DEWATERING WELLS WITH MOYNO PUMPS - A NEW TECHNOLOGIC ISSUE IN MINE DEWATERING

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ABSTRACT

In the Velenje Colliery, hanging wall and foot wall dewatering has been a technologic must since early sixties. The waters in the dewatered Pliocene multi-aquifer system are containing some methane and a considerable quantity of dissolved carbon dioxide, which are being liberated with the pressure drop.

Historically, various types of dewatering wells were either applied or tested. First, rather thin diameter boreholes were used to drop the water from the hanging wall aquifers into the mine.

Second to this, an attempt was made to pump this water directly to the surface and to apply large diameter wells, similar to those introduced by Rhein Braun Kohle, equipped with submergible pumps. Due to a liberation of carbon dioxide, this attempt failed completely, with cavitation destroying the pumps within a couple of months.

After such failure, wells of a somewhat more refined design and construction were again applied to drop the water into the mine.

Recent developments in Moyno pumps technology have enabled us to test these pumps in the above described rough conditions, requiring a 500 m water rise and a 5-10 l/s pumping rate, and to pump the water to the surface. During the installation and testing of the well-pump system, we solved a series of problems involved with such an installation and are now happy to conduct a long duration test of the Moyno pumps performance.

So far, we can conclude that the system, if properly designed, assembled and installed is a quite performing one and that, as yet, no cavitation problems were observed. We therefore believe that it will enable us to dewater cost-effectively both the hanging wall and the bottom wall aquifers and to liberate the Velenje Colliery of costs and nuisances inherent to wells dropping the hanging wall aquifer water to be pumped to the surface first into the mine.

INTRODUCTION

The results of studies dedicated to solve the problem of safe mining under the hanging wall aquifers in the Velenje Colliery showed that a depressurization of the hanging wall aquifers above the long wall production areas, with sublevel caving as production method, is necessary to provide the required safety conditions [1]. It was found that by dewatering the bottom 100-150 m of the multi-aquifer hanging wall strata, the required safety is achieved. Within these aquifers, most of the dewatering effect can be achieved through preliminary dewatering by wells drilled from the surface and situated on the rim of the planned production area, especially in the lower parts of the synclinal structure [2]. However, due to a rather low permeability of the lowest hanging wall aquifers, an additional depressurization over the production fields has to be subsequently achieved by the in-mine dewatering boreholes drilled from the workings of the colliery [2,3].

Past attempts to pump the water from the hanging wall aquifers onto the surface had failed for various technologic reasons. Actually, the wells drilled from the surface are connected through the dewatering galleries and pipelines to the main pumping station of the colliery. They are dropping the water from the hanging wall aquifers into the colliery and this water is subsequently pumped to the surface.

Maintenance costs of the dewatering galleries and of the in-mine connecting structures of the wells are quite important. Besides, by their positions relative to the existing coal reserves, these wells are within their protection pillars restraining substantial coal reserves from production.

The above reasons are driving the Velenje Colliery to search for new technical and technological solutions which would enable it to attain sufficient dewatering without restraining its coal reserves from production. Among these, the offset dewatering wells, equipped with Moyno pumps and pumping the water directly to the surface, appear as a very viable solution. For this reason they were recently tested for performance. According to our information, wells equipped with Moyno pumps were until now used in the coal industry only for methane producing purposes [4]. We therefore consider that an information on their observed dewatering performance might be of a general interest.

HYDROGEOLOGICAL CONDITIONS

Structural setting

Velenje Colliery is excavating a lignite seam, spreading within the Southeast - Northwest or Dinaric oriented Šalek Valley in central Slovenia. It is situated nearly entirely in the southwestern part of the Šalek Valley, known as the Velenje graben structure. The lignite seam is 8.5 km long, 2.5 km wide and is elongated along the axis of this graben structure. It has the form of a concave lens, reaching in its deepest part a productive thickness of up to 165 m. With low quality lignite included, the lens thickness is reaching close to 220 m and representing the world second thickest coal seam known.

The Velenje graben structure is filled with Quaternary and Pliocene clastites, whose basement is made from Tertiary and Mesozoic strata. In the central part of the graben structure, the overall thickness of Quaternary and Pliocene strata may reach 1200 metres, with coal seam being covered by as much as 450 metres of hanging wall Pliocene and Quaternary strata.

Hydrogeologically, the Pliocene and the Quaternary hanging wall strata represent a very complex multi-aquifer system, formed of clastic fan deposits that facially border and locally alternate with marshy and lacustrine deposits. Lateral and vertical permeability variations are both pronounced and irregular and it is virtually impossible to follow an individual sand or gravel strip aquifer over a greater area. However, it was possible to delimitate aquifer systems which behave similarly enough to be assimilated to a single aquifer. Mean permeability values of these aquifers lie between 5×10^{-5} and 5×10^{-7} m/s. Hydrogeologically strictly speaking, the later should better be considered as magazine rocks and not as aquifers. Yet, in the underground mining, a proven water and mud inrush risk potential of such water bearing rocks imposes their cautious dewatering and therefore their practical consideration as of aquifers.

Effects of past dewatering

Paka river represents the hydrological base level of Šalek Valley. In natural hydrological conditions, still undisturbed by mining, were Paka and her tributaries Sopota, Velunja, Bečovnica and Toplica draining surface and ground waters from this area. Except for the outcropping and shallow parts of the fissured and karstic carbonate aquifers, was the natural groundwater flow in most of the deep-seated Quaternary, Pliocene or Triassic aquifers very slow.

Past dewatering has differentiated ground water levels in the hanging wall aquifers. The near-surface, very little affected, Quaternary multi-aquifer system is reaching maximum depths of 150-250 metres. The underlying Pliocene series could be subdivided in three multi-aquifer systems. Of these the bottom two, PL1 and PL2, constitute a 100-150 metres thick layer above the coal seam and are dewatered into the mine through the surface drilled wells.

Groundwater levels, which were in the valleys originally artesian and exceeding an absolute level of 380 metres are now lowered to absolute levels close to 200 metres and will be in the vicinity of the wells further lowered to an absolute level of 30 metres only. With wells openings situated at absolute levels 400-500 m, the working heads of the implemented pumps have to exceed 500 metres.

Hydrogeochemical data

Slow natural flow of groundwater within the Pliocene strata, coupled with large quantities of coal seam emanating CO_2, led to the formation of a very pronounced hydrogeochemical aureola around the Velenje lignite seam. Due to this aureola, the water mineralization in the Pliocene aquifers above the lignite seam and in the Miocene and part of the Triassic aquifers below the lignite seam is very elevated. Some of the Pliocene and Miocene aquifers may contain free methane and liberate CO_2 when depressurized (5).

The waters in Pliocene aquifers are of the Na-Mg-Ca-Hydrogencarbonate type, with the mineralisation close to the coal seam reaching up to 5000 mg/l. However, the mean mineralisation of the waters that are dewatered through the active dewatering wells is not exceeding 2000 mg/l.

Measurements done in the year 1987 have shown that in the centre of the graben structure, the well mouth shut-in gas pressures during the dewatering were between 2 and 10 bars. This indicates, that the lower gas liberation limits in the wells were situated 70 to 170 m's below the water levels in the wells. Therefore, if we wanted to prevent carbon dioxide from being liberated from the pumped water, we should either apply well mouth pressures exceeding 7 bars, or install a Moyno pump coupled gas anchor into the well as an alternative. We opted for the first solution.

PAST DEWATERING WELL TECHNOLOGY

Historically, various types of dewatering wells were either applied or tested. First, rather thin diameter boreholes were used to drop the water from the hanging wall aquifers into the mine. Wells were of simple construction and were connected through narrow well access galleries. No major connection problems were reported, but the wells did not last very long and were not very productive.

Second to this, an attempt was made to pump this water directly to the surface and to apply large diameter wells, similar to those introduced by Rhein Braun Kohle and equipped with submergible pumps. With these wells some major construction, casing quality and installation problems occurred, which were preventing any further implementation of such wells. Yet, the biggest problems were related to the submersible pumps. Due to a liberation of carbon dioxide, a subsequent cavitation destroyed the pumps within a couple of months and made their application totally uneconomic. We believe, however, that a proper depth of pump submergence and an excess well mouth shut-in pressure might have reduced these problems. But it cannot be claimed that this would lead to an efficient application of these pumps.

After such a failure, wells of a somewhat more refined design and construction were again applied to drop the water into the mine. The wells were equipped with a compensator situated at the top of the screened section. The compensator should compensate for overburden subsidence due to the multi-aquifer system dewatering related intrinsic consolidation of such system. It should prevent the screened part of the well from being overloaded by subsided overburden strata. In its bottom part, the well is equipped with a telescope, allowing for small axial displacements due to an in-mine well access gallery excavation. Unfortunately, all to often these displacements do not follow the well axis and the telescope gets damaged by transverse deformation or shear. This is leading to considerable repairing costs. These wells are otherwise hydraulically quite performing and can be with this respect their construction properties maintained.

TEST WELL WITH MOYNO PUMP

Recent developments in Moyno pumps technology have enabled us to test these pumps in the above described rough conditions, requiring a 500 m water rise and a pumping rate of 5-6 l/sec, and to pump the water to the surface. During the installation and testing of the well-pump system, we solved some of the problems involved with such an installation and are now happy to conduct a long duration test of the Moyno pump's performance.

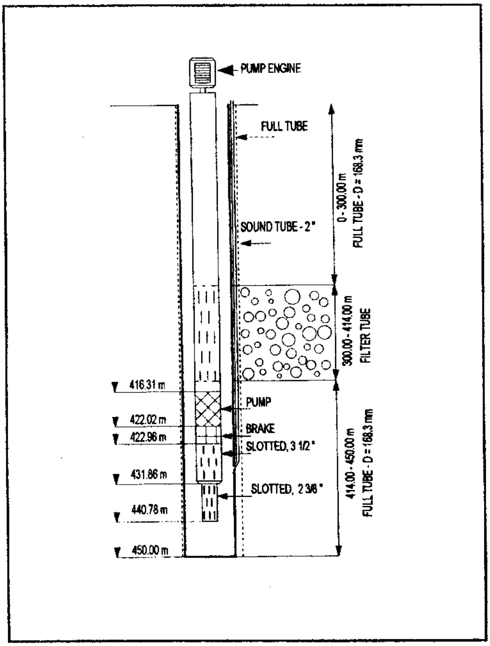

Figure 1: Schematic cross section of well BV-23

Test well design parameters

Test well BV-23 is constructed similarly to the other dewatering wells, but without the telescopic junction to the in-mine dewatering system. Test well is 450 m deep and is tapping ca 45 m of variably permeable sandy layers. Screens are of welded wedge wire type and due to the water quality made, as well as the casing, of Φ168.3 mm AISI 304 stainless steel. Initial absolute water level was at 190 m and was planned to be lowered to the level 30 m. The expected well discharge was planned on other wells discharge basis to be in the 2.50-5.0 l/sec range and was foreseen to diminish with the time of pumping. The expected well mouth shut-in pressure was to be 7 bars.

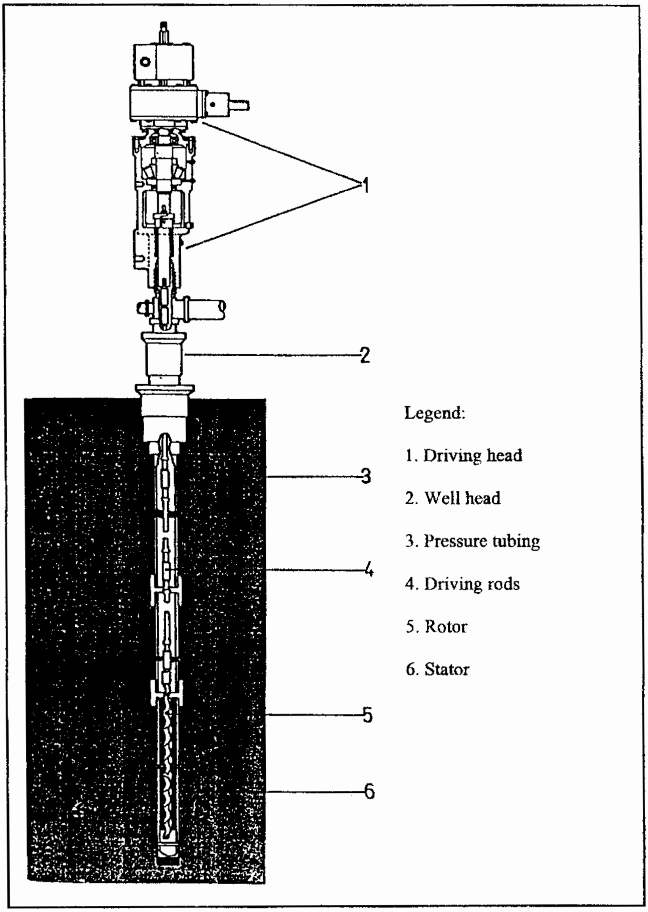

Figure 2: Moyno pump installation scheme

Moyno pump design parameters

Moyno pump design parameters were selected with the help of the "PETROLE" computer programme, designed by PCM POMPES. The planned depth of pump installation was 440 m's, with 20 m submergence relative to the planned dynamic water level. The calculated pump capacity was 2.5-5.0 l/sec, the total maximum pressure loss 42.5 bars and the designed pumps motor power 44.8 kW. On this basis a type 600TP600 PCM POMPES Moyno pump was selected as appropriate.

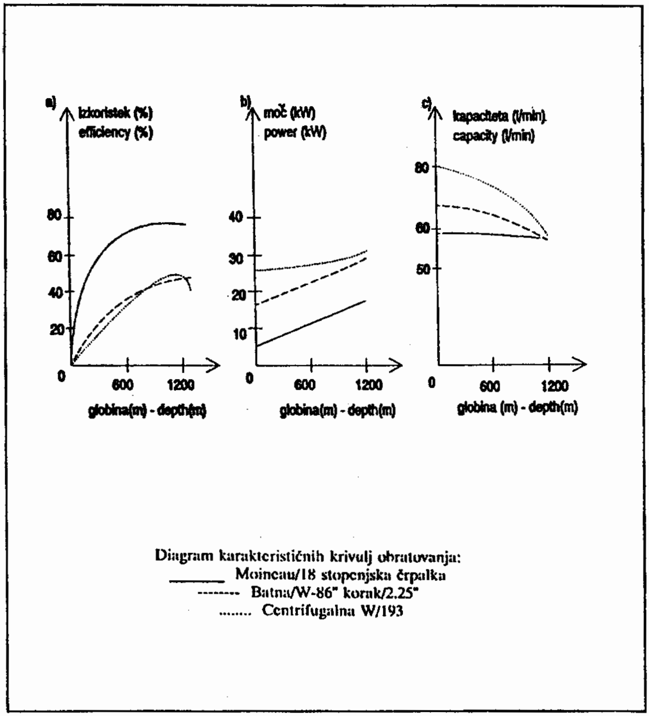

Figure 3: Characteristic performance diagrams

Preliminary results

Due to some pump assembling mistakes, the pump was functioning erroneously for several months. Finally, these problems were solved and since than, the pump and the well are performing as expected. Breaks in pumping due to pump reassembling are seen from the corresponding diagram in Figure 4. In the last months the pump is functioning correctly and is constantly inspected (6).

The pumped water rate before pump reassembling was of the order of less than 3.0 l/sec. Since then, it has risen to the planned level. The observed gas liberation is lower than indicated from the old data. This may be due to the fact that the well is offset with respect to the productive coal seam. As expected, no cavitation has as yet been observed. The well was sand free and the resistance towards the solids could not be tested. It is felt, however, that it should be high due to the low rotational speed of the pump.

The well construction cost is 25% less than the standard one since no junction to the mine is necessary. The pump installation costs are 40% higher than with classical submergible pumps, but as seen from the diagrams in Figure 3, the working costs are 30% lower. Although the maintenance cost may involve occasional changes in the rubber stator of the Moyno pump (not exceeding 2% of the pump installation costs), this is with time leading to a substantial financial gain also with usual mine dewatering wells where no well mine junction elimination related cost reduction can be expected.

In the specific case of the Velenje Colliery, the biggest financial gains are expected from the additional coal reserves liberation and from the in-mine dewatering system maintenance costs reduction.

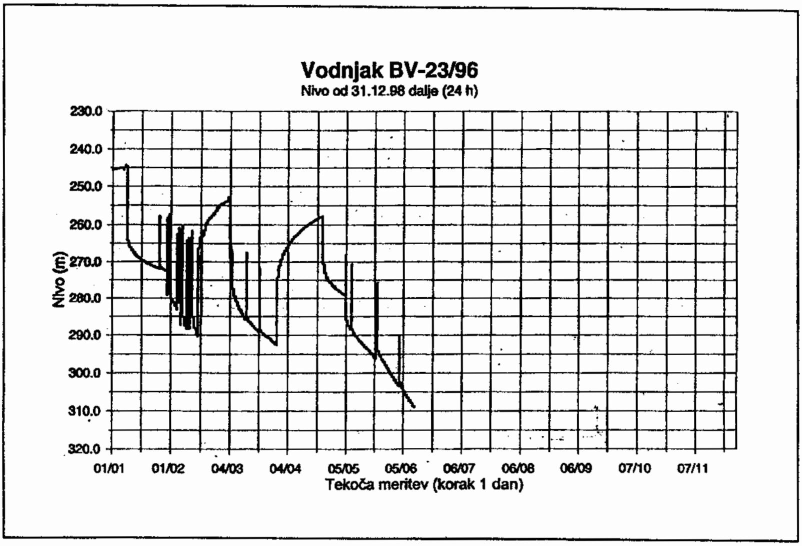

Figure 4: Diagram of test pumping

CONCLUSIONS

So far, we can conclude that the system, if properly designed, assembled and installed is a quite performing one. As no cavitation problems were observed, we believe that it will enable us to dewater both hanging wall and bottom wall aquifers cost-effectively and liberate the Velenje Colliery of costs and nuisances inherent to wells that drop the dewatered hanging wall aquifers water first into the mine and let the central mine pumping station do the work of pumping it to the surface.

The well construction with no mine junction is 25% less than the actually standard one. The pump installation costs are higher than with classical submergible pumps, but the working costs are 30% lower, which is with time leading to a substantial gain. We believe that this is an important indication for all cases, where gas liberation and sand inflow are causing or might cause severe submergible pump wear or damages, even when the applied standard dewatering well construction does not involve an extra cost reduction due to an elimination of the well mine dewatering system junction.

Acknowledgement
We thank the Velenje Colliery for their allowance to publish these results and make it therefore open to the general scientific and mining community.

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