Pumps for Operation in Mines

by Dr.-Ing. Paul Uwe Thamsen (Pleuger Worthington GmbH)

Abstract:

The paper deals with some different applications of submersible pumps in mines. Some mining companys, nowadays, prefer smaller single suction pumps running at two pole speed instead of larger double suction pumps running mostly at four pole speed. The main advantages are lower investment costs and lower operation costs which reduce the overall costs for each cubic metre of water to be pumped.

\- - - - - -

Often the volume of water from the mine is higher than the tonnage of the product extracted. For example, in some open pit mines up to 16 m^3 of water have to be pumped to get one ton of coal. Increasing maximum depths of mines require an economic system for dewatering.
On the other hand, the reliability of the pump units is important because the safety of personnel and machinery depends on it.

Submersible pumps are more and more used for dewatering of open pit mines as well as of underground mines. Figure 1 shows different installations of submersible pumps for mine drainage.

The main advantage of using submersible pumps in mines is the simple and low cost installation. A normal tube well, which ends into a sump for gathering the water, is sufficient. Therefore, no pumping stations with expensive installations such as ventilation shafts, watertight doors etc. are necessary.
A further advantage of using submersible pumps is that there are no priming problems as the pump is always submerged, which is additionally an important safety aspect in the event of a sudden break-in of water.

For many years, the mining industry preferred a small number of very large pumps of up to more than 1500 kW rated power. These pumps are normally designed as double suction pumps running at four pole speed.
Nowadays, mining companys use more and more single suction pumps running at two pole speed. The reasons are the reduced dimensions and weights and the easier handling of the smaller units. This is an important fact in the case of limited operation time intervalls by clogging with ochre or other deposits.
In many cases, the efficiency of a two pole pump is as high as for the larger four pole units due to the higher specific speed of the single flow pumps.

Pleuger Worthington mining pumps are based on standard pumps by modifications especially in view of material to meet the requirements of the working conditions in the mine. A typical submersible pump for mining application is shown in figure 2.

This pump is one of a project in Australia, where they are dewatering an old underground gold mine. This mine has been closed down because of the lack of pump technology and newly developed gold recovering techniques only now make this project economic.

The pumping challenge was difficult because the mine operators needed an early high capacity pumping rate in order to examine the upper levels of the underground mine and to determine the water infiltration rate. The greater difficulty, however, was to come up with economic pumping from depths of 650-750 metres.

The difficulties of the pump installation were solved in two steps:

Step 1: Two pumps were initially operated in parallel on separate pipe lines to the surface delivering a high flow rate of approximately 800 m^3/h at about 270 m pumping head.

Step 2: The two pumps were then converted to in-line series operation using a high strength booster casing (see figure 1). At the in-line series installation the pump units deliver a flow rate of approximately 350 m^3/h at a total head of about 750 m.

Design work for the in-line series installation covered many areas such as:

- voltage drop in the 750 metres long power line
- structural design of the booster case and pipe work to support the total weight of the pumpset with its pipework
- hydraulic studies of water hammer in the riser pipe
- electric control to ensure that the bottom pump started first and then the intermediate pump only when the water reached the intermediate level.

Submersible pumps provided for operation in mines require a high standard of reliability. Therefore, the pumps have to be designed for the rough environment in mines. The water often contains solids like slack or stone dust. Water temperature and specific weight are often above normal values. In many cases the water is aggressive.

To ensure a sufficient time of operation for the pump it is necessary to design all parts exposed to the medium being pumped accordingly and to select the best suitable material.
The material to be selected in dependence on the aggressiveness of the pumping medium is shown in figure 3.

High temperature applications are possible with special motor cooling systems:

Temperatures up to 35°C require a submersible motor with an internal cooling circuit. A small impeller fitted to the motor shaft provides an internal forced circulation, which transfers the heat from the inner parts like windings and bearings to the cold outside wall of the motor.

For temperatures up to 45°C it is necessary to fit a shroud over the motor in order to induces an increased flow upwards over the motor surface. The higher flow velocity in the small gap between shroud and motor assures sufficient cooling conditions.

For temperatures up to 65°C, Pleuger Worthington has designed a riser pipe cooling device, shown in figure 4. Some sections of the riser pipes are of double-walled pipe. The warm cooling water of the motor flows against the pumping direction with a sufficient heat exchange to the colder pumping medium in the inner part of the riser pipe.
A further advantage of using a riser pipe cooling device is that this system works independent of any sedimentations at the motor surface.

One of the key parts of the submersible motor is the thrust bearing. The thrust bearing has to carry the hydraulic thrust in addition to the combined weight of pump and motor rotating elements.
As a result of consequent development, Pleuger Worthington designed a new so-called fixed pad thrust bearing, shown in figure 5.
The main advantage of the fixed pad thrust bearing is the exact finish machining of the height of the pads. In comparison with the Michell type thrust bearing, which consists of more than 30 parts, the fixed pad type provides a higher degree of reliability. Load tests at the Pleuger test rig for thrust bearings demonstrated that fixed pad thrust bearings could carry the same loads as the Michell type ones.

<u>Conclusion:</u>

As a result of development, the economic working range of two pole single flow submersible pumps can be extended up to 900 kW rated power without reducing the reliability of the pump units. The lower price of the pump unit and lower costs for the installation and maintenance of submersible pumps reduce the overall costs for each cubic metre water to be pumped.
Therefore, the submersible pump unit with the 'wet' motor is a recommendable solution for mining applications.

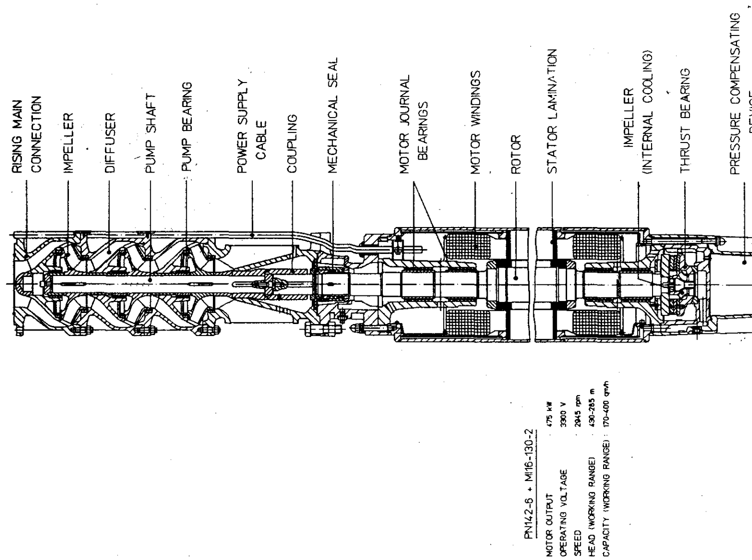

FIG. 2: MINE DRAINAGE SUBMERSIBLE PUMP

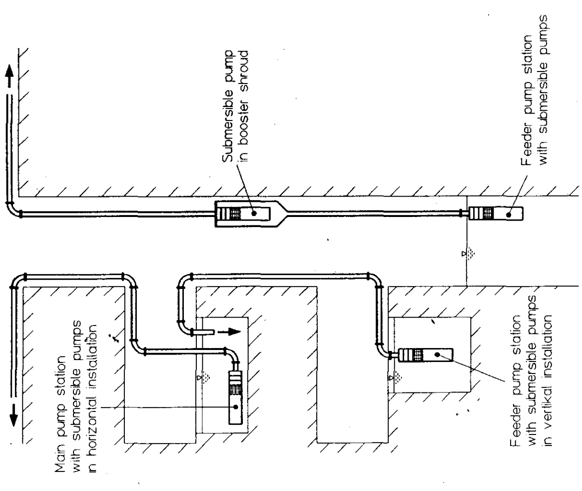

FIG. 1: DIFFERENT SUBMERSIBLE PUMPS INSTALLATIONS IN MINES

Quality of Water	Properties of Water	Selection of Material
not aggressive	pH-value and carbonate hardness in balance or max. 0.2 less than equilibrium curve aggressive CO_2 up to 10 mg/l and electrical conductivity up to 500 microS/cm chloride Cl' < 150 mg/l nitrate NO_3' < 40 mg/l sulphate SO_4'' < 250 mg/l	Pump: cast iron (GG-20); plastic for impellers and diffusors Motor: cast iron (GG-20); steel
slightly aggressive	pH-value more than 0.2 below equilibrium curve aggressive CO_2 > 10 mg/l up to 500 mg/l electrical conductivity > 500 up to 1000 microS/cm chloride Cl' < 150 mg/l nitrate NO_3' < 40 mg/l sulphate SO_4'' < 250 mg/l	Pump: gun metal (G-CuSn5(7)ZnPb) Motor: chromium steel (Cr-st 1.4301); zincfree bronze (G-CuSn10(12))
very aggressive	aggressive CO_2 > 500 mg/l up to 1000 mg/l	Pump: zincfree bronze (G-CuSn10(12)); Motor: chromium steel (Cr-st 1.4301); zincfree bronze (G-CuSn10(12))
	electrical conductivity > 1000 mg/l microS/cm total dissolved solid > 500 mg/l (minus calcium and/or magnesium carbonate) chloride Cl' > 150 mg/l nitrate NO_3' > 40 mg/l sulphate SO_4'' > 250 mg/l mineral water (salt content > 1 g/l) brine (salt content > 15 g/l and temperature up to 35° C) seawater (temperature up to 35° C) humic acids	Pump: zincfree bronze (G-CuSn10(12)) Motor: chromium steel (Cr-st 1.4301); zincfree bronze (G-CuSn10(12))
	strong acids (phosphoric, nitric, hydrochloric, sulphuric acid) pH-value < 4 ammonia NH_3 ammonium NH_4 sulphur S sulphide S'' hydrogen sulphide H_2S brine (salt content > 15 g/l and temperature more than 35° C) seawater (temperature more than 35° C)	Special material selection for pump and motor: castings in nickel aluminium bronze; chromium steel or Niresist; duplex stainless steel

FIG. 3: GUIDE TO SELECTION OF MATERIAL DEPENDENT ON QUALITY OF WATER

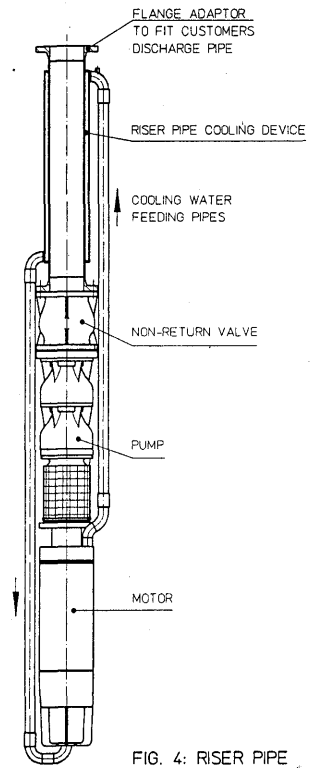

FIG. 4: RISER PIPE COOLING DEVICE

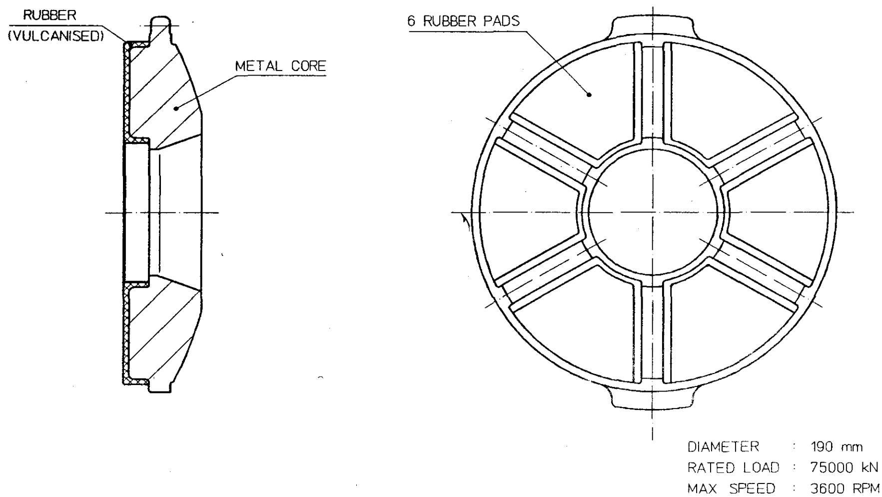

FIG. 5: FIXED PADS AXIAL THRUST BEARING