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# DEVELOPMENTS IN PUMPS & MIXERS FOR THE MINING INDUSTRY

## - THE ADVANCE OF SUBMERSIBLE TECHNOLOGY *

W. NONDE - BEng, MSc, DIC, AIMechE.
[ A. D. McLEAN & COMPANY LIMITED ]

The advent of submersible pumps opened a new era in mine drainage: Because they were capable of pumping highly polluted and abbrasive water, it became possible, for the first time, to pump unsettled mine water.

In addition, the risk of flooding the pump motor disappeared and pumps became portable. There are five basic applications for pumps in underground mining, and submersible pumps are highly effective in all of them:

**THE MAIN PUMP**

The main pump station is the mine's water heart. The other pumps in the mine, which all feed into it, are its veins. The very existence of the mine, the safety of its personnel and machinery, depend on the reliability of the main pump station. Consequently, the main pump is not only the mine's water heart but the very heart of the mine.

Traditionally, the main pump design has consisted of a horizontally mounted, centrifugal, "clean water" pump driven by a non-submersible electric motor. This system has two major drawbacks, however: Firstly, it requires large and expensive settling basins and holding tanks and, second, there's risk of the motor being flooded. In addition, this system has no mobility and requires a lot of servicing

A more advanced alternative is a large, heavy-duty, high head, submersible pump. This solution eliminates the need for settling basins storage tanks and the handling of accumulated sediment because it can pump contaminated water directly - including water containing abrasive particles.

It is also highly mobile, so it's easy to replace. For example, when servicing is required the entire unit can be simply taken out and moved to a workshop. Submersible pumps of between 90 to 180 kW are now available. These have, respectively, a total head of 200m or a maximum output of approx. 9,000 lit/min. and a total head of 350m or a maxium output of 3,000 lit/min.

**FACE & STAGE PUMPS**

Moving out from the "heart" of the mine's pumping system to its "capillaries", these are the face pumps. They are used to keep water out of working stopes. Small submersible pumps, up to 6 kW in size and with a max 4 inch discharge, are ideal here: They are portable, wear resistant and able to withstand dry running. The face pumps pump the water to larger, stage pumps located at suitable intervals along drifts or ramps. In addition to pumping the face water the stage pumps also collect the gravity drainage from the roadway and pump it along the drift. It's preferrable to use pumps for this purpose, rather than gravity flow in ditches, because it avoids the accumulate of solids in the drainage water, which can cause damaging errosion on roadways.

**FEEDER PUMPS**

These are bigger and function as the main pumps on each level. Their principal task is to pump the water flow from their level to the mine's main pump. The locations of feeder pumps are only semi-permanent - they are moved as the mine is developed. Normally they must have static heads of up to 50 - 70 metres. In addition to water from the face and stage pumps, the feeder pumps also receive the contaminated water flowing by gravity through ditches on their level.

Submersible, heavy duty pumps of between 20 to 40 kW are now commonly used as feeders because they're portable, have a duty point between 50 - 70 metres, and are able to pump unsettled water. Feeder pumps should also be designed with a capacity for tandem operation. This is an important feature in modern mining, where vertical shafts are now frequently being replaced by ramps. In a modern mine lay-out total pump head is becoming more important than the static head. This means that the pumps selected must be flexible with regards to head requirements.

**STATIONARY SHAFT PUMPS**

These pumps are located at the bottom of mine shafts and must, therefore, be able to operate for long periods without attendance. Consequently, highly complex pumping systems are rarely used in this application. The features required for a shaft pump are the same as for a feeder pump, except for two points: First, the required pumping capacity is normally less for shaft than for feeder pumps. This is because most of the mine's drainage water has already been taken up in the pumping system before it can reach the shaft bottom. On the other hand it must be capable of dealing with a constant flow and high heads.

Secondly, a stationary shaft pump must be more of a sludge pump, because the water which accumulates at the bottom of shafts has a high solids content, 15%, or more, by volume. (Much of this comes from spillage from skip stations above the shaft bottom). In addition, this sludge often contains abrasive materials, such as sand and stones. Shaft pumps should therefore be equipped with a torque flow impeller and a pump housing of cast Ni-hard. Even with these features, however, effective pump operation requires that the shaft bottom be cleaned out at regular intervals.

**TEMPORARY SHAFT PUMPS**

When sinking mine shafts, the pumps used must be able to follow the work, pumping from different levels up to the surface. They also need to be tough and capable of handling abrasive water. A space saving "slim line" design is a further advantage. For these reasons, submersible pumps are becoming more popular here too (often offering the only solution). Temporary pump systems for shaft sinking usually consist of in-shaft pumps plus a temporary pump station. The static pump head for the in-shaft pump is normally not more than 40 - 50 metres. To reduce maintenace in such extremely tough conditions, frequent rotation of the pumps and a high level of back-up is necessary. For this reason the pump system chosen should have a high degree of flexibility allowing the pumps to be used both as in-shaft pumps, and in the temporary station.

**PUMPS IN EXPLOSIVE ATMOSPHERES**

In coal mining, as well as in many other industrial branches, combustible materials, which can form explosive gas, are present.

Accidental ignition of such explosive atmospheres, i.e., by a spark or an excessively hot surface, may cause an explosion which will endanger life and property.

Consequently a great deal of legislation and regulation relating to safety in mines now exists. With regard to electrical equipment, the first directive was issued in 1912 by the Association of Germany Electrical Engineers (VDE). This dealt with the use of electrical equipment in mines where a fire-damp hazard existed. Since then many countries have established their own national regulations. In 1975 the European Economic Community released a degree covering the use of electrical devices in explosive atmospheres.

Based on this, a joint standard valid in most of the European countries has been worked out and published by **CENELEC.**

Briefly, the point of these regulations is to try to prevent the occurance of mechanical and electrical sparks, electrical arcs and high temperature surfaces in connection with the use of electrical equipment in mines. These objectives can be achieved in the following ways:Mechanical sparks, generated by collision, friction etc., can be avoided by simply selecting "non-spark" material for manufacture of the product. Electrical arcs and sparks which may be generated inside the equipment must be contained through the use of closer tolerances and increased path lengths in the design of the motor casing parts. This must also be able to withstand the pressures from any possible explosion inside the equipment. To keep the temperature of exterior surfaces below the maximum permissible temperature, the equipment should be manufactured from appropriate materials and designed to have good heat transfer characteristics.

Since the of the 1960's approved explosion-proof, submersible pumps for the coal mining industry have been available and today almost all sizes of standard submersible pumps are available in versions which conform to the European norm **(EN)** and a variety of national standards. Tens of thousand of submersible pumps of this type have now been delivered to coal mines worldwide.

## PUMPS IN OPEN-PIT MINES

The superiority of submersible pumps for the dewatering of open-pit mines is now well established. They are used in two main types of configuration, depending on the layout of the mine and the local conditions regarding ground-water and the prevailing rainfall.

In fairly flat and level mines covering an extensive area, a number of small and/or medium sized submersible pumps can be installed in simple pumping stations or sumps. These, normally need consist of no more than a pit or a natural cave. A prefabricated, perforated concrete pipe is sometimes necessary, when wall support is required. These pumps then convey the water to a main pumping station which removes it from the mine. This main station and its pumps are normally of the same type and design as those in the surrounding stations, just, of course, larger.

In deeper mines with relatively moderate lateral expansion (small bottom diameter) it is normally preferable to install all the pumping capacity at one location. In open-pit mines where the water inflow is both highly irregular, and potentially very large, submersible pumps can be installed on rafts that rise and fall with the level of the water.

Because wear-resistant submersible pumps with large head capacities (300-350m) are now available, water can often be pumped out of a mine in a single stage. Where this is not possible, an intermediate pumping station must be established.

A submersible or non-submersible booster pump can be used here. However, non-submersible pumps must be adequately protected in tough climates and installed high enough to avoid being flooded. Cases of flooding have actually occurred, with costly consequences, in regions with periods of heavy rainfall.

## SUBMERSIBLE MIXERS IN MINING OPERATIONS

Submersible technology for mining has now also been extended to mixers, for solid suspension and blending applications. The systems available consist of integrated submersible electric motors, propellers and guide bars.

One of the key advantages with this new mixer system is that the mixer can be adjusted after installation. This means that "fine-tuning" can be carried out after operations have started to ensure that required results are obtained. Submersible mixing systems also provide great flexibility: They can be installed in all types of tanks, irrespective of volume and shape. In addition, since the mixer is submerged, it is almost completely silent.

This new mixing concept has been very successfully employed in a new, cost-cutting mixer application; the re-suspension of material accumulated in settling basins or storage tanks in order to facilitate pumping. Sediment in these tanks has been a common problem for pumping operations: The sediment either blocks the pump inlet or, because of its high density, causes excessive wear on the pump. Various methods of keeping the sediment in suspension have been employed, the most common being the use of compressed air. This method, however, is both costly and not very effective. With a submersible mixer, on the hand, it is easy to achieve the complete and uniform mixing, which is important for the efficient operation of pumps, at a much lower cost.

## RESUSPENSION OF LAGOONS

Submersible mixers and pumps can now also be used in a highly cost-effective combination to empty and clean-up sludge lagoons.

The cost of disposing of waste material from mining operations has tended to increase. This has been the result of both increased safety and ecological awareness, and of the development of more complex mineral processing techniques, e.g., the exploitation of lower-grade ores, etc. The cost of waste material handling has become a major factor in many mining operations.

Sludge deposit lagoons have to be cleaned up for two main reasons; environmental regulations, and reutilization of the lagoon. Cleaning the lagoons often presents big problems because of the nature of the material: The physical properties of "tailing sludge" in mining operations can vary a lot. The water content may be anything from 15-20% up to 80-85%, by weight.

Generally speaking, this material never dries out and usually has a quite plastic (tixo-tropic) form, capable of flowing. The use of conventional equipment for this operation is time-consuming, difficult and expensive. Now, however, a submersible mixer and a heavy duty submersible pump mounted on a raft can be used in this application. This combination has shown a very good performance and is technically superior, compared to more regular equipment such as drag-lines, front-end loaders etc. In addition the investment cost of the equipment is considerably lower.

## 45 YEARS OF SUBMERSIBLE TECHNOLOGY IN MINES

1993 has marked the 40 anniversary of the advent of the heavy-duty, submersible pump. Its areas of application in mine drainage have expanded progressively during these four decades: Early in the period submersible pumps were merely a peripheral part of mine drainage systems, used in applications such as face and wall drainage. Then they were used for pumping from level to level and shaft to shaft. Now submersible pumps with a head capacity of 300m are available for use as main pumps in mines.

Although newer than the submersible pump, it's possible to detect a similar pattern in the development emerging for the submersible technology is capable of supplying the safe, optimal solution to all the drainage requirements of modern mines.

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