BELT FILTER PRESS – FACT OR FICTION ?

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ABSTRACT

Over the last 10 years improvements in mechanical biosolids dewatering have been limited to incremental changes within a proven design. Belt presses have reviewed roller configurations and belt tension, centrifuges have focused upon differential speeds and beach angle, whilst filter frame presses still rely on cycle time and filtration pressure to achieve the desired performance.

In parallel, we have seen developments from the chemical suppliers with changes in flocculant structure and the method of application being the major reason for process improvements.

External to mechanical dewatering machines we have seen the advancement of hydrolysis and other high temperature and/or pressure systems that as a by product of cell lysis have enabled the release of previously entrapped water molecules. These processes often result in a biosolids structure that is more amenable to dewater albeit with a major capital cost impact.

However, the future is about to change. The adoption of electro kinetic geosynthetics (EKG) technology [1] to the dewatering of biosolids (and other materials) will allow the belt filter press to enter a new phase, achieving levels of performance previously thought impossible by conventional mechanical dewatering techniques

KEY WORDS

Belt Filter Press, Dewatering, Sewage Sludge, Electro Kinetic Geosynthetics.

INTRODUCTION TO THE BELT FILTER PREES

Misunderstood, misapplied, or simply misused, the belt filter press has often failed to win over sceptics who ‘tried it once’ didn’t like the experience and have never utilised the technology since. Yet despite these apparent misgivings the belt filter press does have a very successful track record in a number of process industries, especially in the dewatering of biomass sludge arising from the sewage treatment process and other industrial organic based sludges.

Originating in the 1970’s, the belt filter press is an offshoot from the pulp and paper industry where its ‘big brother’ is still in use today. Both possess frames, rollers and media fabric, but the paper machines operate at very high speeds producing a variety of valuable consumer products, whilst the belt filter press has found its home in the dewatering of low value waste sludge.

Over the last 30 years, the belt filter press has changed its appearance numerous times, although in essence it has remained functionally the same; conditioning, draining and squeezing its feedstock to produce a friable stable low solids cake for subsequent treatment and/or ultimate disposal. Early versions were simple drainage bands where a lower porous filter media drained and supported the flocculated sludge, whilst an upper non-porous belt applied compaction. (Fig 1) Cake solids and throughput were low, but suddenly the industry had a continuous machine capable of dewatering these difficult sludges.

Over time, experience with the machines increased and they began to change in shape adding separate drainage and squeezing sections to improve throughout and final cake solids.

Today, the belt filter press design follows a number of traditional filtration and separation theories, focusing on separate physical and chemical process within a single framework. However, it is at this stage that things start to differ from other proven process equipment, with the explanation as to how it works tending to be more art than science. In attempting to understand why and how the belt filter press works, it is necessary to go back to the beginning of its creation when the development of polymeric flocculants (polyelectrolyte) brought about a revolution in the thickening and dewatering of organic based sludges. Until then, inorganic coagulants and filter aids had been the norm, with the biomass dewatering market dominated by filter plate presses and vacuum drums, both in their own ways effective, but requiring high levels of operational manpower and/or suffering from low efficiency. The development of polyelectrolyte allowed the ill defined, biologically active materials to be converted in to a manageable feedstock capable of achieving clear solids liquid separation, drainage, and compaction. Enter the belt filter press.

Scientifically, the belt filter press has proven to be difficult to quantify or predict in terms of its performance, with manufacturers and users relying heavily on previous application knowledge and/or site testing. The problems start (or differ from other process industries) with the feedstock, where not only the solids content, but also the physiochemical make-up of the material can change throughout a working cycle. In addition site variations in up stream process, driven by the current environmental demands of the day, further compound this design issue.

So given the inevitability of an ever changing feedstock, the belt filter press has had to evolve to maximise its overall process efficiency by segregating the design into separate but integrated process zones (Fig. 2), the principal ones being:

- Chemical conditioning
- Gravity drainage
- Compression

Each of the individual process zones is designed specifically to meet the requirements of the variable feedstock. The chemical (polymer) mixing zone allows the selection of variable energy input followed by quiescent flocculation. The remainder of the machine is then designed to accommodate and protect the fragile flocculated particles.

The drainage zone utilises the flocculated sludge itself to facilitate and enhance solids capture, supported by a variable speed travelling filter media. Mechanical ploughs and filter media support grids assist to maximise drainage efficiency.

The compression zone starts with a gentle build up of pressure before encapsulating the sludge between two porous filter belts, which rapidly increase compression (belt tension) and shear forces to expel the remaining free water. As the dewatered cake is discharged continuously, both belts are individually washed before fresh flocculated material is added. The selection of filtration media also plays a major part in the overall design, with filtration rate, mechanical strength and surface finish being a fundamental part of the selection criteria.

As the water industry has become more competitive designs have developed to either increase overall efficiency (throughput and cake solids), through the addition of independent drainage sections and/or more rollers, or to embrace more difficult sludges through unique squeezing devices.

Defining and predicting the physical forces involved relative to actual dewatering performance has been linked to a number of factors ranging from feedstock CST values (a measurement of the ability of the feedstock to release free water), the rate of water release during the initial drainage phase and finally the amount of belt tension and shear applied at the point of compression. The results are of interest but fail to strictly follow any definable rules. Subsequently, few if any substantiated scientific formulae have been extracted and proven, but experienced practioners do get a good insight into the performance of the belt filter press.

Although organic wastewater sludges are the major market application for belt filter press, they also have a role in other industries e.g. mineral recovery, beverages, and chemicals. Here the designs are often more simplified as the feedstock tend to be more predictable and it is possible to focus on the mechanical aspects necessary for optimum dewatering.

Feedstock characteristics tend to be inorganic and more physically predictable, and the emphasis of the belt filter press design switches to rapid drainage with shear forces minimised to match the physical packing characteristics of the feedstock, maximising the release of available free water. Chemical conditioning is used as appropriate. However, again it appears that much of the machine sizing relies on experience and past application rather than scientific fact.

Overall many thousands of belt filter presses exist around the world with performance and reputation varying widely. The lack of real quantifiable scientific design data is undoubtedly one of the reasons the market has evolved this way. Fact or fiction, art or science, love it or hate it, the belt filter press is here to stay. We just have to take the time to understand it

THE FUTURE

So over the last 10 years where has belt press technology moved forward, where is the next 10 years of development going to come from? Experience indicates that previous problem areas have been with reliability, odour and process performance. In the UK, the move towards supplier frameworks has all but eliminated the availability of low quality manufacturers, to the extent where '24/7 service agreements' have become the industry norm resulting in machine availability levels in excess of 95%.

Odour has long been the Achilles heel of the belt filter press, since by definition the internal processes allow sludge to dewater and release odour as the filtrate falls through the atmosphere before finally going to drain. However, the introduction of enclosed design and integral drainage systems has made odour sludge loss a thing of the past. Maintenance access is preserved through externally mounted bearings and drives. (Fig.3)

This leads us on to the development of process performance. Although this has improved over the years, it has been achieved by incremental improvements in the efficiency of existing process steps rather than the introduction of any fundamental technology change. That is until now!

EKG DEWATERING TECHNOLOGY

External to mechanical dewatering machines we have seen the advancement of hydrolysis and other high temperature and/or pressure systems that as a by product of cell lysis have enabled the release of previously entrapped water molecules. These processes often result in a sludge structure that is more amenable to dewater albeit at a major capital cost impact.

However, through the adoption of electrokinetic geosynthetic (EKG*) technology to the dewatering of biosolids (and other materials) has allowed the belt filter press to enter a new phase, achieving levels of performance previously though impossible by conventional mechanical dewatering techniques. EKG technology employs electroosmosis whereby hydraulic flow of water through the biosolids is educed by a voltage gradient generated within the machine. (Fig.4). The process is simple, but the results are staggering. Figure 5 shows the level of performance that can be achieved from a conventional belt filter press dewatering municipally digested sewage sludge. The lower line represents the level of performance achieved by a standard design belt filter press, whilst the top line indicates the level of performance available with EKG.

2.

The results in Figure 5 only represent EKG operating at a voltage gradient of 15V. During the initial development phases, voltage gradient of up to 30V produced cake solids in excess of 40% dry solids! The effect of such dewatering performance can have a significant impact on operation disposal costs. A typical belt press dewatering operating on a continuous basis can reduce the off site disposal costs by >£130,000 (Table 1). If the sludge is feed to a dryer or incineration unit the savings can be even greater. Finally, EKG does not only increase cake solids, it can also reduce pathogens. Tests have indicated that pathogen reductions of up to 6-log can be achieved with no additional energy input. The price for this benefit has yet to be calculated!

CONCLUSIONS

1. Belt presses have been tried, tested and incrementally improved over many years. In the municipal water industry the results are not remarkable, but at least the process has become consistently reliable and the odour problems contained.

2. However, EKG is about to change all that offering the capability to produce a pathogen free cake with dry solids of up to 40%. The future for belt filter presses suddenly looks exciting.

REFERENCES

1. EKG Technology has been developed by Electrokinetic Limited and is exclusively available through Ashbrook Simon-Hartley Limited.

TABLES

TABLE 1. COST COMPARISON BETWEEN BFP AND EKG

	BFP	**EKG**
Loading kg dry solids/h	540	540
Operating hours/year	8000	8000
Volume of cake m^3/year	22,700	13,900
Disposal cost £/m^3	15	15
Total disposal cost £/year	340,500	208,500
Saving with EKG £/year		**132,000**

FIGURES

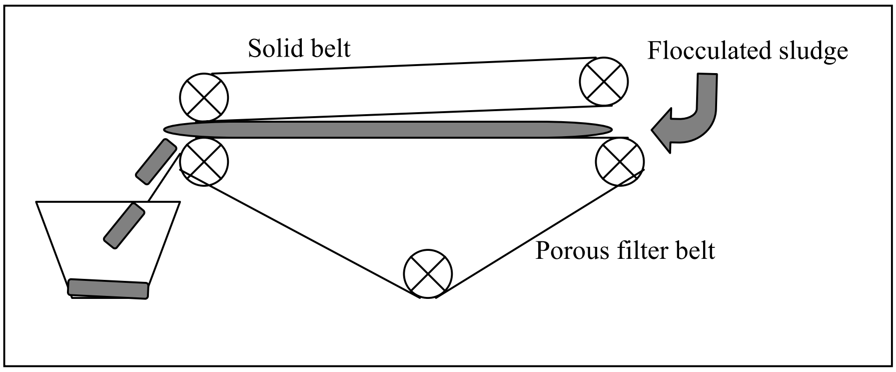

FIGURE 1 – DIAGRAM OF EARLY BELT FILTER PRESS

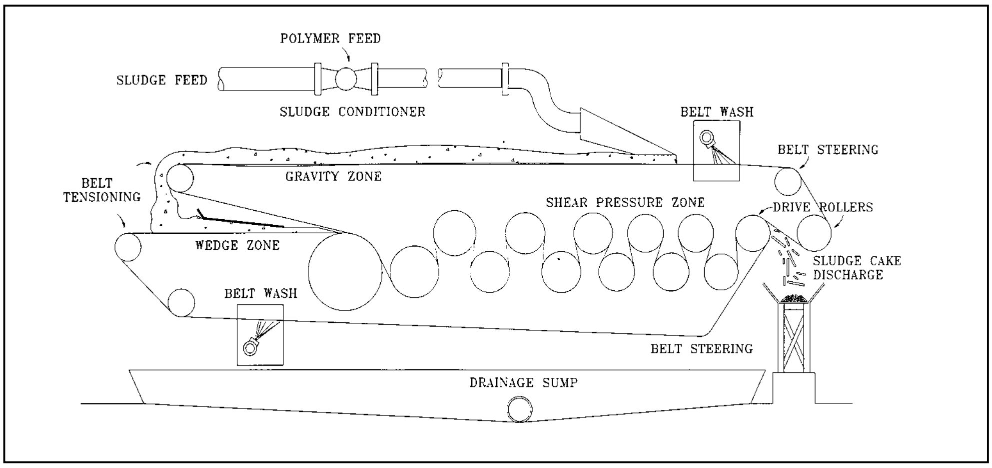

FIGURE 2 – MODERN BELT FILTER PRESS DESIGN

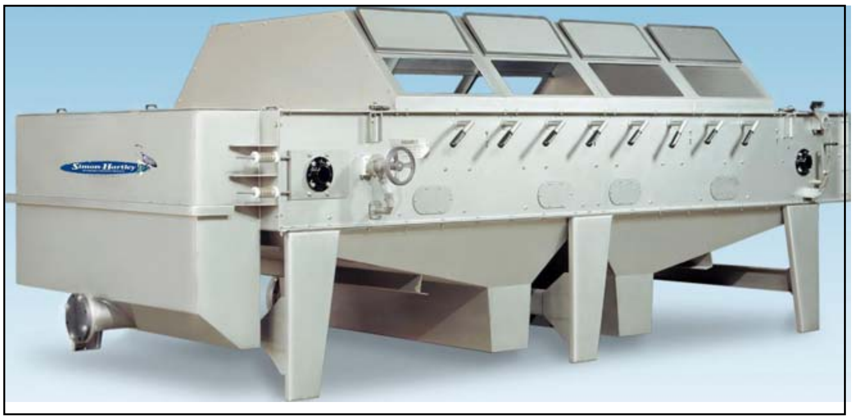

FIGURE 3 – ENCLOSED BELT THICKENER

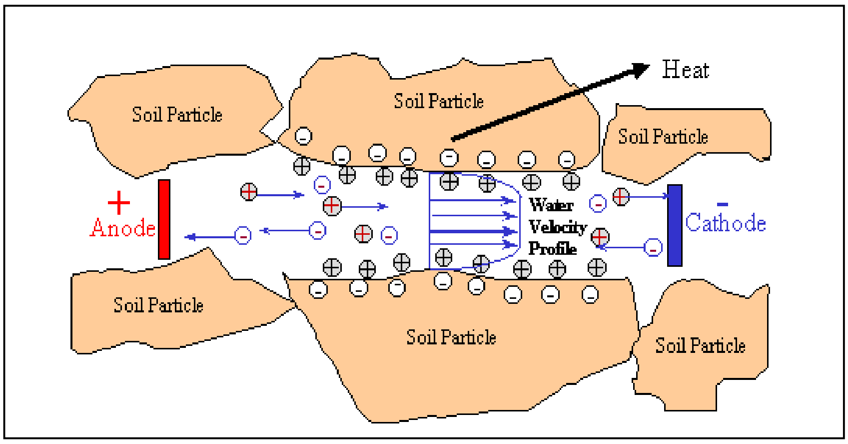

FIGURE 4 – ELECTROOSMOTIC FLOW INDUCED BY VOLTAGE GRADIENT

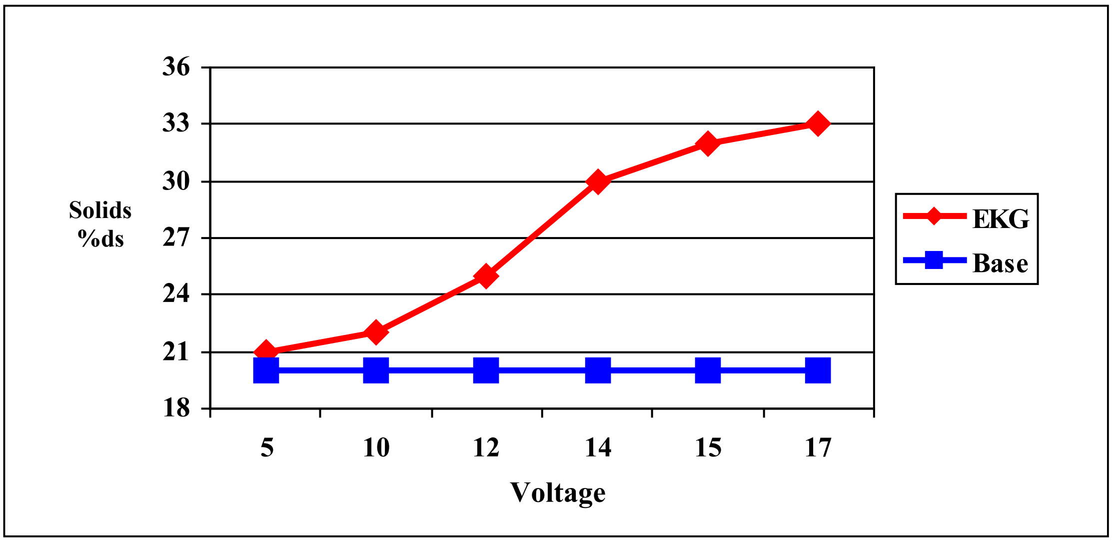

FIGURE 5 – EFFECT OF EKG ON DEWATERING OF SEWAGE SLUDGE