Remote maintenance and diagnosis of mobile machinery

Export demands new service ways

The manufacturers and distributors of mobile machines and vehicles achieve a large part of their turnover by means of their export business. Examples of such machines are various construction machinery and vehicles, tunnel boring equipment as well as agricultural vehicles.

Remote maintenance improves the availability of modern agricultural vehicles

In these areas fault-related downtimes are to be absolutely avoided or at least to be kept as short as possible. Just think of the farmer whose combine harvester fails during the harvest in a period of good weather. The suitable spare part and the respective service person have to be available as soon as possible. It would be even better if the service center were informed automatically at an early stage about the wear of certain parts on the vehicles. Thus the replacement of components can be planned exactly and the spare part is on site when it is needed. In Germany and other parts of Europe fast reaction to a malfunction is possible due to a close service network. This is far more difficult in case of machines and vehicles, which are far away from any service center. Due to the favorable export situation these are often more than 50%. In these locations, however, the classical on-site service is hardly justifiable any more due to the high costs and the time delay connected with it. Sometimes the faults, which lead to the failure of the vehicles, are not even serious ones.

If the exact fault status of the vehicle is known in the service center the operator can often rectify it himself with the support via remote diagnosis. Thus the topic remote maintenance and remote diagnosis is getting more and more important.

Controllers with CANopen bus systems

Powerful controllers, on-board computers or programmable logic controller (PLC) for mobile applications with CANopen interfaces are increasingly carrying out the complex control tasks in mobile machines. Apart from controllers a wide range of I/O modules, sensors and dialogue modules is now available for the CANopen standard. They are all tailored to the special requirements of mobile applications. The company ifm electronic is also a supplier in this area. Furthermore this supplier provides GPS and GSM devices as well as data logger units with CANopen interfaces in versions suitable for mobile applications. On the basis of these devices the machine can already be set up in...
a "remote maintenance-friendly" way at the design stage. It is also possible to retrofit existing vehicles with these components if a CAN bus system has been used. As in most cases extensive on-board diagnosis has been implemented in the control systems, these data can be used for the remote maintenance.

Service concept with GSM

In the area of wireless telecommunications the GSM standard (Global System for Mobile Communication) has gained worldwide acceptance. In most countries the 900 MHz frequency band is used for the transmission. Sometimes the 1800 MHz band is still being used as well as the 1900 MHz band in North America. What possibilities does the GSM network offer for remote service and remote maintenance? Basically GSM offers the possibility of SMS and direct transmission. An important service of the GSM network is the Short-Massage-Service (SMS). This allows the exchange of text messages with maximum 160 characters between GSM devices. This service is now increasingly being offered by Internet providers.

In practice the SMS service can be used on the mobile machine in a very versatile way. Normally the controller program will automatically send an SMS to the service center if a fault in the system is detected. The malfunctions can already be sorted in advance. The message is sent to different target numbers, depending on the type of fault. If e.g. there is a malfunction in the hydraulic system the corresponding specialist is informed directly, a fact which of course accelerates fault rectification considerably. Furthermore the user can decide if the messages are to be passed on to another mobile number, to a fax machine or to an email connection. However, remote maintenance does not only provide advantages in case of malfunctions. The controller program can for example be designed in such a way that all important data are sent to a central computer which is also connected to a GSM unit at regular intervals while the machine is still in operation. Thus any tendencies of wear, unacceptable operations or maintenance times can be analyzed remotely and can be detected at an early stage.

If many SMS messages from the machines have to be dealt with by the service staff on the reception side a fax machine or a mobile phone are of course not a suitable solution. For these cases a special PC program, the basic software, is available. This program preprocesses the data automatically so that the service staff has the overview even in case of large amounts of data. Furthermore the user can carry out an evaluation according to his own requirements via an OLE interface with PC standard programs (e.g. MS-Excel) without special programming knowledge. When an SMS is received the basic software can start a macro in other programs, thus enabling the user to program automatic procedures in an easy way. The GSM basic software does not only support the receipt of messages, however. This data transmission is no one-way street. It is also possible to send information in the other direction via SMS, e.g. to send unit parameters to the mobile machines. Depending on the application the control station can set the machine for the corresponding task in an optimum way.

The GSM basic software also supports automatic operation in these cases. Thus both the time and the day of the SMS transmission to the machines can be programmed. Thus the SMS service, often used as a way of passing the time in the private sector, is important in the professional sector. The advantage is the simple handling, it is even possible to use a prepaid card.

For the transmission of larger amounts of data the SMS service is not a suitable medium any more due to its restriction to 160 characters per SMS. Furthermore it is not possible to establish an online connection between transmitter and receiver. Other possibilities arise with direct transmission, a special GSM data service, which allows a permanent modem connection with 9600 baud between two GSM modems. The prerequisite is a SIM card, which supports this data service. The transmission of larger amounts of data, online debugging as well as program download is possible with this operating mode.

Despite very careful design and high reliability of the individual components in modern machines the electrical connections are sometimes destroyed due to the harsh application and environmental conditions. This of course does not exclude the CAN network. Here the question arises for the user if the GSM modem can still transmit this fault state to the service center. Even in case of a serious malfunction of the CAN bus or a failure of the CAN master controller the GSM module can still independently send a fault message. The user can program the required target telephone number in the GSM modem in advance.

Design of the GSM devices for the use

In principle the GSM devices for the use in mobile machines are designed like a standard mobile telephone. Nevertheless they are considerably different from the standard devices in order to be suitable for industrial use. There is no keyboard and no display, as this is not required. The input and the transmission of the data are carried out in a digital way directly from the connected controller. The GSM modem is connected to the control system via an integrated CAN gateway. It assumes the task of the data conversion between the CAN and GSM network.
works. Before the transmission all data are converted into a text. The GSM test and safety mechanisms monitor the correctness of the transmitted data. Additionally a check sum mechanism and a password protection can be used for the data transmission. The device can be supplied with the standard on-board network voltages between 10 and 30 volts.

The electronics is integrated in a compact and rugged housing. Due to the protection rating IP65 it can also be built into the machines afterwards without any problems. The aerial can be mounted in the place which is best suitable for the reception, maybe also outside the vehicle. The GSM device has a socket for an aerial cable; a fixed aerial on the device would lead to transmission problems e.g. when mounted in control cabinets.

Firmware update possible via PC

An update of the unit firmware can be carried out on request via an additional RS232 connection. In the standard mobile phones many parameters and settings of the device, like e.g. the PIN no. or the number of the SMS service center, which depends on the provider can be changed via a menu. Configuration software is available, as this device has no input possibilities. The device can be set easily with a PC by means of the above-mentioned RS232 connection.

CANopen GPS as additional option

The GPS (Global Positioning System) can be used in addition to the GSM. The device described above is offered with a GPS option and can be used by the programmer like a CANopen device. In case of a fault it is thus possible to receive the fault message and detect the location of the machine with a precision of 10 meters. But these are not the only advantages of GPS, it has additional advantages for the user in the area of theft surveillance or position-dependent process control (example: output quantity of fertilizers) and in vehicle logistics. The device provides the GPS data in the standard NMEA-0183 format. Information like degree of longitude and degree of latitude and a number of additional parameters like speed or height are available. These data can e.g. provide information about reduced performance of a diesel drive. This is the case if the vehicle is used for example in the mountains at an extreme height. The basic software described above is available for the evaluation. Furthermore the data can be included in different map programs in which a graphic location analysis of the machines and vehicles can be carried out.

If no controller is available in the vehicle the device can also be operated stand-alone. In that case the GPS data of the mobile system can be requested via a special SMS sequence. This can be interesting if the location of a vehicle is to be queried outside the operating time. This is possible if the GPS module remains connected to the on-board network voltage when the vehicle is switched off.

A further addition in the area of remote maintenance can be a compact data memory and data logger for CANopen networks. The use of devices in PC-Card (PCM-CIA) data cards with up to 24 Mb bytes offers many possibilities to the user.

CANopen data logger

Different applications, for example the use as fault memory or accident data memory are possible. In some machines it is necessary to save the operating and machine data at very short intervals.

A typical application is in the area of large boring equipment e.g. for tunnel construction. In these cases the customer often asks for a permanent documentation of the boring coordinates for reasons of quality assurance. In this case a permanent transmission of the data via GSM would not make sense for cost reasons alone. In connection with the GSM module, however, the content of the logger can be queried specifically on request. The integrated real-time clock enables exact data evaluation with time-stamp. The program can either write the data directly to an address, or data can also be written automatically in time intervals of between 10 ms and 24 h.

Conclusion

At first glance, the use of the described components leads to higher costs. However, this system and its costs are accepted by the customer, especially in case of bigger machines due to the cost savings to be expected because of shorter downtime, in particular as the saving potential is considerably higher than the investment costs.

However, not only the operator but also the machine manufacturer benefits from the possibilities of the remote maintenance and diagnostic system. Not only the service, but also all other areas of the company, i.e. development, design and sales have access to the data.

The analysis of the data provides information about possible weak points as well as a solid basis for further optimization of the machines. Only after a short time both the manufacturer and the customer benefit from the advantages of remote maintenance. The investments may already be amortized during the first malfunction the rectification of which requires no specialist on site.