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On lifetime costs of flotation operations

Antti Rinne, Aleksi Peltola *

Outotec, Riihitontuntie 7, P.O. Box 84, Espoo, Finland

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ABSTRACT

Overall economy of a flotation operation bears much more than investment costs. The lifetime operation and maintenance of a flotation machine may affect the economy of a project far more than a million saved in investment.

Studying the long-term effects on investments is worthwhile as they often surpass any apparent savings in capital expenditure. The optimal solution does not even need to be more expensive. Besides, with high operating costs, time is never on one's side.

In the paper various flotation cell arrangements are compared in a simplified example. The example considers capital equipment investment costs, power delivery arrangements, energy costs, and maintenance costs throughout a 25-year ownership. Also effects on CO_2 emissions are discussed.

The paper will illustrate how proper choice of equipment and modern power delivery and control methods will result in significant benefits in lifetime costs and profitability of flotation operations.

1. Introduction

When an investment for a new flotation plant is evaluated, the emphasis is often in minimizing the capital expenditures. Until recently, life cycle cost (LCC) as a criterion for selecting beneficiation equipment has played only a small role in the final decision making. A quick analysis discussed below shows that roughly 60–80% of the total 25-year cycle costs for a large flotation machine are spent on energy while the initial investment comprises less than 10%. As a result, if a small saving in investment is achieved by compromising energy efficiency, it can quickly turn into big losses in operational costs. If one looks for savings in the long run, life cycle cost analysis shows that the importance of the investment cost is almost negligible.

Modern technology can offer completely new solutions for optimizing flotation processes both in terms of efficiency and metallurgy. Mechanical flotation machines have traditionally been limited by their relatively narrow range of aeration rate, fixed mechanism dimensions and speed. New flotation machine designs allow much wider adaptability with speed control, shear adjustment and wider range of air feed.

More attention should be paid on maintenance of critical components. Cases are known where significant metallurgical losses have been observed due to poor condition of critical wear parts.

This paper discusses the economy of flotation projects from the life cycle cost perspective. The examples have been calculated based on generic average values. There is a wide variation in costs between locations and specific processes, but averages give a good starting point to more specific analysis.

2. Life cycle costs of flotation operations

Life cycle cost analysis simply considers the lifetime operation and maintenance costs of a flotation operation in addition to the initial investment, in selecting the most economical equipment. It may be feasible to pay higher initial cost if one saves in operational expenditures.

The relevant cost factors for a flotation plant are investment, energy and reagent consumption, and maintenance. All these should be quantified for the estimated service life of the equipment. In order to illustrate the typical deviation of the relevant cost factors, typical ownership costs of a large mechanical flotation machine (100–200 m^3) are considered in brief.

In this consideration, the investment costs consist of merely equipment costs since the deviation in infrastructure, installation, and assembly is significant. Power draw of the equipment considers the power required for agitation and aeration. Maintenance proportion is determined by studying failure rates, costs, and normalized maintenance times of the wearing parts. Unit prices for maintenance services, electricity, and reagents are presented in Table 1. Typical total ownership costs over the time span of 25 years are presented in Fig. 1.

There is high variation in the cost factors; more specific results can be easily obtained by inserting the actual rates for electricity, reagents and labor as well as for the cost of capital in the calculation model. In order to achieve accurate costing, a sensitivity analysis should be performed to understand the relationships between

* Corresponding author. Tel.: +358 20 529 2772; fax: +358 20 529 2998.
E-mail address: aleksi.peltola@outotec.com (A. Peltola).

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Table 1
Average rates for electricity, reagents, and maintenance labor

Power draw	138.82	kW
Cost of electricity	0.06	€/kWh
Annual operating hours	8300.00	h
Cost of capital	10.00	%
Reagents	13,800.00	€/a
Hourly rate of maintenance services	50.00	€/a

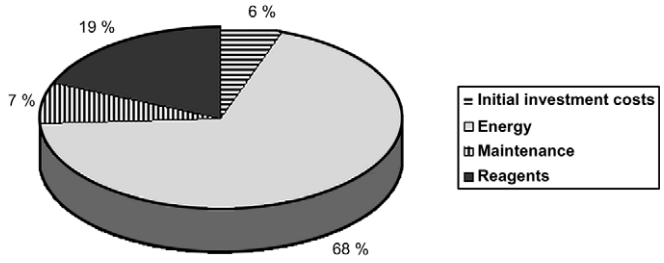

Fig. 1. Breakdown of a large flotation cell expenses over the lifespan of 25 years.

total ownership costs and uncertainties of each activity. That is, issues such as inflation rate, expected efficiency of resources, expected variation in energy costs etc. should be considered.

The breakdown strongly suggests that the most significant life cycle cost item in flotation operations is the cost of electricity. Thus the operational expenditures are heavily influenced by the energy price and the energy efficiency of the equipment used for production.

2.1. Capital expenditures

A given requirement for flotation capacity may be satisfied by several scenarios which may differ significantly in terms of required footprint, investment cost and required maintenance resources, etc. The most significant decisions concern the implemented unit size and the principle of operation of the equipment. In general, larger flotation cell units lead to lower investment, energy and maintenance costs as measured in unit price per unit of installed volume.

2.2. Operational expenditures

The operational costs of a flotation machine depend on the efficiency of the equipment. Process efficiency, energy efficiency and availability are discussed below.

2.2.1. Process efficiency

The key mechanical aspect for good flotation process efficiency is the proper condition of critical wear components. Missing rotor or stator parts make the cell surface wavy and cause the froth to collapse. Air dispersion is reduced and decreased pumping causes sanding. The use of copied spare parts has often caused problems (see Fig. 2). Experience has shown that non-standard spare parts often give a shorter wear life and in some cases decrease the metallurgical efficiency. The real savings that can be achieved by using worn out or low quality parts are negligible when compared to energy costs of the same equipment. If even small metallurgical losses occur because of poorly working equipment the savings in maintenance quickly become expenses. In order to obtain optimal availability performance it is safest to use only original equipment manufacturer's spare parts.

Comparisons of flotation operations using different technologies are published in two recent papers (Froehling et al., 2005; Coleman et al., 2006). These papers give a good view of the effect of metallurgical performance as well as maintenance aspects on overall economics. The first paper discusses of a retrofit from self-aspirated flotation cells to forced air TankCell® mixing technology which resulted in significant improvements in performance. The second paper compares Escondida's self-aspirated flotation cell circuit to the TankCell® circuit. The latter showed significantly better performance also in this comparison.

2.2.2. Energy efficiency

The traditional drive mechanism of a flotation machine consists of a single-staged V-belt drive connected to a low-speed induction motor. Theoretically the efficiency of the V-belt drive is 97–98% provided that the belts are optimally sized, properly aligned and tightened to correct belt tension. Unfortunately in practice this situation is rather rare and the actual efficiency is therefore lower. As the belts wear and stretch readjustments are required. This is often impossible without shutdown of the equipment, which, in turn, would result in reduced availability. Similar challenges occur also

Fig. 2. Pirate flotation cell mixer spare parts after two weeks of use.