The International Journal of Mine Water , Vol.7, No. 2, June 1988, pp. 33 46

PUMPS AND PUMPING, REMOTE OPERATION AND MONITORING

C.E. Marr

Systems Engineer, Mining Division,
Transmitton Ltd.

INTRODUCTION

Transmitton Ltd, formed in 1972 and now part of BICC plc, specialises in the design, manufacture and supply of remote monitoring and control systems,. The company is split into separate operating divisions, each with its own individual market sector, i.e. Industrial, Mining, Energy, Management and Process Control.

The Mining Division provides remote control and monitoring systems for use worldwide, covering all areas of Colliery operations, e.g. Underground Coal Transport and Coal Preparation Plant automation. The division has specialised in the design and supply of Intrinsically Safe electronic and computer equipment.

From the earliest days remote monitoring and control of pumps and pumping systems has played a significant part in the company's growth, originally in mining and later in the water supply industry.

This paper will concentrate on the development of systems for use in coal mines, although the general principal apply universally.

Paper presented at the Symposium on Pump and Pumping, University of Nottingham, 11-12 August 1987.

MANUAL PUMPING AND PROTECTION

For many years pumping was confined mainly to centrifugal type pumps operating from well constructed pump lodges and sumps. Smaller pumps tended to be of the reciprocating ram type to simplify priming. In both cases they required continuous manning during mining operation.

The advent of the positive displacement pumps with moulded stators permitted less manual intervention and pumping from less well made sumps, since they needed no priming and would pump dirty water without detriment.

Initially. monitoring equipment developed to assist local operators to identify abnormal conditions, using indicators. Later the same equipment evolved to protect the pumps by wiring switches attached to the indicators directly into the control circuit. Typically, overtemperature monitoring using bimetallic thermostats and flow switches using flap switches became the order of day. These provided some rudimentary protection against destroying the sump due to a lack of water throughput or bearing failures.

The system still relied on a man to stop and start the pump as required. As this tended to be a chore at best, and an easily forgotten extra task at worst, the equipment could easily suffer. Hence the next area to develop centred on protecting the pump from running dry whilst under manual control. The ideal arrangement would be for the pump scheme to pump out the water from a sump at exactly the same rate as the water found its way. In reality the water make up is always variable and pumps come in a range of set outputs to suit the ease and cost of the manufacture.

Hence we usually have a situation where the pump or pumps have a capacity in excess of the normal make and hopefully, equal or greater than the worse case make. Therefore the pump is likely to be capable of emptying its sump. This need to the requirement, first to monitor a sump low level to turn of the pump, and later to a higher level to restart the pump. Many methods of pump level monitoring have been developed and tried, e.g. magnet in level, float and microswitch, compressed airback pressure (the bubbler). Nowadays the methods used in mining appear to have stabilised around mercury switch tilt float switches, with one at each level, or piezoelectric pressure transducers, which provide a continuous variable or analogue pressure. Obviously the latter imply a need for some processing arrangement to provide the requisite stop and start outputs at the set levels.

Having relied on the low level signal to stop the pump rather than a man, it would be a disastrous if the pump did not stop. Hence an extra low level probe below the ;low level was introduced to trip the circuit breaker feeding the pump contactor, to cover for low level probe failure, a frozen contactor or other condition that could make this happen. As pumps need downtime for maintenance and repair, the water make and sump size need to be balanced accordingly. However sump sizes are usually less than ideal and reflect the natural availability of space and the cost to provide more space.

Keeping costs down by providing the minimum size of pump tends to lead to a longer pumping period and hence, a more critical pump availability.

This lead in many cases to the provision of duplicated pumps. A local operator could supervise the need for, and operating involved, in the change over process, but rather than rely on a man some automatic means has become normal. This involves checking that the main pump is producing the required flow within a set time of becoming necessary and, if not, starting the standby pump.

The provision of standby pump also covers for the case of the abnormal water make, as both pumps could run under these conditions. This is usually achieved by monitoring a level higher (called say 'extra high') than the main pump start high level and starting the second or more pumps at this level.

DEVELOPMENT OF REMOTE CONTROL AND MONITORING

As the cost of labour increased and the cost of monitoring and automation decreased, it became very cost effective to remote the man by the provision of a remote monitoring and local automation scheme. Initially this was achieved by directly wiring back the transducers states to some other part of the mine. Reductions in man powers generally underground and the increased number of conditions to be monitored encouraged the use of the telemetry schemes to the surface. Telemetry provides a cost effective way of compressing a lot of states or data on to a small number of cable cores and providing a means of sending this data with accuracy and error detection methods not possible with direct wiring.

A small Scheme

One of Transmitton's very first orders was to remotely monitor and control a large number of nuisance water pumps in a mine.

The mine was shallow and had surface water problems such that, at any one period , approximately 40 pumps were used to pump into a single pump range. The problem of worn stators and variable water make at different times in different parts of the mine inevitable brought manpower back to supervise the system continuously. Each sump was usually so small that a failure to pump caused roadway flooding with loss of equipment and sometimes blockage of ventilation. The supervision was usually by Mine Deputies and weakened coverage rotas were becoming difficult.

The colliery introduce a monitoring system which enables full information on the state of the pumping system to be displayed on the surface of the mine.

The system comprised of a number of outstations, one bolted to each pump and central station sited in the surface control room. The outstations acting as local protection units, monitiored high and low level water in the sump, the pump body temperature and the flow of water in the outlet from the pump. It also transmitted this information to and received overriding stop and start controls from the surface via a 4 core cable common to all outstations and the central station. The outstations functioned as follows:

a) when high level was detected, the pump contactor P130 control circuit closed, energising the pump. After a suitable delay, the flow signal was checked. If flow failed, the P130 circuit was opened and the condition indicated locally and on the surface.

b) Whenever low level or pump body overheat was detected, the P130 circuit was de-energised, either stopping the pump or preventing it from being started, until the conditions were indicated locally and on the surface.

The central station provided indication and remote start and stop pushbuttons for each pump. The starts allowed a surface operator to start a pump any time whilst the sump water level was above the low level. The stops were operative any time assuming the transmission system was healthy. Unhealthy outstations and a failed system were monitored and indicated at the surface and in the case of the latter on the outstation(s).

The system produced a significant man saving, a better utilisation of the pumps and a greater management awareness of the day to day variations in the water make and associated problems.

Effect of Electricity Tariffs

Many systems incorporating the logic necessity for automation main to standby pump changeover have since been produced, mainly for shaft bottom installations. As pumping up shafts require large horsepower motors, means of minimising the electricity costs involved were investigated. Pump systems and monitoring systems have been developed together whereby, pumps capable of clearing the daily water make in approximately eight hours or less are used overnight during the period when the mine's electricity costs or its demand for electricity is lowest. The latter avoids the pumping electricity demand increasing the mine's electricity bill, by increasing its maximum demand. It will be interesting to see what effect the new stye tariffs recently introduced will make to this type of thinking.

Remote Site Pumping

An interesting specialised version of the remote system has been developed for pump installations sited at closed mines. Here the pumps are kept running to protect nearby producing mines from additional ingress of water. At these sites a combination of hazardous area transducers monitor the pumps, usually submersibles, and pass this data to a non-hazardous combined protection and telemetry unit. This transmits the data over leased telephone lines to the production mine's coal room. As these sites are unnamed, the system also monitors the site generally, for security purposes, and other non-pumping equipment, for example the switchgear and methane clearing fan if present.

REMOTE CONTROL AND MONITORING SYSTEMS

The element of a remote control and monitoring systems are (Figure 1):

a) Transducers
b) Local protection scheme
c) Telemetry
d) Central Control and Monitoring

Transducers

These are the heart of the system. They need to be chosen and tailored to work with the pumping system, for without their accuracy or integrity the system as a whole worthless. Fortunately a specialised set of suppliers has grown up to develop, supply and support them. The trend nowadays is to move away from the mechanically based transducers towards electronic non-moving transducers, even increasing their reliability and durability.

Local Protection Schemes

These have developed from stand alone rely logic boxes to the current day practice of using programmable microprocessor based outstations which come compete with a telemetry output. The introduction of microprocessor technology has provided the end user with a great number of real benefits, in addition to making the system cheaper to buy.

a) The electronic technology is the most reliable produced so far.

b) The ability to integrate the logic on to fewer printed circuit boards further increases its reliability.

c) The programmability allows the end user to fine tune the system easily and could even allow the unit to be reused for a different purpose when it become redundant on its current job.

d) The availability of a processor allows the unit to provide a greater diversity of local indications, local fault diagnostics and other help aids.

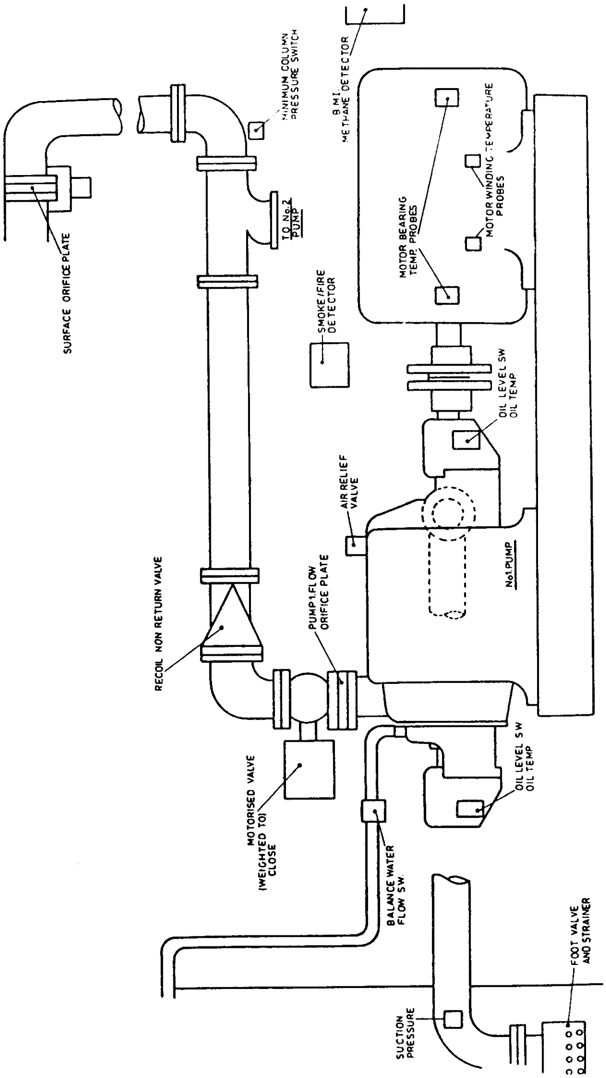

Figure 1 Pump protection monitoring

Telemetry

There are many different techniques available for compressing the data for onward transmission. The time division multiplex arrangement has stood the test of time.

Instead of a dedicated wire being used to interconnect the pump transducer switch directly via a power supply to a surface lamp, a common wire interconnects a number of switches to a number of lamps in time division multiplex, the system samples Switch 1 and outputs the sample state to lamp 1, then it samples Switch 2 and outputs this to lamp 2 and so on until it does them all, and then goes back to lamp 1, lamp 2 exc. hence the common wire time shares the switch states, or data as it is now called, and the time share information is used on the surface to recognise that Switch 1 is destined for lamp 1 etc. The important aspects for a telemetry system are not its technique but:

a) It needs to be rugged enough for its environment and the distance over which it needs to operate, e.g. pit telephone type cables more than10 km in length.

b) Although it needs to have capacity to grow, the techniques employed need to remain rugged and error free.

Central Control and Monitoring- the Man Machine

This has developed from the dedicated pushbutton and lamp panel to the computer systems of to-day, often covering the complete mining operations and not just a lamp scheme. However sophisticated and clever computer become, their purpose remains to provide the man machine interface. It is therefore important to judge them by this criteria and not by how many bits and bytes they have and whether they have this disk or that. Inevitably the bits, bytés and disk type do affect the decision in the way they provide the following criteria:

a) It must be user-friendly. This means its output of information and its input of data must reflect the skills of the person using it. An operator knows about pumps and pumping, not about computer programming, so technical English, not FORTRAN or BASIC is required for instance.

b) It needs to be capable of being tailored to the equipment to be controlled and monitored, preferably with the ability to input local names and terms.

c) It needs to be flexible enough to be capable of expanding, with the increase in pumps, the increase in monitoring and with the increased understanding of the user.

d) It needs to be reliable, well supported and not too easily made obsolete, a particular problem with this technique.

UNDERGROUND PUMP SCHEME - AN EXAMPLE

Requirements

A mine was required to develop a pumping scheme when a nearby mine closed and its pumping operation ceased. The main sump was designed to hold approximately 250000 gallons of water. The plan was to pump all the water during the 'off peak' electricity period between 11.00 pm and 7.00 am. To accomplish this water fro the main sump flowed for 200 m down an incline of 1 in 250 to a small pump sump, the most suitable place for installing the necessary pumps and starters.

The multistage section type centrifugal pumps in a main and standby configuration were installed to pump the water at 600 gallons per minute 300 m to the pit bottom and 730 m vertically to the surface. Each pump was powered by a 6.6KV 700 HP motor.

Pumping Scheme (see Figure 2)

A high (L5) and a low (L6) water level probe in the pump sump was used to regulate a motorized valve, hence the water flow, in the pipe run from main to sump pump.

The traditional high (L3), low (L2) and extra low (L1) probes were used to start main, stop main and trip section switch as outlined before. However, to achieve off peak only pumping, the high level probe was outridden by a signal from the surface during the peak demand period. If, abnormally, during this period, extra high level was reached, the main pump was started irrespective. It was decided in this case that boh pumps would

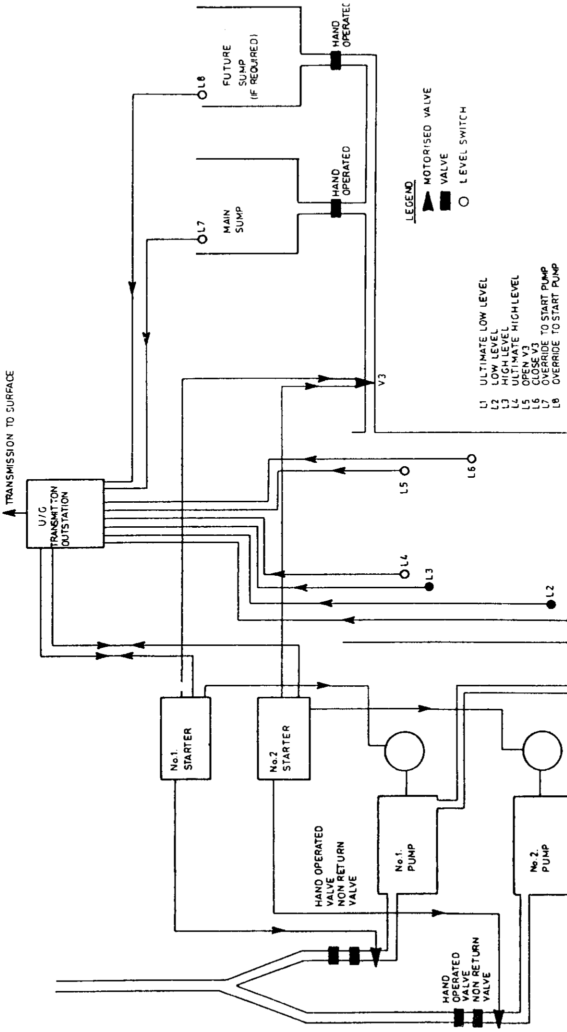

Figure 2 Pumping scheme

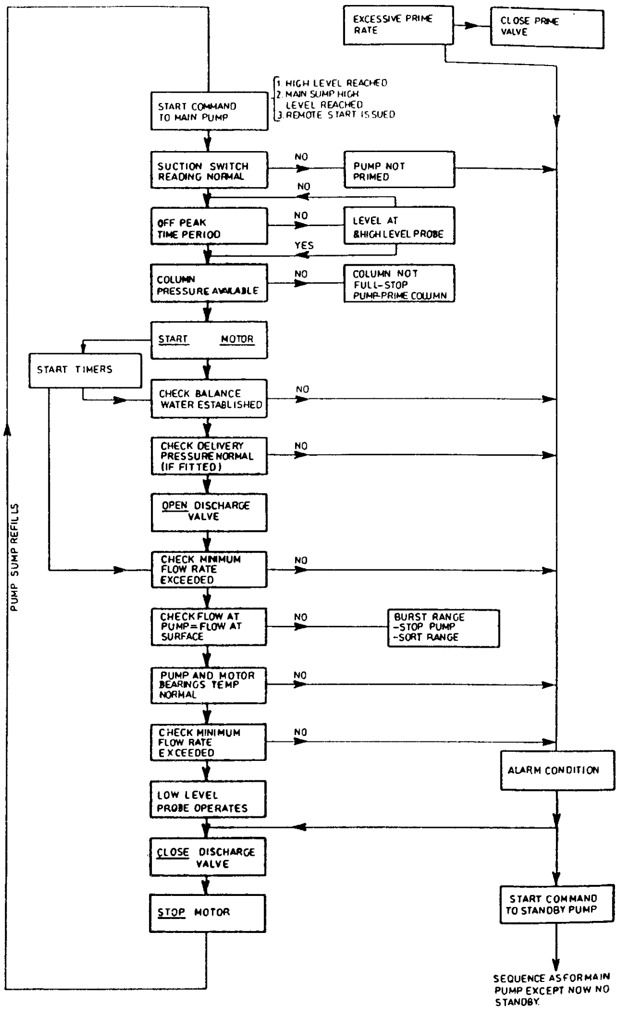

Figure 3 Start up sequence

sump from flooding a high level probe in this sump (L7) was used to open the valve V3 and start the main pump irrespective of other conditions.

Control System

This comprised a surface central station communicating over a 4 core time division multiplex transmission circuit to 3 outstations associated with this pump scheme. There was one outstation associated with each pump and a third outstation that operated valve V3, and hence the water flow between the sumps.

The central stations had general facilities allowing it to monitor and control up to 14 outstations on the same transmission circuit.

Specifically it offered overriding remote manual start and stop controls to either or both pumps, a timer to determine automatically the peak period, selection of which pump is classified main and, in addition, provided an hours-run meter for each pump to assist with maintenance plans.

Each pump outstation controlled and monitored a pump, its associated motorised delivery valve and a priming water valve. Its input comprised all the protection equipment associated with pump running, e.g. overtemperatures, the protection associated with start up, e.g. column pressure, priming and balance water, plus all the water levels associated with the pump sump. The major part of the outstations centred around starting around the main pump and, if this failed, starting of the standbye pump via a interconnecting circuit as can be seen in the logic in Figure 3. The outstation also provides local indication and transmission to the surface of all inputs plus a number of derived states, namely Pump Failed to Start, Valve Failed to Open, Frozen Contactor and Section Switch Trip. The first three are derived via the logic and ultimately by checking that water flow, valve open or the contactor opens within a time period following a control request. In all cases this time period can be varied in the outstation.

The valve outstation controlled and monitored the process surrounding the inter-sump water flow valve V3 control, plus it provides the means for general environmental monitoring of the pump site. Because it provide methane and smoke monitoring, this outstation was provided with up to 8 hours battery support in the event of a mains failure.

This is particularly important if you consider that, if the methane level is above 1.25 per cent, the mains power needs to be removed. At this time the methane level must be continuously monitored for judging the efforts necessary to reduce the methane level again.

Financial Appraisal

To demonstrate the worth of such a system, it is necessary to weight up the cost of the system and compare this with the financial benefits.

Provision of the pump and their immediate protection needs no justification other than to say the mine would be flooded without them. So it is only necessary to concentrate on the costs involved in automating and providing remote monitoring. In this example, provision of a dedicated surface central station is included to show the worst case, but nowadays most mines have this facility already in the form of a mine wide computer based central station.

Central Station	£15000
Outstations	£15000
Transducers	£12000
Cabling	£ 8000
Installation	£10000
Total	**£60000**

This cost can easily be justified by the wages cost saving of continuous manual supervision. Even when pumping is only necessary 1 shift per day, 7 days per week, the wages cost is approximately £20000 per year. This value takes no account of the uneven make causing occasional supervision at other times, plus the cost involved in providing visits to the site during non-pumping periods, particularly at weekends and holidays. Overall, a system of this type can have a pay back period measured in months rather than years.

CONCLUSIONS

Remote operation and monitoring systems, when allied with pump protection and automatic control, can be readily justified on financial grounds in known water make conditions and normal working conditions. When the water make risks the whole mine, or when the working conditions are not normal, as happened during the miners' strike,the value of this systems is incalculable.

However for such a system to deliver the benefits outlined, it is necessary for a user to thoroughly recognise his need and select his system carefully. I hope this paper will assist this selection