Case Study on the Functional Performance of a large Wastewater Pumping Station

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Long Abstract

Introduction

Climate change, demographics and water-sensitive behaviour put a great strain on the urban wastewater system by changing amounts, composition and behaviour of wastewater. Especially, combined sewer systems face big changes of loads between dry-weather runoff as the minimum and stormwater as maximum. Additionally operation conditions, the challenging fluid “Wastewater” and the regulatory background [1],[2],[3] create an operational frame for the main wastewater pumping station that results in a high risk of failures. Especially fibres and textile structures within the wastewater lead to frequent failures in wastewater pumps due to clogging.

The pumping station analysed in this paper is a large pumping station in an urban area. With a connected catchment area of more than 250,000 inhabitants and about 750km of sewer system this main pumping station delivers about 45,000m³/day of dry-weather run-off to the three connected wastewater treatment plants. The power consumption of the 8 installed pumps ranges from 40 kW up to 455 kW for electrical power and up to 711 kW for diesel-driven peak-load pumps. They are used to pump from 100 l/s during nights up to 1450 l/s during rain events.

1. Methods

A Fault Tree Analysis is used to identify the critical assets for the safe operation of the wastewater pumping station. It is observed, that 2 out of 8 pumps show an extremely high number of failures related directly to the wastewater transport. In a next step the critical pumps are analysed in a structured Integrated Asset Management (IAM) approach. It is focused on the actual state and performance of the critical wastewater pumps, the risks and costs of failures including their main influencing parameters and possible strategies to improve the functional performance of wastewater pumping stations. Main focus of this paper is a case study on the performance and risk of failure for the presented wastewater pumping station.

The analysis of the current status of the wastewater pumping station is carried out by gathering technical data, operating schemes, instrumentation and control setups and the current data management.

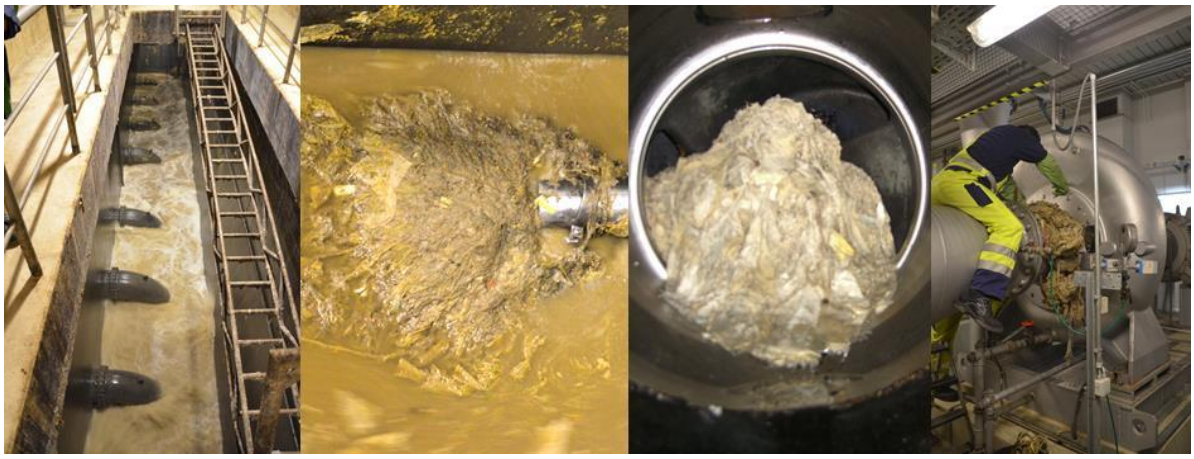

Figure 1.: Operation of a wastewater pumping station (left to right)[6]:
Suction chamber, Fibre accumulation in the suction chamber, Fibre accumulation in front of the impeller, Manual cleaning of a wastewater pump

For the analysis of actual performance of the critical wastewater pumps Performance Indicators (PI's) are defined. For wastewater pumps this includes operating points i.e. pump heads and delivery rates during actual wastewater operation [5] and failure rates. It is shown that certain PI's are not well defined for wastewater applications e.g. acceptable efficiencies. [4] The significance of indicators such as Mean Time between Failures (MTBF) also needs to be discussed. The existing instrumentation setup and data management is adapted to deliver all required data.
The PI's are then used to evaluate the operation under real wastewater conditions in comparison to manufacturers' data and also to identify root causes of failures.
It is overserved that the critical pumps are operated under off-design conditions and pump failures are primarily results of clogging through slowly accumulating fibres.

The risk of failures for the observed pumping station is a combination of the probability of failures and their consequences. The performance analysis shows clogging as the major cause for pump failures. The risk analysis is therefore aimed at pump clogging. While consequences of clogged pumps can be displayed as costs for either fault-clearance, cleaning activities or even fines, the calculation of occurrence probabilities for pump clogging is not yet possible. It is described how certain factors such as wastewater composition or pump operation can contribute to pump clogging and why prediction and calculation of clogging events is difficult.
Based on this risk analysis it is shown that only a system approach can help to increase the performance of wastewater pumping stations since the risk of clogging is based primarily on external system-dependent factor while failures are regarded as pump faults.

Strategies to improve the functional performance of the presented wastewater pumping station are based on two approaches. Passive measures aim at the improvement of flow conditions at the impeller entrance to support the pumps' capability of fibre handling or to counter accumulation of fibres. Active measures are based on early detection of starting fibre accumulation in the pump to trigger counter-measures such as flushing or a so called "Cleaning Sequence" [7].

In the paper it is shown that wastewater pumps are often operated in off-design conditions which can reduce the capability of handling fibres and textiles. The risk of pump failure due to clogging is evaluated and strategies to improve the functional performance of wastewater pumping stations are presented.

References

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