is being exceeded.

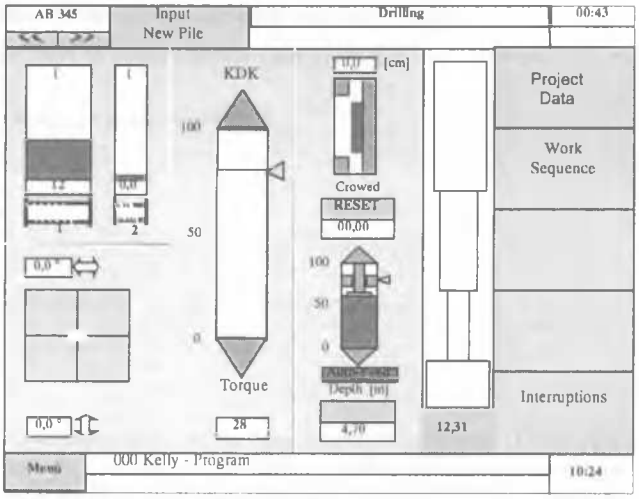

Figure 3. Operating screen in drilling rig with active kelly visualisation

3.1.1 *Kelly Visualisation*

The kelly bar of a rotary drilling rig transfers both the rotary movement and the crowd force from the rotary drive to the drilling tool. The telescopic kelly can be mechanically locked in several positions, so that crowd forces can be applied direct to the drilling tool at great depth.

Safe and low-wear kelly operation requires a lot of experience and demands a high degree of concentration from the rig operator. A critical point is unlocking the telescopic kelly bar during withdrawal from the borehole of the drilling tool filled with drill spoil. If any of the kelly sections are only partially unlocked without the rig operator noticing it, a section could suddenly drop down and cause extensive damage to both the kelly bar and the rotary drive.

Use of the "kelly visualisation system" provides the operator with a crucial aid for preventing problems such as the one described above.

The positions of the lock recesses are displayed graphically on the screen. In addition, the operator can see the actual state of extension of all kelly sections over the full length of the borehole and, crucially, he is shown whether all telescopic kelly sections are fully unlocked during extraction.

3.2 *Quality Assurance and Documentation*

Process-specific data are collected, displayed and stored. The continuous display on the screen of these data enables the rig operator to modify the work process in order to meet specified quality criteria. A printout of the stored data in the form of a report can be used as a document for the purpose of quality assurance documentation.

3.2.1 *CFA Process*

During the construction of in-situ piles by the Continuous-Flight-Auger (CFA) process a long auger is screwed into the ground. On reaching the specified design depth, the auger is slowly withdrawn. At the same time concrete is pumped through the auger's hollow stem to the auger tip, filling the void being left. A fully continuous concrete shaft can only be guaranteed if during withdrawal of the auger the pressure of the concrete flowing out of the auger tip is maintained at a specific and as constant a level as possible. Observance of these parameters determines the speed with which the auger is withdrawn.

The CFA module within the B-TRONIC System aids the rig operator during auger withdrawal by providing continuous information on the actual concrete pressure and the actual concrete volume being placed as well as the depth of the auger. This information is displayed on the screen in graphic diagram format. Based on this data, the operator can then adapt the actual rate of extraction.

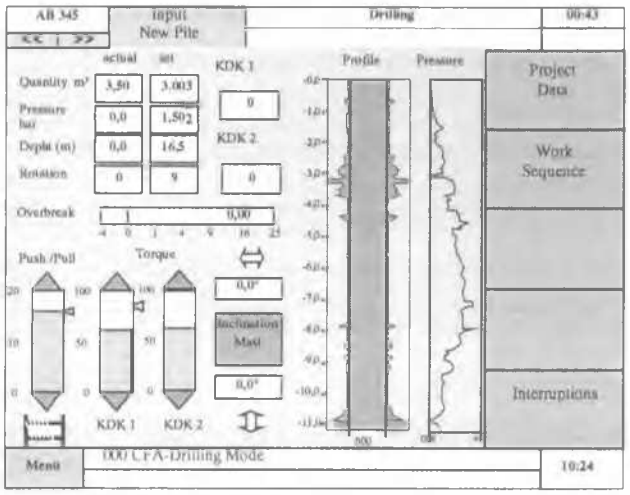

Figure 4. Operating screen in drilling rig with CFA mode. Approximate shape of pile is displayed together with other relevant information

All data is stored and can be printed out in diagrammatic form for each pile and thus provide a complete documentation of the quality of construction.

3.2.2 *Displacement Pile*

A new method for the construction of bored piles is the displacement pile system. A specially shaped starter auger, which is attached to a full-width tubular drill stem, is screwed into the ground by a heavy-duty rotary drilling rig. The geometry of the starter auger section causes loosened soil material to be displaced laterally into the surrounding soil layers. Practically no spoil is removed to the surface during auger penetration. On reaching the specified design depth, the drilling tube with the displacement head is slowly withdrawn, whilst at the same time concrete is pumped through the hollow drill stem to the tip of the displacement starter auger, filling the void being left.

To provide the quality assurance necessary for ensuring continuity of the concrete shaft and also full documentation of all production data, the same B-TRONIC processes can be used that were detailed earlier for the CFA piling technique.

In addition to this data, it is possible to obtain information concerning the relative load-bearing capacity of the pile itself. For this purpose, a reference pile is constructed and subjected to a static load test. During construction of this pile both the required torque and rate of auger penetration are recorded over the full length of the pile.

The same parameters are then collected during construction

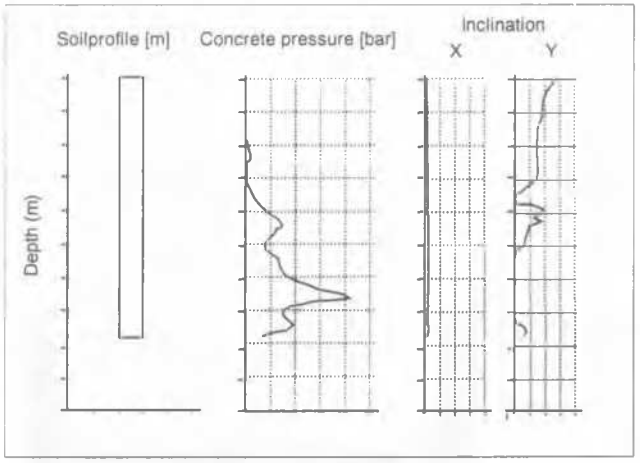

Figure 5. Pile record (displacement pile) with concrete pressure and inclination over depth, optional area for input of soil profile. General data (pile number, date, staff are not shown on this example

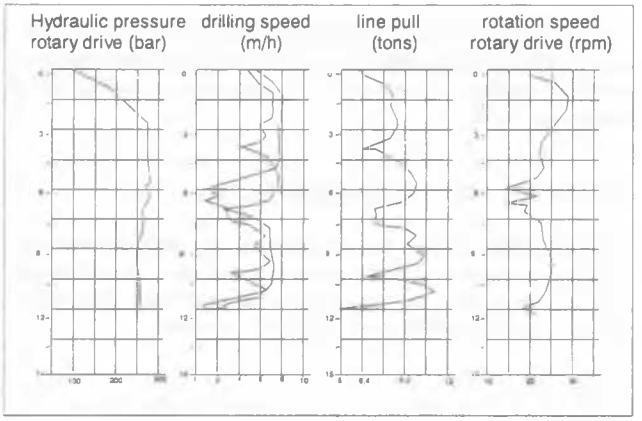

Figure 6. Pile record (displacement pile) with torque and drilling speed

of the working piles and printed out in the form of pile record sheets. If the torque and rate of penetration graphs for a working pile are similar to those of the reference pile, then it can be assumed that a similar displacement effect has been achieved. Significant differences in the graphs would suggest that it may be necessary to investigate affected piles more closely (e.g. by further pile tests).

3.3 *Site Process Data*

An important component of the B-TRONIC System is its "electronic log-book" facility which records the time sequences of all work processes as well as any unforeseen stoppages. Evaluation of this data enables stoppages and down times, including their causes, to be documented in detail, which in turn makes it possible to determine the causes for reduced production rates and provides a platform for optimising site construction processes.

The continuously produced data flow is automatically stored. All data can be transferred to external computers with the help of a data memory card. Evaluation programs are available for generating graphic displays of the data.

By using appropriate filter criteria, it is for instance possible to automatically produce a diagram showing drilling depth over time.

As all data are automatically converted in numeric format, it is possible for the user to prepare his own analysis and interpretation of the data.

3.4 *Machine Operating Data*

Constant recording of all machine operating data, the data interrogation feature and a clear display of the electrical status of the rig's components enable a fast diagnostic check to be carried out and faults to be repaired on site.

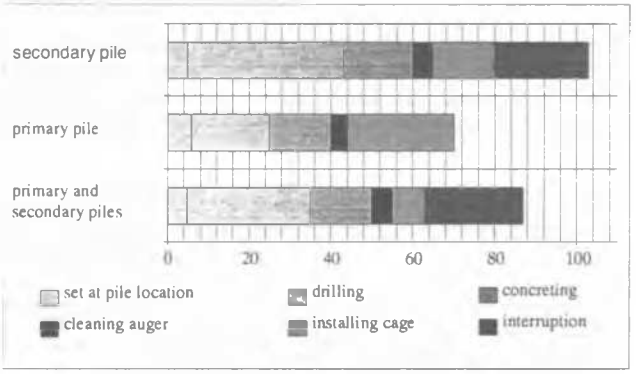

Figure 7. Typical diagram of summarised activities for one pile (including non-productive periods) after analysing the "electronic logbook" data

With the help of the remote data transfer facility (see following chapter), it is possible to involve specialists not only from ones own company but also from the equipment manufacturer in tracing any faults.

4 REMOTE DATA TRANSMISSION

The B-TRONIC System can be supplied with an additional data transmission module which enables information to be exchanged between the drilling rig and an external computer. Data transmission can be achieved by the following options:

- data memory card
- local data transmission (typically used as transmission medium between rig and site office)
  global data transmission (GSM) mobile telephone network for data transmission over long distances.

5 SUMMARY

The "B-TRONIC" control, visualisation and recording system provides an invaluable aid to the rig operator in all work processes and assists him in maintaining a constantly high quality standard throughout the work. The system is capable of providing very detailed reports on all work processes and quality assurance documentation for construction supervision and main contractor alike. Rig utilisation can be significantly increased by a fast and efficient diagnostic fault tracing facility and by preventing operator errors as a result of data visualisation.

The paper describes the use of the B-TRONIC system in drilling rigs. It is however also already in use in diaphragm walling machines (BC cutter), in hydraulic grab units for diaphragm walls. The base modules of the B-TRONIC System are designed to allow future extension of the system to other applications in both specialist foundation construction processes and equipment.