Peer Review- Group 732

Disclaimer:

We understand that the project is somewhat specified upon receipt, therefore you should probably disregard the novelty and significance to some extent, as you are not too much in control of what the project should contain regarding the concepts used.

Novelty:

We would not say that there is anything new in the article. As you state yourselves, one of the articles you reference does pipe dynamics and the other takes network delay into account. So, the only novelty here would be combining them, as you already do. Which may also have been done by other people already, looking at AUB (link).

Correctness:

In general, it seems that the equations are correct, since they refer to the master's thesis. Graphs and figures are hard to read. There are missing legends, figure text explanations are insufficient and missing units on axes. This makes it difficult to see what the graphs are telling you. Hereby very hard to reproduce.

Significance:

We feel that the article doesn't really provide anything scientifically new as all the concepts are already known and used/performed in other work, hereby making the impact almost insignificant. Moreover, it doesn't seem like the results will lead to further development as it appears to only be minor extensions of the results from the master's thesis.

Overall assessment:

Our overall assessment of the formalities in terms of structure and grammar, is good! The way that the references were used in terms of the equations in the article could have been narrowed down quite a bit. What we mean is that you are including all the findings of the previous work and try to half-explain it (to an extent where it seems like you did the work), instead of listing the results in one go and base your work off of that (see **SC11** (the picture)).

Perhaps put more focus on what you do in article and not so much on what has already been done in previous reports.

Nice work nonetheless!

General comments:

GC1. Reevaluate what the reader needs in order to understand your work. Ex, eq. 12 combines the "non-referenced nodal demands", however the result of this is never used in your article. This adds lots of confusion like what is "non-referenced". So maybe just leave it out.

GC2. It has not been explained how the ON/OFF system works, making it very hard to understand what you are comparing your results to.

Specific comments:

SC1. Your "nonlinear full description of the network model" **equations 14: a,b,c,d** is cited to (S. S. Rathore," Nonlinear Optimal Control in Water Distribution Network", Aalborg Universitet, 2020.) however we cannot find it at all in the reference.

SC2. Equation (13a) uses f(x,u) however in text f(x) is used as a function of 1 variable.

SC3. Starting the sentence with "and" before equation (13d)

SC4. Results are given in section (Delay) with the delay time. Maybe move to Results chapter instead (in relation to the IMRaD structure).

SC5. Figure 3 caption has a capital letter at the start of each word unlike the rest of the paper.

SC6. Equation (26) specifies the "$-K\ =$ .." when this minus can be omitted. However, it is up to you.

SC7. When referring to figure 7 and 8, you write "figure X" with lower case letter but in the rest of the paper, it is in capital letter "Figure X".

SC8. This comment refers to the text being a little hard to read. If a reader were to read equation (14d) for example, and this reader has to remind himself what the **µ** etc. is. The reader then finds the last time this was used, which is in eq. (5), then realizes that this is equal to ΔPk, which is explained as pressure drop even further back in the paper, just after figure 1. Since the reader will not immediately remember all variables, this makes it such that the paper takes a very long time to fully understand.

SC9: Reading chapter 3, A) Delay -> "As seen in figure 3 the time difference between control input and sensor output is 1.25 seconds." This is not easily seen. The labels says that the graphs are pumping stations 1 and 2, while the reader expects to see a sensor input and a control output. Figure text says that the figure shows a time delay at pumping station 1 and 2, while the y axis shows flow – how can this be a time difference? The values in the boxes show 11 and 14 – what is this showing? This would then be a time difference of $14 - 11 = 3 \cdot 100ms\ =\ 0{,}3s$. The y values show a flow difference of $0{,}01\ L/min$, which does not help in finding any time difference.

SC10: From Fig 8 (and 7) is it not clear how these are supposed to be interpreted. The following questions come to mind:
What is the unit of these pump speeds? What are the graphs? Right and left shows that red is a pump speed and dark blue is an OD, but what is the light blue then? Is it a combination of control inputs and consumer demand patterns? What is the unit of this? Text in the start of chapter 5 states that it is simulated results from two controllers. How did you make the ON/OFF graphs? What is the idea/strategy in such a control scheme? Why is ON/OFF bad and why do you want to improve on this? Is ON/OFF something that is actually used in reality?

SC11.

$$p = hg\rho \tag{1}$$

Therefore, the dynamical equation that describes the relation between flow and pressure across a pipe section is given by [1]

$$\Delta p_k = J_k \dot{q}_k + \lambda_k(q_k) - \rho g \Delta z_k \tag{2}$$

where J_k represents the mass inertia of the water in the pipe, $\dot{q}_k$ is the rate of change of flow of water, Δz is the geodesic level difference between pipe terminal, and λ_k is the pressure drop due to friction, calculated by [2] [8]

$$\lambda_k(q_k) = h_f(q_k) g \rho + h_m(q_k) g \rho \tag{3}$$

where h_f is the head loss due to surface friction, and h_m is the head loss due to pipe form, such as fittings and bending.

2) Valve Model: The valve is modelled similar to a pipe, but assuming that length L and the geodesic level difference Δz are zero for valves. The manufacturer's datasheets provides an accurate K_{vs} parameter, defined as the conductivity of a fully open valve. Since the opening degree (OD) of a valve varies, the pressure loss across a valve can be expressed as a function of OD [2]

$$K_v(OD) = \frac{q}{\sqrt{\Delta p}} \tag{4}$$

Where $K_v(OD) \in [0, K_{vs}]$. A general model of a valve in a water distribution network is then expressed by [2]

$$\Delta p_k = \frac{1}{K_v(OD_k)^2}|q_k|q_k = \mu_k(q_k, OD_k) \tag{5}$$

3) Pump Model: The pumps in a hydraulic network provides a positive pressure difference, which creates flow. A general model of the k^{th} centrifugal pump is given by [2] [8]

$$\Delta p_k = -a_{h2_k}|q_k|q_k + a_{h1_k} q_k \omega_k + a_{h0_k} \omega_k^2 = \alpha_k(q_k, \omega_k) \tag{6}$$

Where a_{h2_k}, a_{h1_k}, a_{h0_k} are the pump constants and ω_k is the rotational speed. The differential pressure of the k^{th} pump can then be given as a function of the flow through the pump q_k and the pump's rotational speed ω_k.

4) Elevated Reservoir Model: In a hydraulic network, it is possible to efficiently create pressure by an elevated reservoir, or tank for short. The pressure at the bottom of the tank is mainly affected by the water level in the tank. The tank is modelled by the dynamic relation [2]

$$\dot{p}_t = -\tau d_t \tag{7}$$

The pressure at the bottom of the tank given by p_t, $\tau > 0$ is a parameter dependent on the tank's cross sectional area, and $d_t > 0$ is the flow out of the tank.

Suggestion

a) Component models

The models of the pipe, valve, pump and reservoir is based on previous work from [2] and looks as follows:

(Eq 2)

(Eq 5)

(Eq 6)

(Eq 7)

b) Network model

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SC12. Network model. You say nodes and edges are N,E respectively. But then on the graph itself you use v and e. It is a bit confusing. Maybe stick to v and e like you do in the caption on figure 2 in the text.

SC13. The title is not very descriptive. You could add what kind of controller you are making or the kind of network you are working with here.

SC14. It is not very obvious what states need to be estimated, thus arguing why the observer is designed. Moreover, we are in doubt if you're using it in regards to packet loss mitigation.

SC15. Abstract makes it sound like packet loss is implemented.