Pneumatic Sludge Pump Re-Design for Performance Enhancement in the Conditions of Bogala Mines

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Abstract: Bogala Graphite mine is one of the well known high grade underground graphite mine in the world. Dewatering is one of the major lost component in the mine. Diesel or electric pumps can not be used in underground mines such as in the case of Bogala due to safety issues. In such conditions, a reliable and economical sludge pump for underground mining operations is a prime necesscity. In this study it has been subjected to analyse underground dewatering process, available solutions for associated problems and selected types of pneumatic sludge pumps. A mathematical model was developed to explain the pump mechanism and a pump was re-designed. A cost analysis was carried out to find out the financial feasibility and the design was changed according to the available technology. Sand casting method was used to produce pump head. Other parts were produced according to feasible and cost effective methods. Performance evaluation was duly carried out using redesigned pump. Maximum efficiency and the maximum pump head were observed at inlet pressure of 20 psi. Problems and other issues were identified and with the results of the performance evaluation, pump design was developed. Finally we could conclude that we can fabricate the pump economically, by locally available technologies. In this paper, pump design, production and performance evaluation process and other associated problems which arose throughout were analysed.

Keywords: dewatering, pneumatic, sludge, winzing

1. Introduction

In the mining industry, water is associated with various types of activities. Huge amount of water is used for mining (alluvial mining, hydraulic mining, etc.) activities themselves, that is flushing medium for drilling, human consumption, dust control, mineral processing (wet processing- crushing, screening, separation, froth floatation etc) activities and for other mining related activities. Dewatering can be carried out either using manual water lifting

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devices or using animal powered (scoops, buckets, Archimedean screws, water wheels etc.) or by means of pumps with power sources, such as electricity, pneumatic, etc. Most suitable way for dewatering is by using the pumps, specially in underground mines where higher lifting head and efficiency is required. Among pumps, pneumatic sludge pumps are more preferred for dewatering specially in underground wet and water environments where small space is available for installation, handling and non use of electricity. These pumps do not contain impellers and much prefer for handling thicker slurries which lead to wear of impellers in normal (centrifugal etc.) pumps. So the major objective of the research is designing and fabricating a durable, economical pneumatic sludge pump locally for underground mining activities.

2. Material and Methods

As the first part of our research project we gathered information which relates to the area of study. Discarded sludge pump was brought to the university laboratory from Bogala mine.

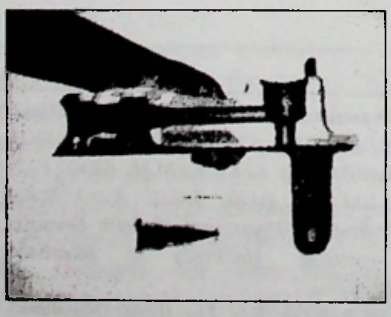

Figure1: Pump head cross section

Reverse engineering was carried out to identify the parts and mechanism including the valves and other parts which have been used to control the air flows and the material used to fabricate pump (**Figure 1**). A mathematical model was developed to analyse the pressure variations, flow rates. Pump parts were designed to get the maximum efficiency and with aid drawing were done using critical soft ware (**Figure 2**). The designing part of the pump was carried out under this session.

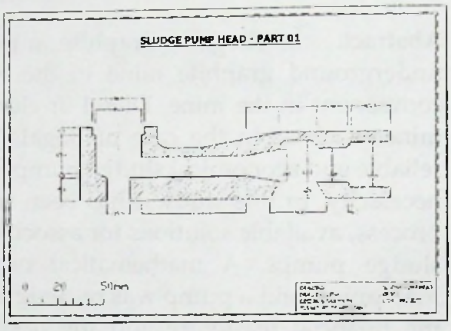

Figure 2: Pump head drawing

The design was changed according to the available production technology with via reduce the production cost. A cost analysis and a feasibility study were carried out before the fabrication work according to our design. In accordance with the results of the cost analysis and the gathered information, the production plan was developed. The production plan had to be fin tuned in order to make it cost effective. All operations were closely monitored to achieve the objectives. Sludge pump was installed in Bogala graphite mine followed by a performance evaluation. Pump head variations were observed with the inlet pneumatic pressure variation and the pump efficiency also measured with the variation of the inlet pressure. Fluid pumping rates were calculated with the variation of inlet pressure and fluid type. Finally new sludge pump design was developed with the positive performance evaluation.

3. Results

A mathematical model was developed to explain the mechanism of the pump.

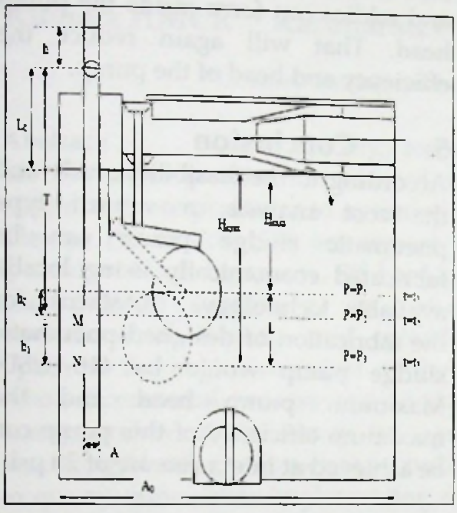

Figure 3: Pump mechanism

Maximum pump head: Hdis

Hdis =
[P inlet -{(T+ h1) ρwg+π}]/ρwg.....(1)

T - Cycle time
ρw - Density of water
g - Acceleration of gravity

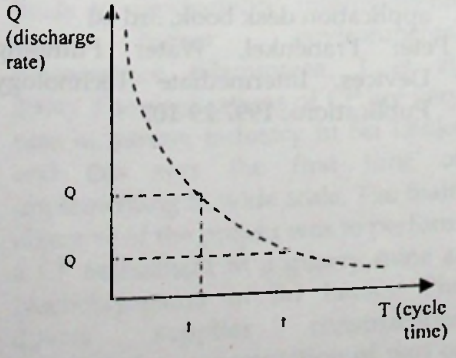

Figure 4: Pressure variations in a cycle

Results of the performance evaluation

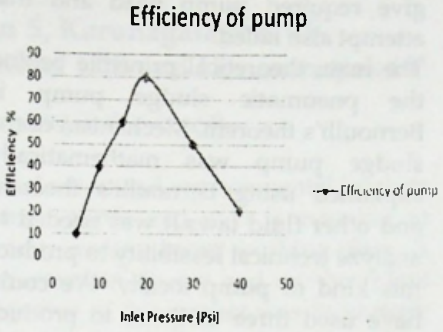

Figure 5: Pump efficiency variations

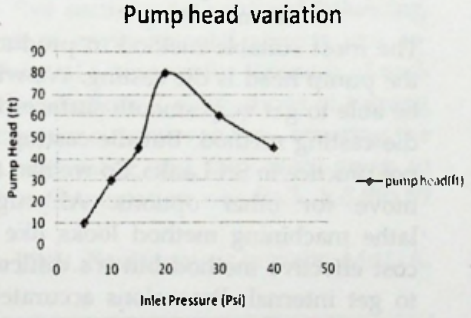

Figure 6: Pump head variation

Maximum efficiency and the maximum pump head was observed at inlet pressure of 20 psi

4. Discussion

We considered that the most suitable pneumatic pump type for underground applications is pneumatic venturi type pumps since they are durable compared to other pneumatic pumps like diaphragm or piston pumps. Therefore, this in this study we mainly focussed on pneumatic venturi pumps and the Holman MK ii ejector type was used for our research. By the time we started our research project, Bogala work shop had tried to reproduce this pump and they had failed. Then they

had sent all the details of this pump to Germany to get produced this pump. German pump head was unable to give required pump head and that attempt also failed.

The main theoretical principle behind the pneumatic sludge pump is Bernoulli's theorem. Mechanism of the sludge pump was mathematically explained using Bernoulli's theorem and other fluid laws.It was needed to analyze technical feasibility to produce this kind of pump locally. We could have used three methods to produce this pump head. Those are;

Die casting
Sand casing
Lathe machining

The most suitable method to produce the pump head is die casting. We will be able to get very smooth surfaces in die casting method. But die casting is not practice in Sri Lanka. So we had to move for other options. Although lathe machining method looks like a cost effective method but it's difficult to get internal dimensions accurately in boring. Then we moved to sand casting method.

Usually sand casting products have rough surfaces. But we wanted to get all internal surfaces which are very smooth. Otherwise that could make a considerable head loss of the pump. But we decided to sand cast with special care by using graphite dust to get smooth surfaces. Wooden pattern and moulds .were prepared by us to make sure the dimensions are correct.

Performance evaluation was performed by changing the inlet air pressure. Though it's needed to measure the pump head variation with the cross sectional area of the pump head, it was not possible to carry out practically. Pressure inside the pump vessel is increased with the inlet pressure at the time of lifting water inside the vessel and the high vacuum is created during suction time. Because of this reason pump efficiency and the pump head increase with inlet pressure (**Figure 5, 6**). But under high pressure condition turbulent air flows and eddies can form inside the pump head. That will again reduce the efficiency and head of the pump.

5. Conclusion

According to the feasibility study and the cost analysis, a venturi type pneumatic sludge pump can be fabricated economically using locally available technology. Total cost for the fabrication of designed pneumatic sludge pump would be 410 USD. Maximum pump head and the maximum efficiency of this pump can be achieved at inlet pressure of 20 psi.

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