Dividing-flow manifold calculations with a spreadsheet

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Abstract

Dividing-flow manifolds are widely used in water and waste-water treatment plants. Although many mathematical models for calculating the appropriate flows are available, the calculations are generally so laborious that often rule-of-thumb methods are used in design. Calculating problems can be greatly overcome by making use of the built-in functions of most modem spreadsheet programs. The use of a spreadsheet program to calculate the hydraulics of a dividing-flow manifold is demonstrated.

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Introduction

Dividing-flow manifolds are often used in water and waste-water treatment plants (Fairetal, 1968). Various mathematical models exist for calculating the flow distribution for a given manifold system (Benefield et al., 1984). Many of these models require iterative calculations, which could be tedious if it is to be used as a design tool. To speed up calculations, Benefield and co-workers compiled a FORTRAN computer code for calculating the flow distribution of a model developed by Hudson et al. (1979). Chaudhry and Reis (1992) used the Hudson model, but greatly simplified its

applications by re-writing the equations in dimensionless form in order to solve them directly with a forward difference solution method. Lombard and Haarhoff (1995) used this simplified model on a spreadsheet computer program to calculate the relative flows in a typical filter underfloor system. Although the method of Chaudhry and Reis (1992) does not require iterative calculations, dimensionless head loss values must still be obtained graphically, introducing an error which must be corrected for.

Most modern spreadsheet computer programs have built-in functions and tools that bring the solutions of quite complicated calculations within the reach of anyone proficient in the use of spreadsheets. Once it is recognised that the Hudson dividingflow model consists essentially of a number of equations (proportional to the number of laterals) to be solved simultaneously, it is a relatively simple matter to use, for example the *Optimizer* built-in tool (Borland, 1993) of a spreadsheet computer program to solve these equations. For illustrative purposes, a spreadsheet set-up and solution to the dividing-flow manifold problem shown by Hudson et al. (1979) are given here.

Spreadsheet set-up for a dividing-flow manifold

Example

In this problem a 101.6 mm diameter manifold divides a flow of 50.97 m³/h to 5 consecutive 50.8 mm diameter short laterals. Each lateral is orientated at 90° to the manifold and is square-



Figure 1 Dividing manifold with laterals (Hudson et al., 1979)

edged. The problem is to determine the flow distribution amongst the laterals. A definition sketch of the manifold - lateral is shown in Fig. 1.

The basic assumption that Hudson et al. (1979) made is that the head loss in the energy line from manifold through lateral is the same at every point. They include all components of head loss in a single term, p:

$$\boldsymbol{\beta} = \boldsymbol{\Phi} \left(\frac{\mathbf{V}_{\mathbf{m}}}{\mathbf{V}_{\mathbf{L}}} \right)^2 + 0 + 1.0 \tag{1}$$

where:

$$\oint \left(\frac{\mathbf{v_m} \mathbf{\hat{f}}}{\mathbf{v_L}} + 6 = \text{ entry loss coefficient} \right)$$

for short laterals, $\oint = 0.7$ $v_{L} = velocity of flow in manifold$ $v_{L} = velocity of flow in lateral.$

Since the loss from the manifold through the port exit is the same at each lateral, then for lateral i:

$$\frac{\text{Pi V}^2_{\text{Li}}}{2 \text{ g}} = \text{constant}$$
(2)

Since there are 5 laterals, there are 5 equations with 5 unknowns which must be solved simultaneously. This can be readily done using a spreadsheet computer program.

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