Optical detection system for polymer dosing optimization for a sludge thickening process – a case study on a full-scale

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INDRODUCTION

The use of polymer for sludge conditioning prior to mechanical thickening and dewatering processes is a costly but also unavoidable measure to achieve reasonable performance for a proper separation of solids and liquids as well as to achieve a high degree of thickening and dewatering of suspended solids.

Especially for industrial and municipal wastewater treatment processes such polymer consumption contributes in a significant proportion to the operation costs of the plant. Therefore a proper control system for the polymer dosing which optimizes the polymer consumption of a thickening or dewatering equipment can provide high economic benefit for plant operation expenses.

The optimization of the polymer dosing is quite complicated due to the unpredictable changes in the sludge qualities, colours, reflection behaviour of sludge surfaces or fouling of sensors in contact with sludge or filtrate.

The new optical detection system sticks to the principle of contactless detection of the sludge behaviour based on the degree of flocculation. This new technology uses the flow characteristics of a flocculated sludge which significantly changes when the polymer dosage is varied. This behaviour can be easily detected on a belt thickener or on the gravity section of a belt press. The variations in the flow pattern on the edges of the sludge floating on a belt thickener can be used as control parameter to optimize the polymer dosing for sludge flocculation.

The targets of this case study which was operational over a 1 and a half month evaluation period (from 1th of June till 17th of July 2015) on a full-scale were:

- Optimize and reduce polymer consumption at the belt thickener by achieving a minimum thickening performance of > 5% dry solids.
- Check influence of such PE-reduction on digester performance - mainly with respect to biogas production.
- Check influence of PE-reduction in Thickening on PE- consumption of centrifuge dewatering system.

MATERIALS AND METHODS

The optical detection system Rheoscan (Andritz 2015) was used. It uses the human approach of an operator how to evaluate visually the optimal degree of polymer dosing at belt thickener filled with sludge. The sludge concentration was measured with on-line measurement systems. A camera is scanning continuously the side parts of the belt in the gravity dewatering zone in the area where sludge surface is getting almost stable and not free flowing. Based on a pre-set flocculation condition the control system does control the polymer addition always in such a way that this free side area remains constant. If the free area is getting smaller, polymer addition is increased in order to achieve a “thicker” sludge which still remains inside the pre-set limits and does not flood over the belt. On the other hand a high free area indicates excessive polymer dosing and hence the optical control system reduces polymer addition.

In order to allow a comprehensive data evaluation a special software tool from Andritz named “SMART Service” –was used, which provides an immediate evaluation of online process data together with laboratory data. With this tool also calculations of total mass flow in dry solids, exact operation time of RheoScan activation, specific values such as the specific polymer consumption in kg PE t^{-1} DS for every set of online signals from the thickener as well as from the centrifuges were achieved and recorded. RheoScan – camera was mounted on top of the belt thickener in the middle of the belt in order to watch both sides of the belt.

Data transfer from WWTPL’s SCADA system to RheoScan control switchboard was installed for following signals from the belt thickener process:

- RheoScan – On/Off.
- Polymer flow – actual value.
- Polymer flow – control signal to VFD drive of polymer pump.
- Dry solids content from sludge feed to belt thickener – online measurement signals.
- Dry solids content from sludge discharge of belt thickener – online measurement signals.
- Belt speed.

RESULTS AND DISCUSSION

Thickening:

Own surplus sludge from the WWTP Ljubljana (further record to as WWTPL, website 2016), together with fats and oils removed from the aerated grease and sand trap, are collected in the primary thickening tank by gravity. The mechanical pre-thickening is provided with the addition of flocculants on belt thickener (Andritz 2006). It is then alternately taken to one of two parallel identical digesters.

Following data were recorded and results achieved in average (Figure 1):

Sludge flow:	48.2 m^3h^{-1}
Sludge feed consistency:	17.7 gL^{-1}
Discharge cons. from belt thickener:	5.8 %
Polymer consumption:	1.9 kg $PEt^{-1}DS$

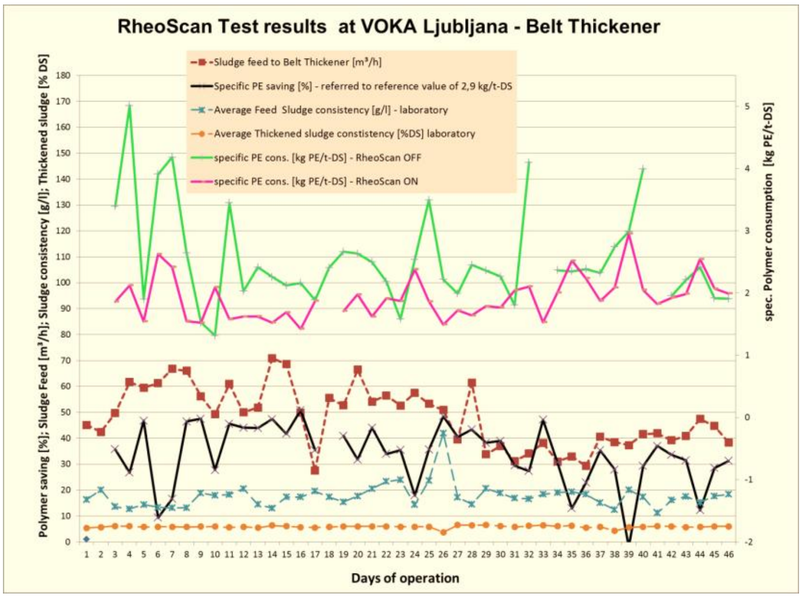
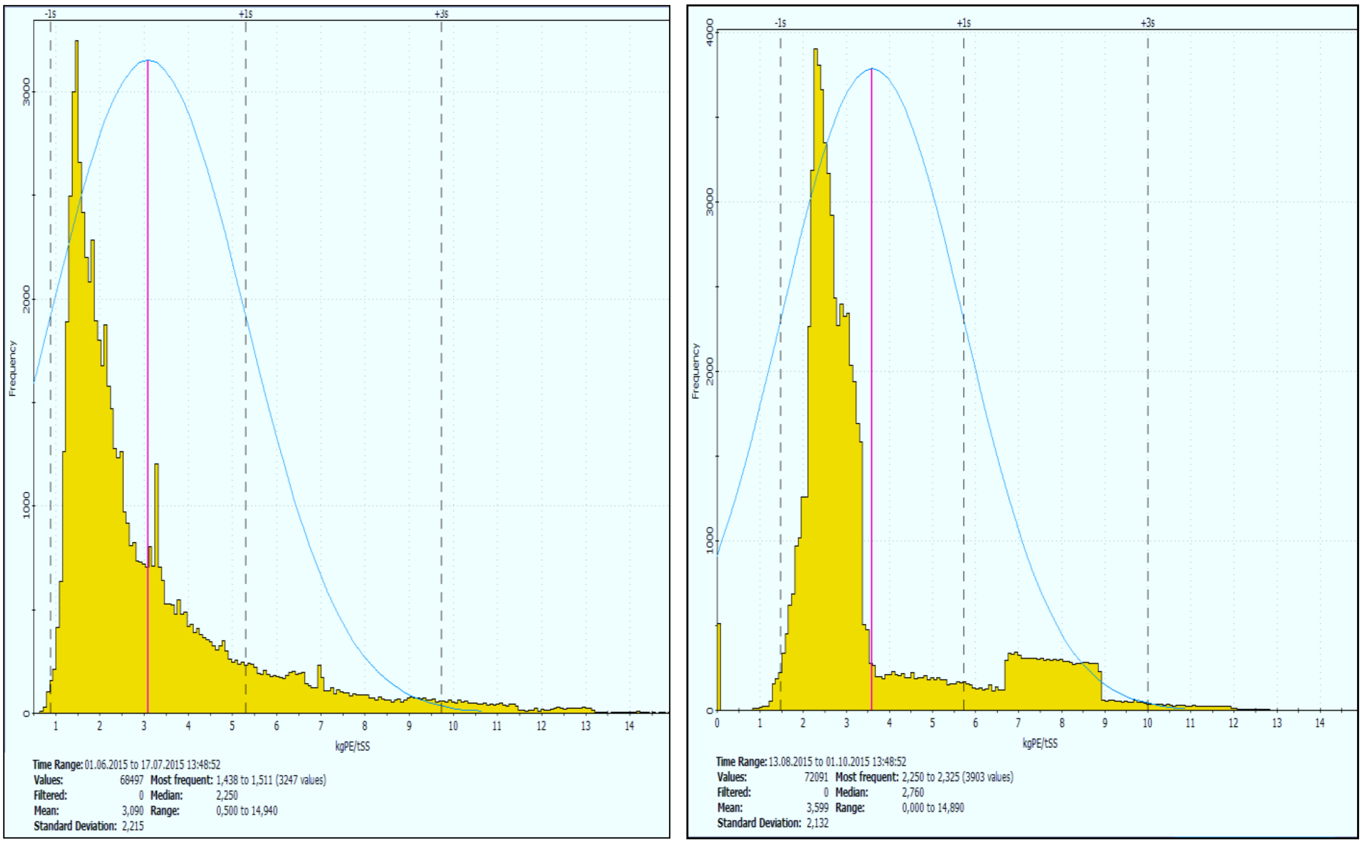


Figure 1: Trends of major parameters evaluated during test period at the belt thickener

The histogram view of the test period compared with the period after the RheoScan was dismantled does show the significant difference of the polymer consumption with and without RheoScan use (Figure 2).



a) b)

Figure 2: Results for PE-consumption: a) with the use of RheoScan, from 1th of June to 17th of July 2015, most frequent PE-consumption 1,44 – 1,51 kg PEt^{-1} DS and b) results for PE-consumption without the use of RheoScan, in August and September 2015, most frequent PE-consumption 2,25 – 2,33 kg PEt^{-1} DS.

Digestion Process

The Sludge Retention Time (SRT) in one digester, operated at 36 ± 1 ^{o}C, is from 37 to 42 days. Anaerobic digestion efficiency, expressed as reduction of organic matter content, is 49 % (Mislej et al 2013). The digested sludge contains 3.0 - 3.5 % dry matter. It is collected into a 1,850 m^3 secondary thickening tank. When full, the digestate dehydration process is started. With the rate of about 20 m^3/h sludge feed to the centrifuge (Andritz 2006) and a cationic polyelectrolyte consumption of about 9.0 kgton^{-1} digestate (DS), the dry matter is 21 - 23 %. More than 90% of the biogas is already released within a period of 7 days in the digester, after 10 days more than 95% is released and finally in 18 days 100% of the biogas production has occurred (Vrtovšek et al 2012).
In theory and from practice it is known that polymer addition is counterproductive for the digestion process since it hinders the degradation of the biomass in the digester. The target for the tests was to quantify the increase in biogas production based on the polymer reduction in the thickening process due to the RheoScan control system. In the following diagram the specific gas production trend has been calculated alternatively for 7, 10 and 15 days delay in biogas release in order to see if there is a difference in the increase.
Actually the overall increase over the test period is more than 12 %. Maximum daily increase of

biogas production was up to 40 % (Figure 3).

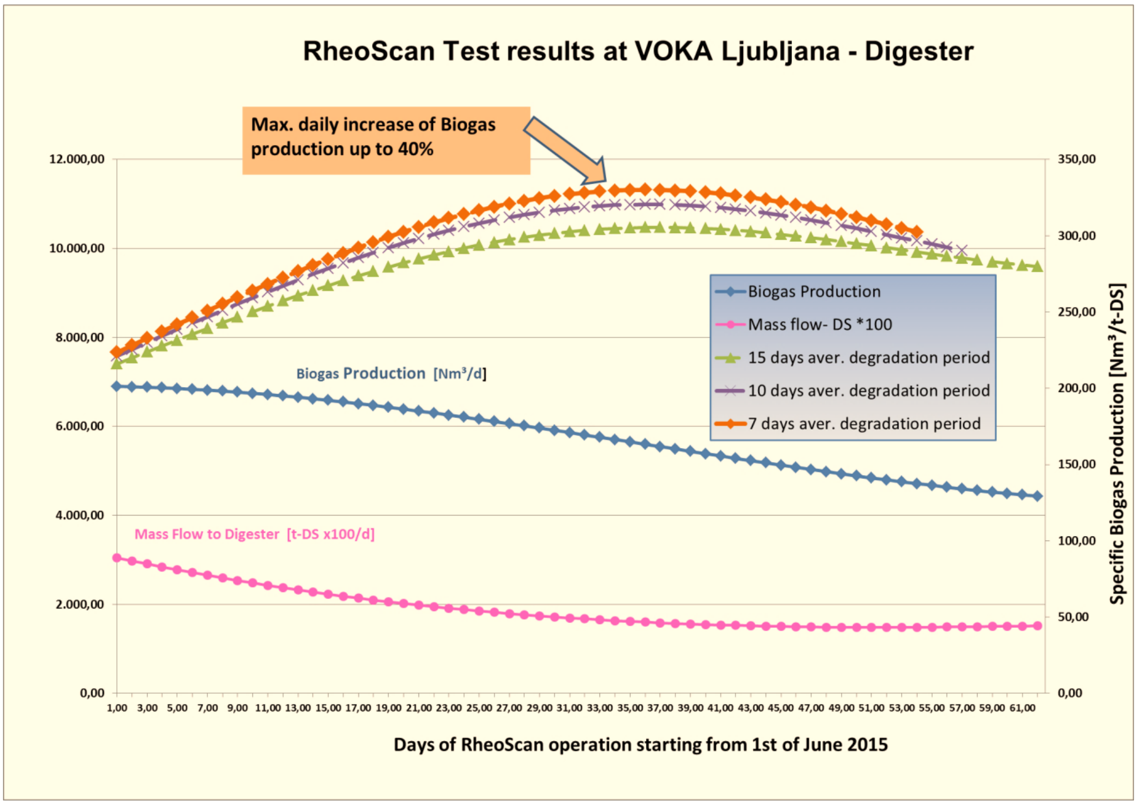


Figure 3: Increase in Biogas production caused by reduced PE-consumption at belt thickener

Centrifuge Dewatering Process

From the 2 installed Decanters always one is in standby and the other is operational. Because of the large volume of the 2 digesters which are fed with the surplus sludge from the belt thickener a delay of the sludge flow of 42 days had to be considered. Therefore day 1 in the diagram in Figure 3 does start on 13th of July (43rd day after start of RheoScan operation).

In average over the test period following results were monitored at the centrifuge dewatering process:

Sludge flow:	19.3 m^3h^{-1}
Sludge feed consistency:	3.6 % DS
Sludge cake from centrifuge:	19.6 % DS
Polymer consumption:	8.9 kg $PEt^{-1}DS$

From these trends there is clear conclusion that the operation of RheoScan at the belt thickener does provide a significant polymer reduction also at the centrifuge which can be explained because of the effect of better efficiency of the flocculation prior to centrifuge dewatering due to less remaining weak binding forces from the pre-flocculation at the belt thickener (Figure 4). In this respect it has to be noted that neither the cake dryness nor the throughput was compromised during this period of less polymer addition.

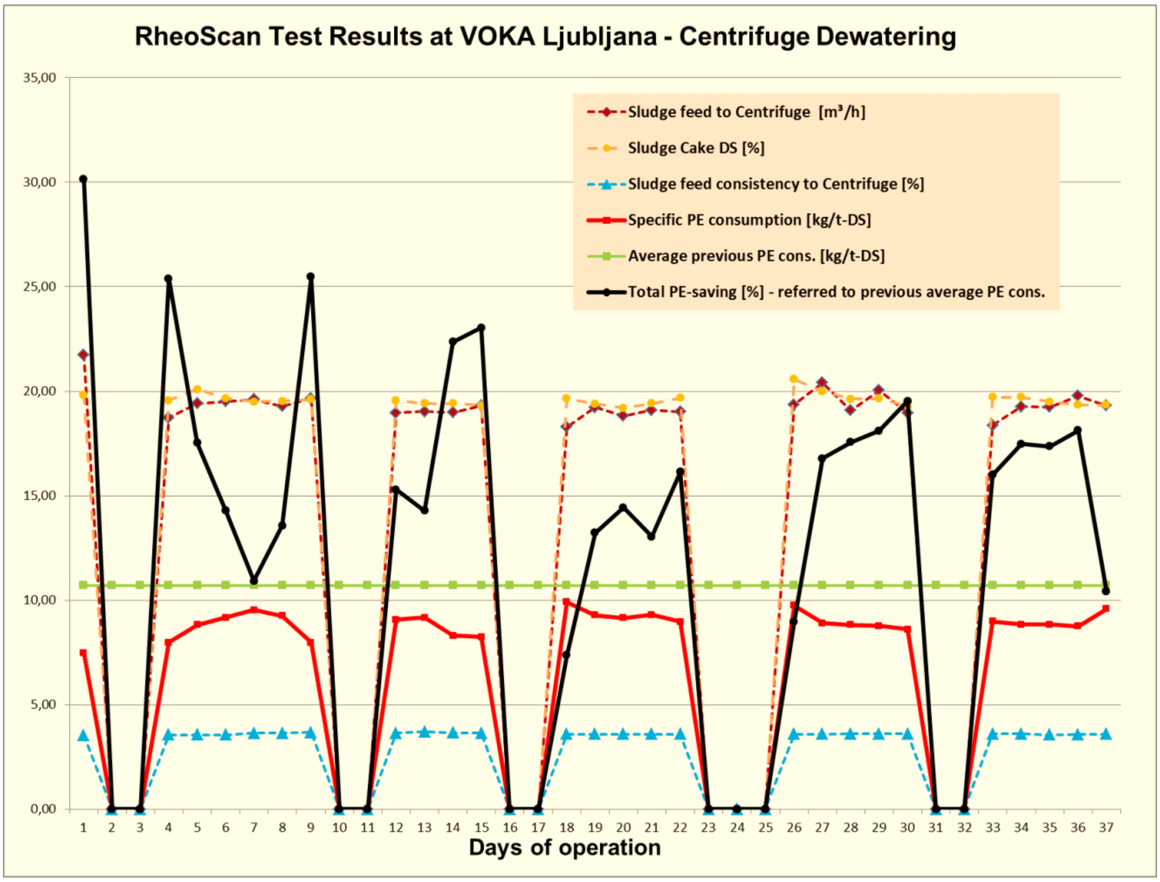


Figure 4: Polymer reduction due to reduced polymer addition at the belt thickener

CONCLUSIONS

Test experience showed that normal belt speed setting on a belt thickener is usually too high for optimum dewatering efficiency simply because it is more save in preventing a sludge overflow on the belt. The negative side is that sludge retention time on the belt is lower and hence the thickening result is worse compared to lower belt speed.

With the optical detection of the belt side parts by the RheoScan camera there is a continuous automatic control to avoid sludge overflow since polymer dosing is adjusted accordingly. This allows to reduce the belt speed considerably compared to normal manual operation. The RheoScan can be used to achieve a fully automated operation of the belt thickener and polymer dosing.

Overall the tests have proven, that this new polymer optimization system enables significant polymer savings together with a fully automatic operation of a belt thickener.

Summary of results with respect to set targets:

- Polymer consumption at the belt thickener was reduced in average by 28,5 %.
- Increase in total biogas production over test period of more than 12 %.
- Polymer consumption at the centrifuge was reduced in average by 12,1 %.
- RheoScan was in use for 85,5 % of the whole operation time of the thickener.

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