2 The HYDRA Concept

IT-based systems used in the manufacturing environment, such as MES, must satisfy special requirements, which among other things also have consequences for the system structure. These include, for example, requirements arising from the horizontal and vertical integration we have described, from the production organization to be mapped, from availability requirements, from ergonomics and ease of operation, or even from difficult environmental conditions at the machines and systems. Rigid MES systems do not offer enough flexibility to be able to adapt with reasonable effort to the boundary conditions given, since every instance of production is unique. It consists of a heterogeneous machine landscape with processes which can be variously designed. A modern MES system must be variably adjustable by customizing to individual conditions and ensure smooth communication with systems not only on the production level but on the management level as well. The following essential requirements were therefore taken into account in the system design of MES HYDRA:

- Standard software of modular design which is able to grow with the requirements of the user (expandability)
- Pays due regard to the MES and IT standards customary in the market (standards, operating systems, databases and so on)
- Full mapping of the data generated across all processes in production (horizontal integration)
- Communication with adjacent systems such as ERP, machine and system controllers or sub-systems (vertical integration)
- Easy customization of the standard modules not only to the processes but also to the functional requirements of the user
- High availability and data security
- Simple, ergonomic and secure data collection functions
- Mapping individual user and authorization concepts.

To meet these requirements and also to ensure technologically up-to-date performance, HYDRA has been developed in accordance with SOA guidelines (service-oriented architecture). This means that the internal modular structure provides the technically oriented MES services in the appropriate granularity as ‘services’. These services in turn are created by assembling variable combinations (‘orchestration’) of existing software modules in order to provide the system with the MES functions required.

J. Kletti und R. Deisenroth, *MES Compendium*,
https://doi.org/10.1007/978-3-662-54983-4_2

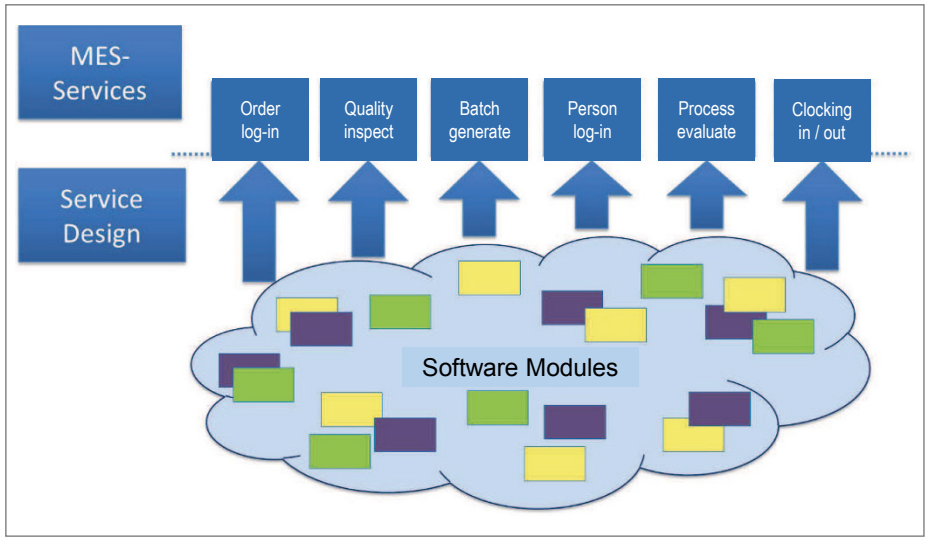

Fig. 2.1 Development of MES services to reproduce typical MES functions on the basis of HYDRA's service-oriented architecture

Regarded in its entirely, HYDRA is thus based on a system concept which is characterized by a high degree of flexibility and a wide range of functions. Only when an MES possesses these properties can it be integrated as a tailored solution into the existing system landscape of a manufacturing company in order to support the implementation of all business processes.

2.1 Special Conditions in Manufacturing

When developing an MES, the special conditions in production must be taken into consideration if all necessary data in production are to be simply and reliably collected. Unlike the IT systems used in office environments, MES systems must offer a high level of ergonomic design if personnel and machine operators are to be able to use them in harsh manufacturing environments without making mistakes. Simple and readily comprehensible operator dialogs are a mandatory requirement for the high degree of acceptance without which an MES cannot be successfully introduced.

Similarly, the harsh environmental conditions in production, such as dirt, spray, vapor or oil mist, must be taken into account. Rugged industrial PCs in housings of the appropriate protection class and robust user interfaces in the form of touchscreens or membrane keyboards as well as suitable accessories such as barcode scanners or RFID readers are required.

In addition, there is an increasing demand for mobility. Large production areas with long distances to be covered or warehouse positions with difficult access force the use of mobile data acquisition devices since the MES must be usable at all times and directly on the spot. Using data collection devices as area or group terminals or even assigning several terminals to one line must be just as possible as a configuration in which a terminal is directly assigned to a single machine.

2.2 HYDRA IT Architecture

The IT architecture defines how the infrastructure is designed with hardware, software and network, which IT components are used, and what form the interfaces between the individual IT systems take. This raises, among other things, the question as to which standards companies rely on: Which operating systems are preferred? Which database systems are used? What form does communication between the systems take? This means that before an MES is selected a thorough investigation should be carried out to see whether it satisfies the diverse needs of the individual IT infrastructure or not.

By supporting the usual proprietary operating and database systems and also the established network technologies, not to mention its service-oriented approach, HYDRA offers good prospects of being seamlessly integratable into an existing IT landscape. The MES services in HYDRA can be accessed at standard clients by any authorized user.

Figure 2.2 shows the typical IT architecture of HYDRA systems. The central element is the MES server, which is integrated into the existing network and in which the so-called production database is installed. It holds not only the master data but also all of the actual data which have been collected. Since quantity structure can vary greatly as far as the data to be processed and the number of clients used are concerned, a corresponding scalability of the MES is provided by, among other things, the design of the MES server. Data backup mechanisms and components, either already in place or to be set up in the future, ensure that the MES data are secured according to their importance.

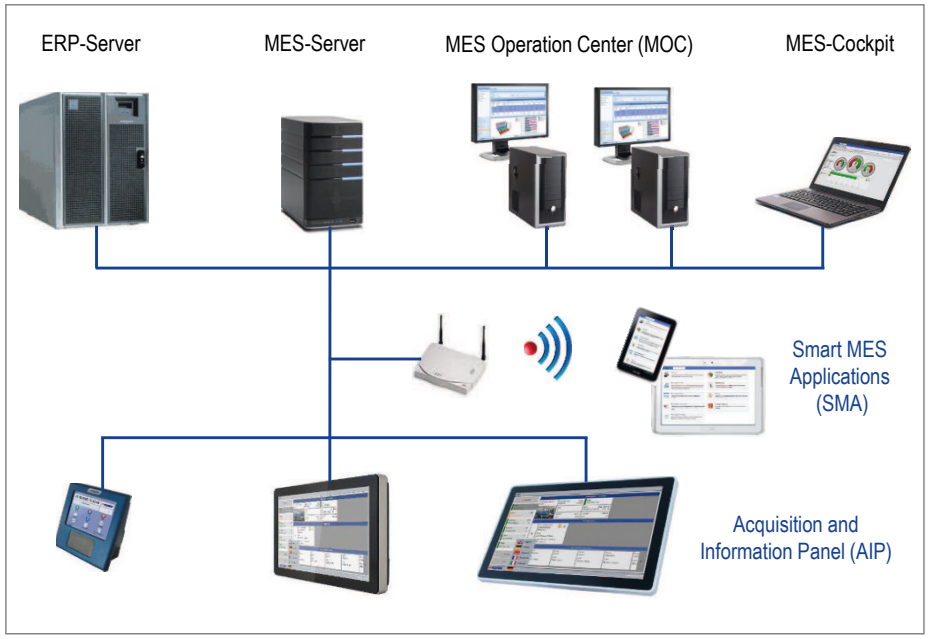

Fig. 2.2 The typical IT architecture of HYDRA systems

The actual MES applications in the form of the MES Operation Center (current overviews, analyses and planning functions, etc.) run on standard PCs in the foreman's office, in production control, in maintenance, in controlling, in the personnel department, in quality assurance, in production management, and in company management. All other Windows-based programs such as Microsoft Office can of course be run on these PCs in parallel with the HYDRA application.

Depending on the tasks of the employees working there, the MOC workplaces can be configured so that firstly, only relevant data are displayed, evaluated or modified and secondly, only the functions and analyses authorized for the user are available.

Either BDE terminals, industrial PCs or standard PCs with the appropriate accessories (barcode readers, card readers, printers, etc.) are used for collecting the data at the machines or workplaces. By on-line communication with the MES server, it is possible to check the data inputs for plausibility and immediately indicate to the operator if his inputs were incorrect. Should on-line communication be interrupted, off-line mode is activated automatically and the data stored locally in the MES terminals. Upon restoration of the connection to the server, the cached data are automatically transferred to the database.

2.3 HYDRA System Structure

As already mentioned, HYDRA is based on a service-oriented architecture. The HYDRA services are organized into functional groups which perform specific tasks in the MES:

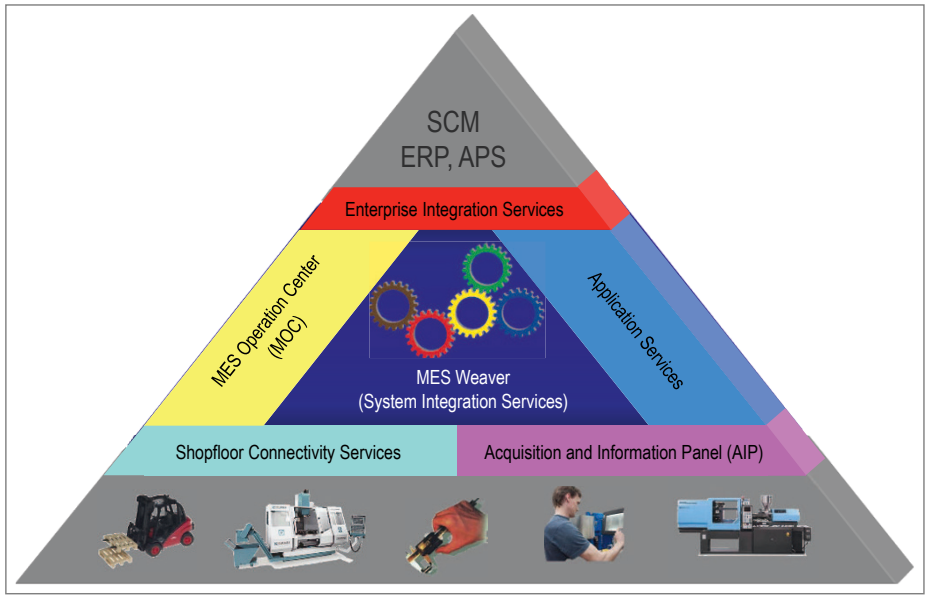

Fig. 2.3 HYDRA services arranged by functional groups

- System Integration Services (MES Weaver) form the functional core of HYDRA
- MES Application Services are application services which look after the preprocessing and further processing of the data collected
- In the MES Operation Center (MOC) the preprocessed data are visualized in many different forms – tools for planning and control are available which offer a wide range of functions for the MES system administrator
- Enterprise Integration Services are used for communication with higher-level systems such as ERP or wage and salary systems
- Shop Floor Connectivity Services are used for bidirectional communication with machines and systems or subsystems
- The Acquisition and Information Panel (AIP) is the user interface which operators and setters use for collecting all data relevant to production, personnel and quality and for displaying information

In the sections which follow, selected services and their interaction within MES HYDRA will be described in more detail.

2.3.1 System integration services

All central administration and control programs and also the general system settings are located in HYDRA MES Weaver. Among other things, they are responsible for HYDRA's system operation running with the highest possible level of automation and administrative tasks being kept to a minimum.

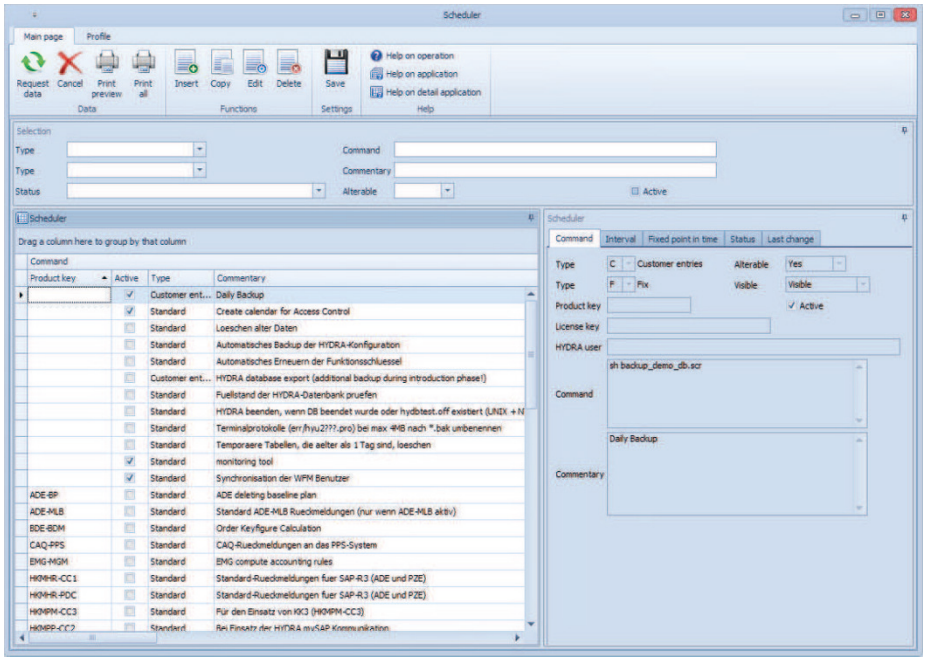

Fig. 2.4 The HYDRA Scheduler for controlling automated processes

A typical example of the sophisticated mechanisms that work in the background of the MES is the HYDRA Scheduler. This is where the starting times are defined for programs which, for example, handle data backup, continuous logging of system events, or the deletion of data. They are started automatically and thus make the system administrator's work easier.

Further convenient functions are also available for managing and monitoring components in the MES. The aim is to simplify the work of system administrators, for example, by continuously monitoring the status of key elements of the MES and informing persons in charge when problems in the system are detected. It is an advantage precisely with large or locally distributed systems when administration can be performed from any location in the network.

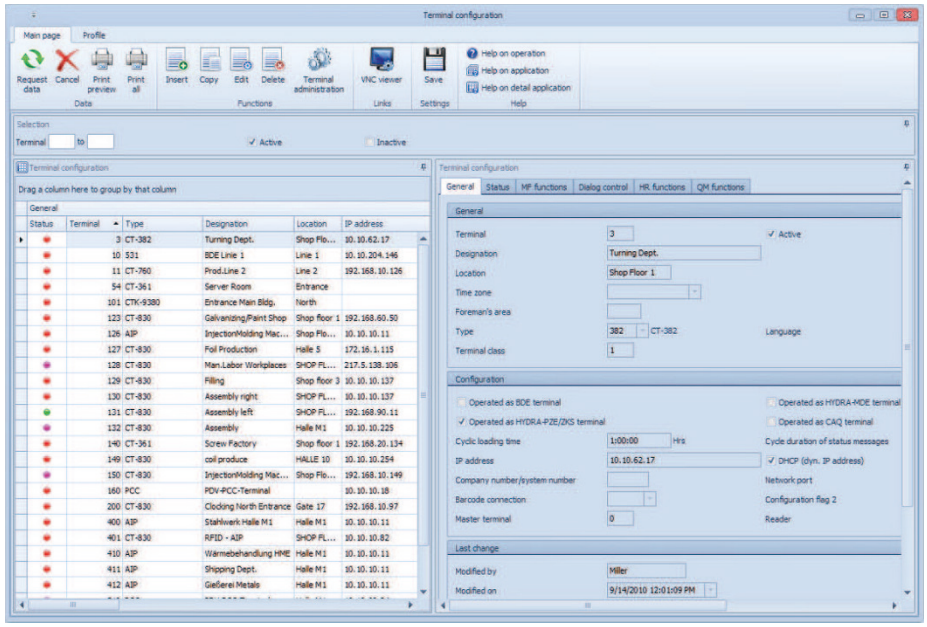

Fig. 2.5 Management and monitoring of data collection terminals as an example of an application providing support for system administrators

User management and authorization concept

HYDRA has a sophisticated password, user and authorization concept: this allows specification of which functions can be used by which users and which data can be viewed or modified. If other systems which implement user and authorization management are already in use, these can also be used by HYDRA.

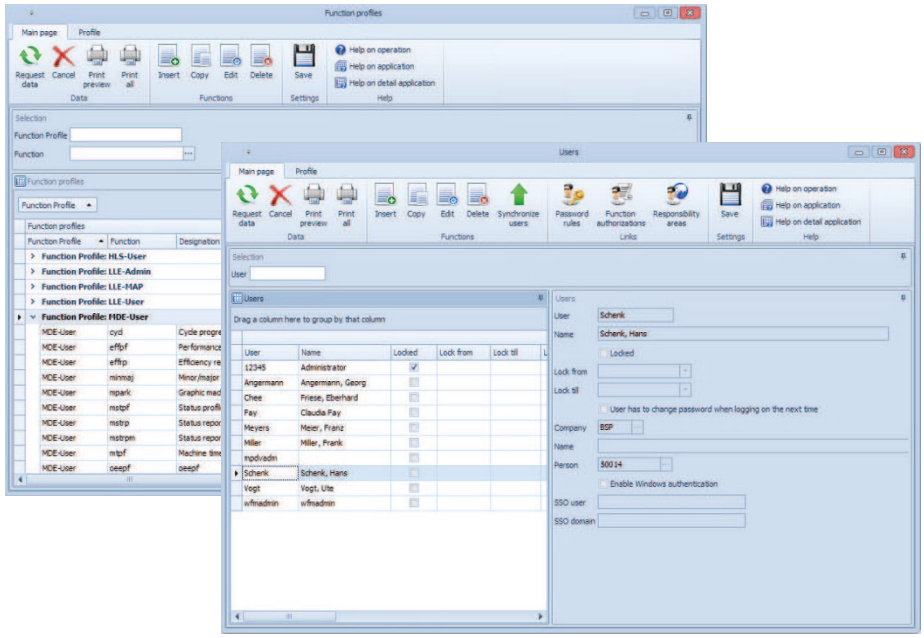

Fig. 2.6 Examples of tables from user management in which all users together with their individual authorizations are entered. To simplify administration, function profiles can be created and assigned.

Escalation management

In HYDRA-MES Weaver, another central functionality with enormous benefits is escalation management. Escalation management ensures that individually configurable events are detected and reported proactively if this means necessary reactions result from them. The range here extends across all HYDRA applications and begins with a message to the system administrator, when, for example, a definable percentage of a database table has been filled. An example from machine data collection shows the wide range of possibilities. A maintenance employee gets a text message on his smartphone that at one machine a problem with the tool has been reported. Or the supervisor receives an email because one of his employees has applied for vacation time. Or the person in charge in quality assurance is notified that the due date for inspection has been exceeded in the production of an article. Used properly, HYDRA Escalation Management allows a workflow to be set up covering several escalation levels and all major events.

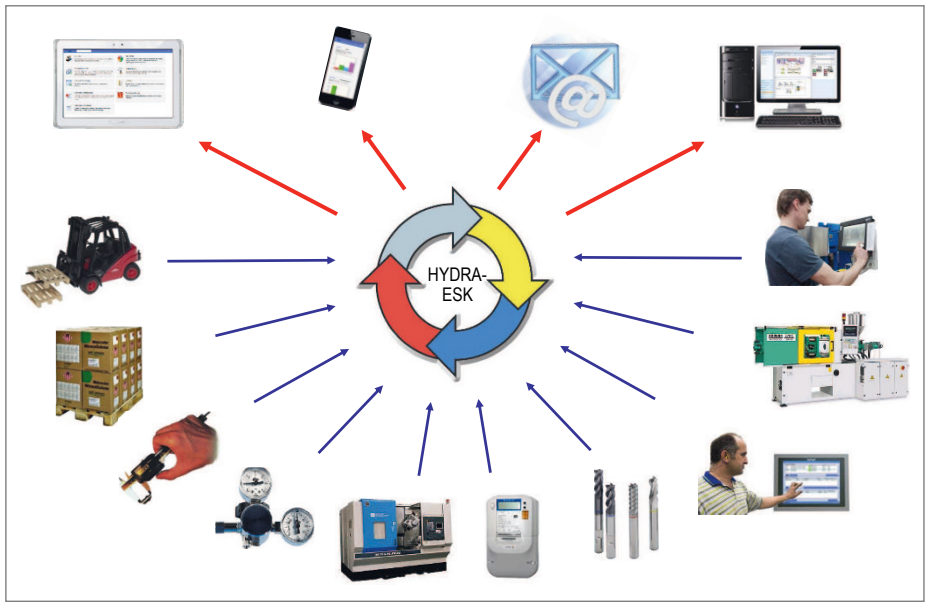

Fig. 2.7 With HYDRA Escalation Management defined situations can be recognized, escalations generated and workflows set up.

2.3.2 MES Application Services

Running in the background, as it were, the powerful MES Application Services are responsible for processing the data stored in the MES, condensing it and preparing it for display in the MOC. The services are configurable within broad limits and can thus be adapted to the specific task without the need for programming. Built-in user exits are available for mapping user-specific requirements: these are used for branching off into individually programmed routines without changes to the HYDRA standard being necessary.

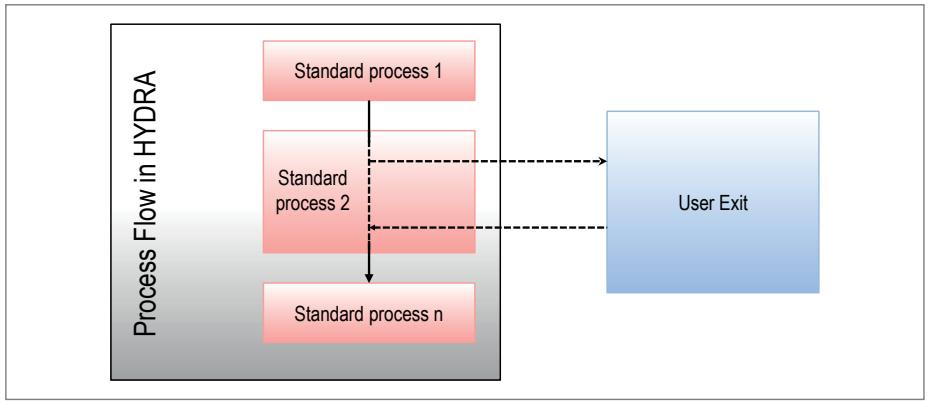

Fig. 2.8 User exits for the user-specific modification of processes

2.3.3 MES Operation Center (MOC)

The MOC is a graphical user interface which was developed on the basis of the latest IT technologies and with which output from application services is displayed in the form of tables or graphics. The MOC communicates via web services with the central services on the MES server. Development was focused on configuration options and ergonomics. Since the user interface is based on modern Windows operating concepts, the MOC provides users with an intuitive and comfortable operating experience. The MOC menu is available in two variants:

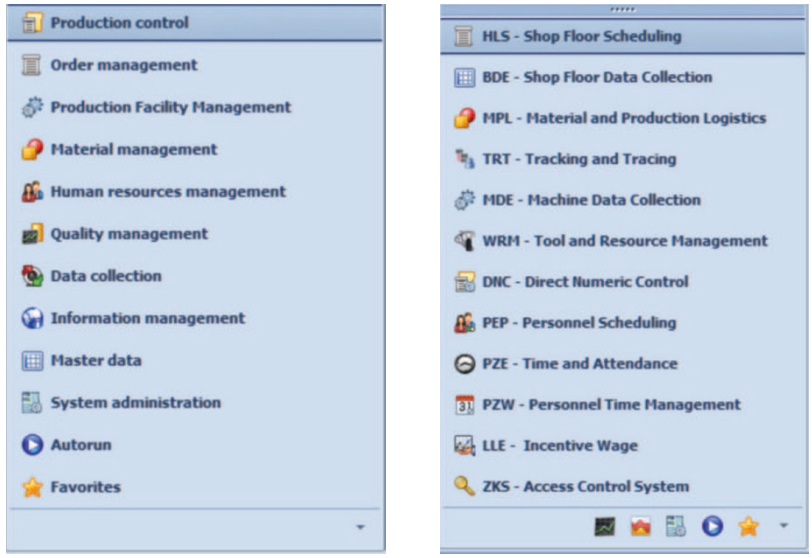

Fig. 2.9 The role-oriented and product-oriented menus of the MES Operation Center

Firstly, a role-based menu structure was developed, which focuses on the daily workflow of the user depending on his role in the company. The task structure of an MES system according to VDI standard 5600 was taken into account here.

Both menus are individually customizable via the menu editor. The user can, for example, change the order of sub-items or simply hide features which are not needed.

Besides launching functions via the menu, the user also has other ways of starting the MES applications. He can, for example, save frequently used functions in a favorites menu and launch them from there. Functions in the Autorun menu will open automatically when the MOC starts. In addition, every application has its own transaction code which can be entered directly in the taskbar.

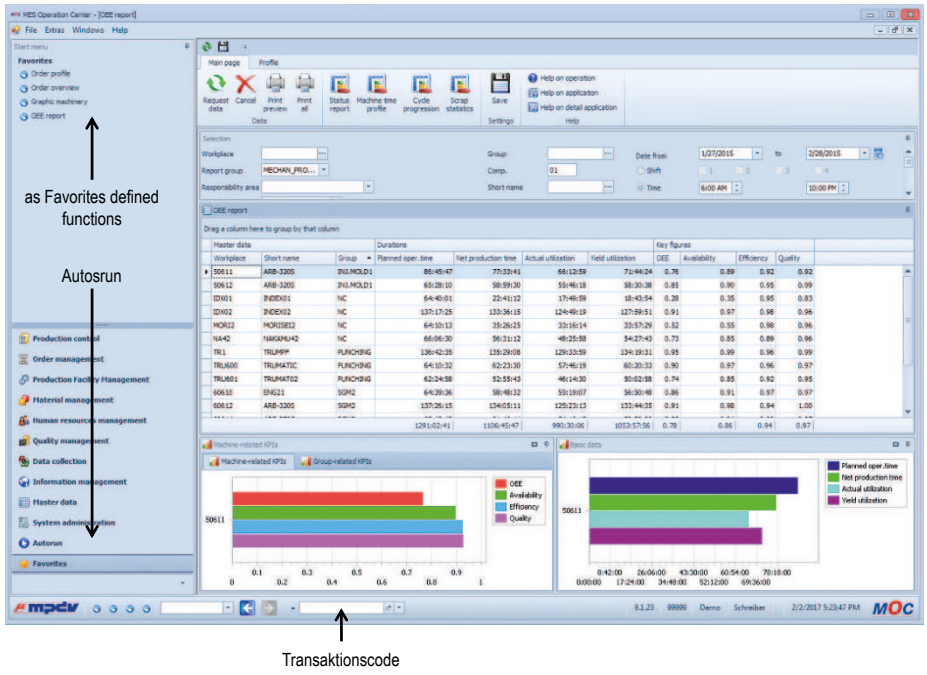

Fig. 2.10 Different ways of calling applications in the MOC

The multi-window functionality provides the user with many ways of customizing the displays in the MOC to his own individual needs. He can open simultaneously the windows he needs to access information or to input data, and switch with ease between them. The screen design is very easily modifiable for the user.

Another highlight which the MOC offers is displaying correlating information and synchronizing different window contents within a single window. When, example, the Workplace over-

view is called, the user is given an overview of operations, maintenance intervals or quantities produced at this workplace. Depending on which set of data was selected, the data in the linked applications also change automatically. If several data sets are selected at the same time, the relevant data are aggregated automatically.

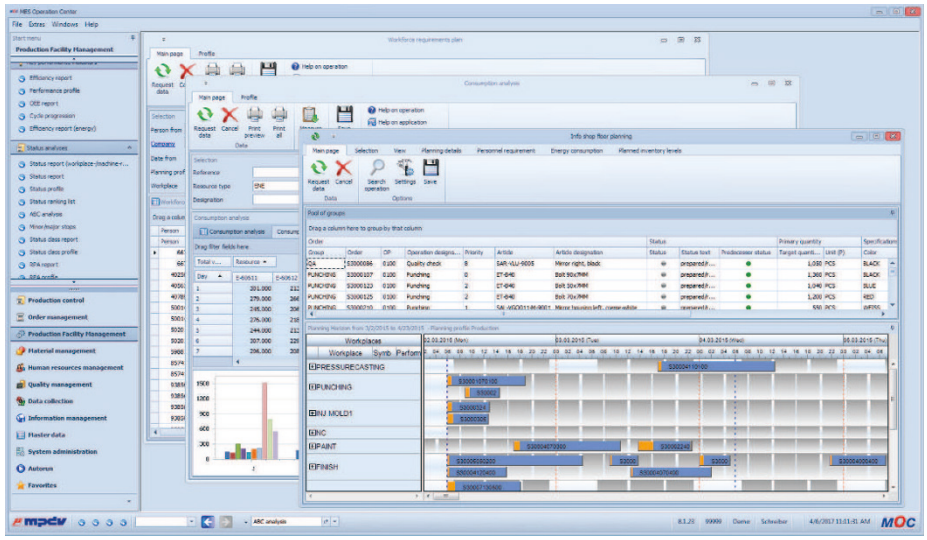

Fig. 2.11 Multiple applications can be opened in parallel in the MOC

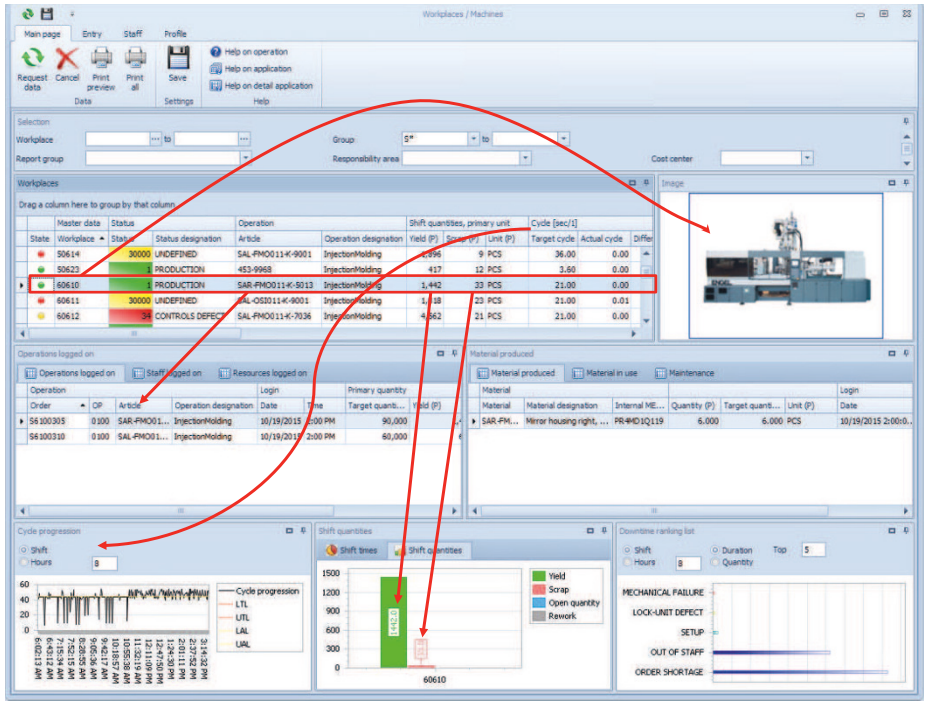

Fig. 2.12 Automatic synchronization of window contents

As mentioned briefly above, there are a number of possibilities for adapting the MOC to individual ideas and habits. This also includes being able to place sub-applications anywhere within the overall application window, hiding or displaying them, and changing colors and backgrounds. In the user settings the system stores the changes made by the user regarding, for example, column widths in tables or the positioning of applications on the desktop: even after an MOC restart these individual modifications are retained. In the same way it is possible to distribute configuration settings to all MES users in order to ensure that the MOC interface has the same appearance throughout the system.

It is of course important, especially for internationally active companies, to display MES applications in the user's own language. Any number of languages can be managed and individual translations made via the so-called HYDRA Language Manager.

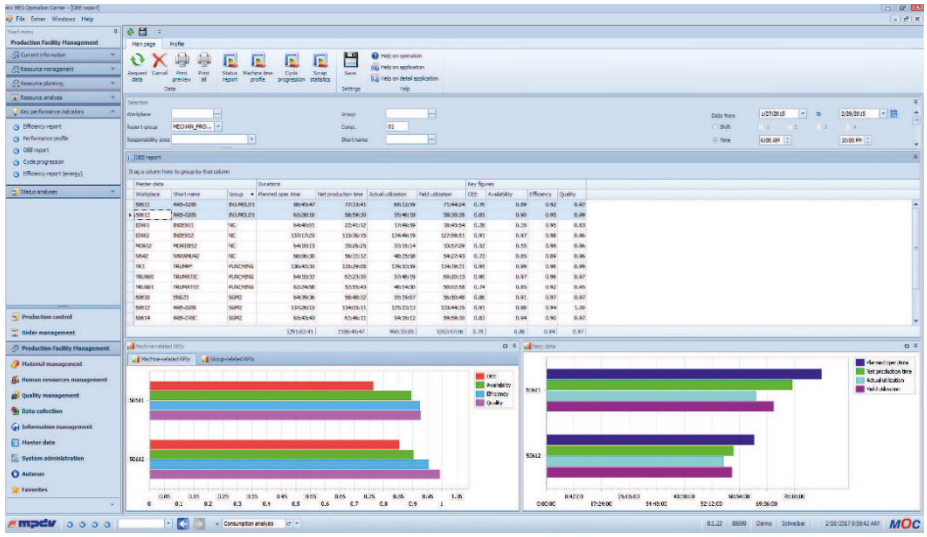

Fig. 2.13 HYDRA's multilingualism allows easy switching to other languages

Another plus of the MOC is the wide selection of ways in which data can be displayed in the MES applications. Visualization, for example, uses a great variety of charts, which relate to the elements in tables. When individual objects are selected in a table, the appropriate charts for the object are displayed. Should multiple data sets be selected, they can also be compared with each other. In table-oriented analyses, sorting, grouping and pivoting functions help to display the contents in a clear form. In addition, functions are available which automatically export table content to Excel – or generate a document in PDF format.

2.3.4 Smart MES Application (SMA)

In order not to be dependent on the intranet or even the user's own workplace PC when accessing data in the MES, various HYDRA functions and MOC views are also available in browser-based form via the internet. Flexibility is rounded off by Smart MES Applications: simple applications, such as the current status of machines and workplaces, can in this way be viewed from any location at any time, also on mobile devices such as smartphones or tablets.

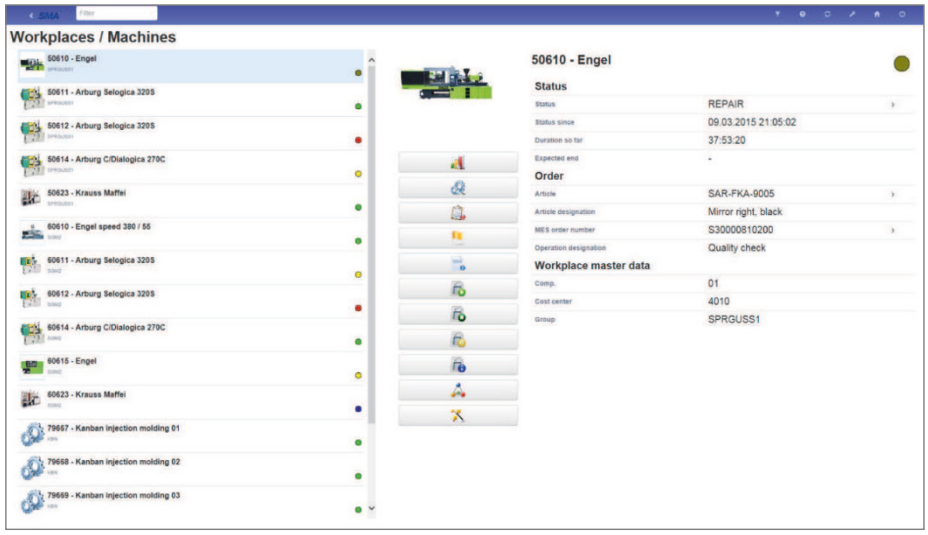

Fig. 2.14 Machine overview in Smart MES Applications

2.3.5 Enterprise Integration Services

In terms of vertical integration, the MES is the link between the production level and the management level. Communication between HYDRA and higher-level systems such as ERP, SCM (supply chain management), APS (advanced production scheduling) or even wage and salary systems is handled by the Enterprise Integration Services, which also include the communication platform MES Link Enabling (MLE).

MLE provides standardized MES interfaces for receiving and transferring data. Here, for example, the master data for production orders including the associated operations, components and much other information besides can be transferred from the ERP systems directly into the HYDRA production database. In the reverse direction, collected actual data are transferred in compressed form to the ERP or other systems. In addition to using interfaces in a standardized form, project-specific modifications are, of course, possible. A sophisticated monitoring of the interfaces with meticulous logging of input and output transactions prevents possible problems during data exchange remaining undetected and thus working with faulty data sets.

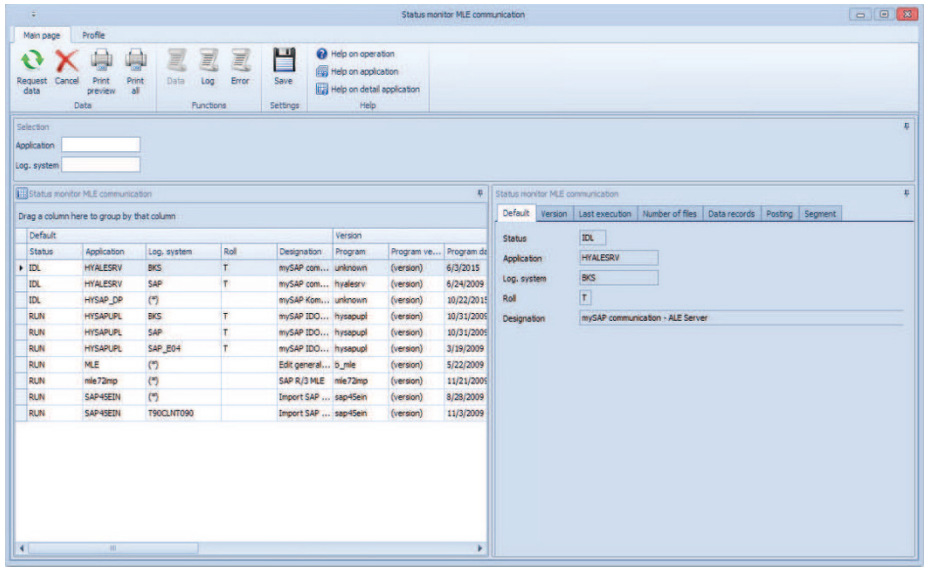

Fig. 2.15 Status monitor for monitoring the interfaces between MES HYDRA and other higher-level systems

Due to their outstanding market presence specific interfaces are used for communication with SAP systems. These interfaces meet SAP conventions and as an indication of their functional capabilities have been officially certified by SAP AG. Data exchange with the SAP modules PP, PP-PI, PP-REM, CO, HR, PM, PS, QM, MM and NetWeaver is optionally based on the certified interfaces HR-PDC and PP-PDC or KK1 and KK2 (PDC-CC1 and -CC2), the standardized interfaces KK3, KK4 (PDC-CC3, -CC4), PI-PCS, PP-REM, QM-IDI and MM-MOB as well as individual interfaces which use RFC, BAPI and iDOC technologies.

2.3.6 Shopfloor Connectivity Services

Communication between HYDRA and machines, systems, weighing equipment and other production facilities is handled by the so-called Shopfloor Connectivity Services. Depending on requirements or on the technical possibilities on the machine side, the wide range of implementation options begins with simple machine interfaces which, via a direct connection with machine sensors, enable simple recording not only of cycles and digital signals but also of analog measured values such as temperature, pressure, speed of rotation or velocity. These inexpensive devices are either directly connected via a serial interface to the shop floor data collection terminals or are integrated via the LAN into the HYDRA system. The machine interfaces can be expanded as required on a modular basis and feature industry-standard installation and connection options.

With higher requirements for data exchange and in particular if setting data or NC datasets are to be transferred to controllers, the HYDRA Process Communication Controller (PCC) will be used. The PCC includes a comprehensive driver library supporting a large number of protocols and interface technologies. The drivers can be configured and thus individually adjusted to suit the particular intended purpose or application case. The PCC guarantees a uniform, application-oriented view with respect to the MES and handles 'translation' from or into the machine / automation language in question.

The Process Communication Controller supports a whole series of sector-specific industrial standards. This includes, for example, Euromap 63 for the integration of injection-molding machines into plastics manufacturing, or the so-called Weihenstephan standards as a quasi-standard for connecting bottling plants in the food and beverages industry. Even the powerful and widely used OPC interfaces (OLE for Process Control) can be implemented with the PCC.

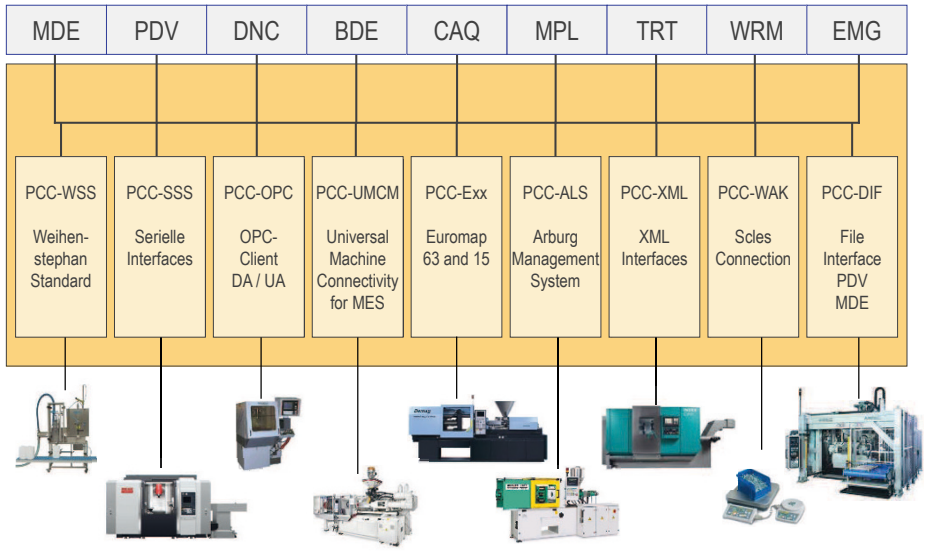

Fig. 2.16 The HYDRA Process Communication Controller offers a wide range of possibilities for connecting machines via standardized interfaces

Another element of the Shop Floor Connectivity Services is the HYDRA Production and Personnel Data Manager which was primarily developed for communication with existing subsystems. For example, the order, personnel, machine and process data which external BDE or PZE systems, data concentrators, machine controllers or the like provide can, for example, be imported via this data manager. The advantage is that existing components and systems as well as established special solutions can continue to be used and replacement purchases or redundant acquisition mechanisms avoided.

2.3.7 Acquisition and Information Panel (AIP)

The AIP is the Windows-based user interface and serves as a link between the individual and the MES system. A user guidance system is used for manual acquisition of relevant data and is optimized for service in the production environment by using touch screens and peripherals such as barcode or RFID readers. The AIP provides HYDRA with the correct entry dialogs for each task since they can be individually configured. Accompanying information such as BOMs, work plans, test instructions or drawings can be displayed to the worker, thereby creating a form of production involving little paperwork or even none at all. Even NC data and setting parameters are displayed and transferred directly into the machine and system controllers.

To simplify data collection and avoid erroneous inputs, the results from weighing equipment or measuring and testing equipment can be read off directly and entered in the input dialogs.

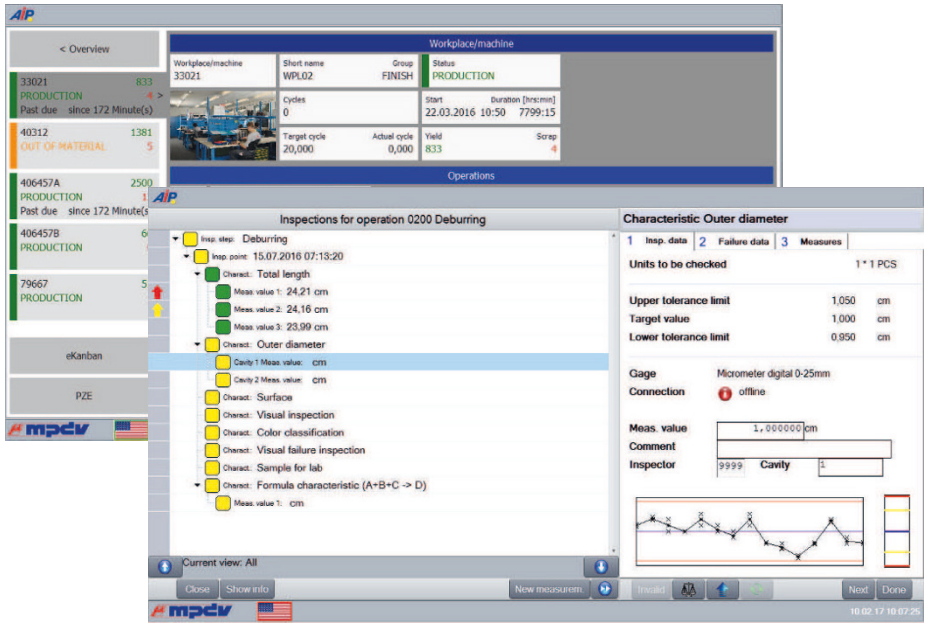

Fig. 2.17 Examples of simple dialogs in BDE and AIP applications for operator-conducted inspections

The AIP inspires confidence with its modern interface and is tailored to the needs of users in production. Its division into application groups and, in extreme cases, the possibility of customizing configurations for individual workplaces means that workers and setters can only use the functions which they actually need and which correspond to their normal workflow. The input screens have been given a multi-stage structure, which pays due regard to an application-oriented collection workflow for all MES applications, thereby making operation intuitive. The range extends from simple applications of personnel time and attendance logging (clock-

ing-in / clocking-out) to normal BDE / MDE dialogs and complex applications in which material reports, inspection results or batch data are collected.

2.3.8 Alternative data collection functions

Fig. 2.18 Examples of HYDRA applications on a smartphone

Where it makes sense, even mobile devices such as smartphones or tablets can be used to collect data on site, especially in extensive production areas.

Here, the user interface has, of course, been adapted to these special conditions with a small screen and limited keyboard.

In addition to stationary or mobile terminals, the use of Smart MES Applications also allows a browser-based interface to be used for collecting data and for accessing information. One example of this is the registration of clocking-in and clocking-out stamps, or applications for vacation which employees on construction sites or in branch offices can submit via PCs with internet connections.

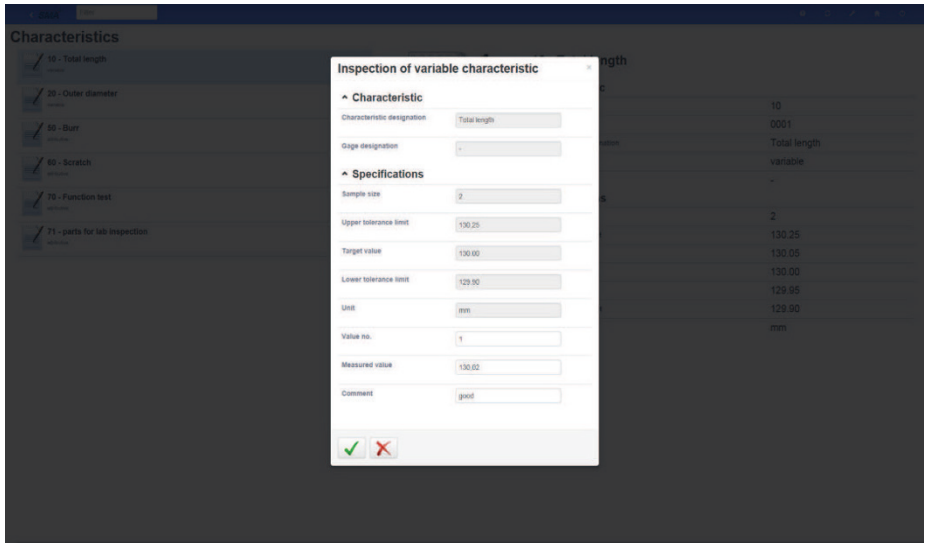

Fig. 2.19 Data acquisition via Smart MES Applications

2.4 The Customized MES

At the end of this section a summary is given of the various possibilities HYDRA offers for designing a tailor-made MES geared to the individual needs of a manufacturing company. At its heart stands a rich fund of standard functions, field-tested and usable without further ado, with which a major proportion of processes can be mapped without any additional programming. However, the question still arises as to which product features distinguish HYDRA and which additional mechanisms are available to achieve a complete adaptation of the MES to the individual processes.

Fig. 2.20 The elements of HYDRA which make a customized MES solution possible

Customizing

The first level for customizing the design of the processes and behavior of the system consists of the various possibilities for influencing the way system functions behave, doing so by means of configuration parameters. With the so-called Customizing feature the user himself is able to configure HYDRA so that the MES meets his requirements. It is thus possible, for example, simply by using parameters, to define different types of order such that the differentiated processing of series orders in production, of maintenance orders in maintenance and of single-item production in toolmaking can be mapped in a single system. Configurable interfaces are the basis for being able to fit HYDRA seamlessly into the existing infrastructure with its heterogeneous collection of machines and higher-level systems such as ERP.

Configurable user interfaces

How an MES is received and accepted by its users depends heavily on, among other things, functions being usable simply and ergonomically. With HYDRA's standard tools the user interfaces of the BDE terminals and of the MOC can be customized to individual requirements. Dynamic terminal dialogs reflect the workflows of the operators, and reports or views can be easily configured so that the user can see at a glance the data he needs in the form he wants.

Report designer

HYDRA provides a report designer with which specific evaluations and reports or working papers, such as routing cards or time tickets, can be designed to comply with the required format and contain the desired data. With the label designer, the user can even configure labels, pallet notes and the like and thus match them to the requirements of his own particular production activities.

User exits

User exits make it possible to modify HYDRA functions by patching individual extensions onto the standard programs at defined exit points but without changing standard operating sequences.

Development environment

A powerful development environment, which can also be used by the user himself, following the appropriate training and assuming compliance with HYDRA design rules, ensures that even highly specialized processes can be reproduced by means of individual adjustments and complex user-specific requirements can be satisfied.

http://www.springer.com/978-3-662-54982-7

MES Compendium
Perfect MES Solutions based on HYDRA
Kletti, J.; Deisenroth, R.
2018, XII, 237 p. 234 illus. in color., Hardcover
ISBN: 978-3-662-54982-7