Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 112 (2017) 11 – 18

Energy Procedia

Sustainable Solutions for Energy and Environment, EENVIRO 2016, 26-28 October 2016, Bucharest, Romania

The adjustment of turbo-pumps' extreme regimes by means of delivery mounted restriction orifice plates

Daniel Toma[a], Diana Ancaş[b], Mihai Profire[b]*

[a] *"Gheorghe Asachi" Technical University of Iasi, Faculty of Hydrotechnical Engineering, Geodesy and Environmental Engineering, 65 Prof. dr. docent Dimitrie Mangeron Street, 700050, Iasi, Romania*

[b] *"Gheorghe Asachi" Technical University of Iasi, Faculty of Civil Engineering and Building Services, 1 Prof. dr. docent Dimitrie Mangeron Street, 700050, Iasi, Romania*

Abstract

In the field of pump-based hydraulic systems sometimes occur certain deviations of real performances, in comparison with those planned by means of design. In general the problem appears due to some discrepancies between the actual parameters of the existing system and those took as assumptions during the pumping station design. The result is that in fact pumps are working at excessive flows, in regimes located nearby the „right" end of head parameters, and this with the corresponding consequences. That is, pumps tend to produce cavitation (this depending on the water levels within associated water tanks). Moreover, in extreme situations, there occurs the risk of motors' overheating, this combined with severe vibrations. In order to avoid this defficiencies it is mandatory to soundly adjust the operational regimes (in real existing conditions) creating a situation in which current regimes to be shifted towards left side, on the real head curve of used pump.

This paper refers to the possibility to avoid unwished operational regimes by mounting adequate restriction orifice plates on the pumps' delivery main.

Peer-review under responsibility of the organizing committee of the international conference on Sustainable Solutions for Energy and Environment 2016

*Keywords:*pumps; extreme regimes; cavitation; restriction orifice plates

* Corresponding author. Tel.: +40721 811373; fax: +40232 270804.
E-mail address:daniel_10hid@yahoo.com

Peer-review under responsibility of the organizing committee of the international conference on Sustainable Solutions for Energy and Environment 2016
doi:10.1016/j.egypro.2017.03.1107

1. Introduction

Considering that:

- in order to ensure a long technologic life of pumps the cavitation risk must be avoided in any operational regime;
- there is a need to avoid flows greater than those took into account in the analysis of nonpermanent regimes and during the design for anti-surge protection systems,

in the next pages authors shall present the possibility to avoid unwished operational regimes by mounting adequate restriction orifice plates on the pumps' delivery main.

The study is focused on a case study in which pumps' operational regimes have been adjusted in order to enhance global hydraulic conditions. It is about the Păcurari 2 pumping station, facility belonging to the Timişeşti water supply system which is one of the two water supply systems of Iasi City in Romania.

2. Basic theory

2.1. The functioning of a pump fitted with restriction orifice plate on delivery

The study is focused on concrete operational conditions, in which pump's regime is located towards the „extreme right" of recommended operational domain, with all the corresponding negative consequences (that is, cavitation and motor's overloading). This situation can be avoided by a „shifting towards left" of the operational point. Considering that network's characteristic curve reflects the effective needs of the system, this „shifting towards left" can be rationally carried only by altering the pump's decreased head characteristic, that is, to achieve the lowering of this characteristic in analysis's (Q,H) plan.

A relatively cheap solution is to mount a restriction orifice plate [1] on the pump's delivery main. Restriction orifice plate's diameter has to be designed in such a way, that the head loss generated by the conveying of the flow of desired operational regime Q_D to be made to correspond to the extra head Δh_{rd} at which would be pumped the respective flow via the actual pump's mains:

$$\Delta h_{rd} = H_P^O(Q_D) - H_P^D(Q_D) = M_{rD} \cdot Q_D^2 \tag{1}$$

where $M_{rD}$is a D diameter restriction orifice plates's hydraulic resistance modulus, restriction orifice plate mounted on a main with internal bore C:

$$M_{rD}(C,D) = \frac{0.0826}{C^4}\left[1-\left(\frac{D}{C}\right)^2\right]^2 \tag{2}$$

2.2. The determination of the diameter of a restriction orifice plate necessary for pumping a pre-defined flow Q_D

As it easily results from those above mentioned, the diameter of the restriction orifice plate needed on pump's delivery side (having a diameter C), necessary for decreasing current flow Q_E to a value Q_D – considered to be acceptable for an optimal operational regime – can be computed from (1). The condition is to know the necessary value needed for the decreasing of the head at which flow $Q_D$is pumped in the analysis' reference section (O) from value $H_P^O(Q_D)$, currently provided by the decreased head characteristic $(H\text{-}Q)_P^O$ with equation: $H_P^O(Q_D) = A_0 + A_1.Q_D + A_{2O}.Q_D^2$, to value $H_P^D(Q_D)$ – in the conditions of restriction orifice plate delivery, on head curve $(H\text{-}Q)_P^D$with equation $H_P^D(Q_D) = A_0 + A_1.Q_D + A_{2D}.Q_D^2$, restriction orifice plate that achieves the head decrease: $\Delta h_{rd} = H_P^O(Q_D) - H_P^D(Q_D)$ (see Fig. 1), to which corresponds the hydraulic resistance modulus M_{rD}.

If the hydraulic resistance modulus needed for pumping the pre-defined flow Q_D is computed, the restriction orifice plate's diameter can be determined by grapho-analytical methods, using the graph of function $M_{rD}(C,D)$.