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Research Paper

Effect of variation of the diameter of the inlet to the distribution manifold on flow uniformity in dividing manifold system

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ABSTRACT: *In this paper, the methodology was studied to per-outlet flow uniformity that is variation of the area of the inlet to the distribution manifold. The base case of these variations is a diameter of 100 mm., and the range is from 100 to 50 mm. The diameter of the distribution manifold (D1) is kept fixed at 100 mm, and the angle at which the flow enters the manifold is perpendicular to the cross-section. the inlet water flow rate is 790 l/min. for all cases. The results of this study showed the methodology of changing cross-section area of main pipe to the header is a negative step in the quest for flow uniformity as the coefficient of non-uniformity increased from 0.3 to 0.401.*

KEYWORDS: *Manifold, Uniformity, Flow distribution, Dividing flow, Distribution sysyem*

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I. INTRODUCTION

Dividing flow takes place in a manifold that distributes a fluid flow uniformly to a series of successive lateral outlet ports. The fluid flow through manifolds has many applications, such as; flow distribution systems in treatment plants that treat water and wastewater, the piping system of pumping stations that involves a main supply manifold with many side branches to pumps [1-5], fuel cell [6-8], automobile [9], solar system [10-13] and in irrigation systems. The function of a pumping station is to transfer water from a source to a required destination such as supplying water to the distribution networks. The manifolds play a very important role in the performance of water pumping station which is the focus of the current study. The water pumping station consists of pumps, pipes of various sizes, valves, pipe fittings, and distribution reservoirs…etc. pumps which pumped water directly into transmission lines, and distribution system. Pipes are divided into two types: in the first, suction and discharge piping of pumps. In the second, supply and collecting manifolds, these pipes carry water from reservoir to each part in pumping station. Valves are used to control the flow of water through the pipes [14].

The applications in which manifolds play a major role extend from traditional situations such as water distribution systems and automobile engines to very recent, high-technology devices such as microchannel heat sinks and critical biological systems such as blood circulation in the human body [15].

A great number experimental, analytical and numerical studies deal with flow distribution in manifold. Bajura [6] developed the first general theoretical model for investigation of the performance of single-phase flow distribution for both intake and exhaust manifolds. Primary emphasis is placed on configurations in which the lateral tubes form sharp-edged junctions at right angles to the manifold axis. A mathematical model was formulated in terms of a momentum balance along the manifold. Bajura and Jones [16] extended the previous model and prediction for the flow rates and the pressures in the headers for the dividing, combining, reverse and parallel manifold configurations.. Majumdar [17] developed a mathematical model with one-dimensional elliptic solution procedure for predicting flows in dividing and combining flow manifolds. The mathematical model has been further used by Datta and Majumdar [18] for numerically investigation of flow distribution in parallel and reverse flow manifolds. In both the studies, the authors have found two non-dimensional parameters (area ratio and friction parameter) which affect the flow distribution. Pigford et al. [19] studied analytically and experimentally the flow distribution in parallel and reverse flow manifolds using air. They found that, for the same geometrical and operating conditions, reverse flow manifold provides more uniform flow distribution as compared to that in a parallel flow manifold. Mueller and Chiou [20] presented in a review article the factors influencing maldistribution in heat exchangers. The flow distribution from manifold has become of interest in predicting the heat transfer performance of compact heat exchangers. Often, flow rates through the channels are not uniform and in extreme cases, there is almost no flow through some of them, which result in a poor heat exchange performance. Choi et al. [21] studied numerically the effect of the area ratio on the flow distribution in manifolds of a liquid cooling module for electronic packaging. Results showed that the flow rate in the last channel was 2.75 times that in the first channel. It is concluded that the area ratio is one of the most important parameters affecting the coolant distribution and should be carefully examined in the design of a liquid cooling module. Kim et al. [22] numerically investigated the effects of header shapes and the Reynolds number on the flow distribution in a parallel flow manifold of a liquid cooling module for electronic packaging, for three different header geometries (i.e., rectangular, triangular, and trapezoidal) with the Z-type flow direction. Their results indicated that the triangular shape provided the best distribution regardless the inlet velocity. Alawee [23-25]

II. EXPERIMANTAL SETUP

The test rig of this study is shown in Fig.1. The rig was assembled at a selected site in fluid laboratory of Machinacl Engineering Department, University of Technology, Iraq. The experimental setup, shown in Figure consists of these parts: the main supply pipe, a test section, a shalow tank to collection water, flow meter, manometer and a centerfugul pump to recycle water to main supply pipe. The water mass flow rate in the test section is controlled through a regulation valve and is measured by a target mass flow-meter. The water flow rate from each lateral pipe was collected in a shallow tank, with dimantioin (1500x1500x400) mm, then discharged continuously through pipe diameter 152.4 mm (6 in) to recycle water by centrifugal pump to main supply tank. The water flow rate is measured by a five glass containers with capacity of 50 liter of each container. The containers are placed on a movable support, which allows it to move freely at the same time during experiments. Nine pressure tapes are located along the length of the test section. these pressure tapes are used to measure the pressure evolution in different positions in the header and at the inlet manifold.

Figure1: experimental setup

Another practical issue to be considered here is variation of the diameter of the inlet to the distribution manifold. A mismatch between the cross-sectional area of the pipe that delivers fluid to a distribution manifold and that of the manifold proper is not uncommon in practice. It is relevant to inquire whether such mismatches might influence the uniformity of the effusion from the manifold. This methodology is illustrated in Figure 2. The range of the variation of the opening is listed in Table 1. The diameter of the distribution manifold is held fixed at 100 mm, and the angle at which the flow enters the manifold is perpendicular to the cross section.

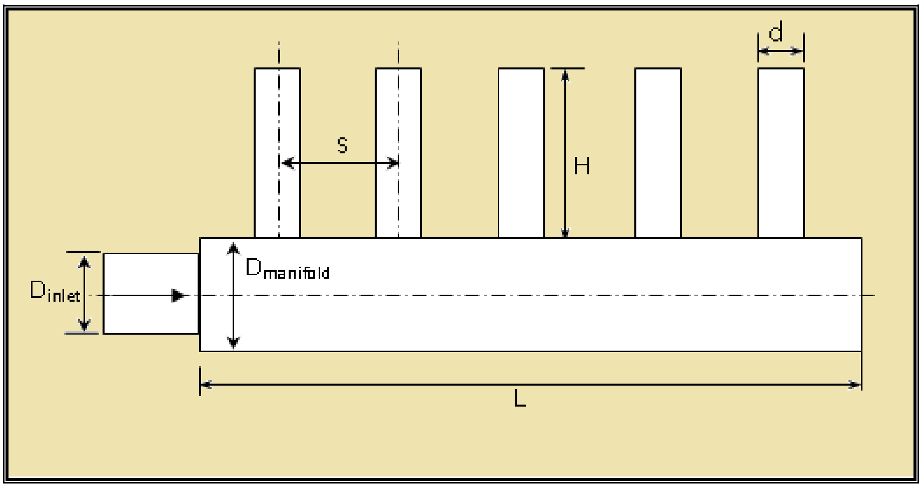

Figure 2: a schematic diagram of test section model

Table 1: Dimensions of cases

case	D_1, mm	D_{inlet}, mm	d, mm	N	S
1	100	100	50	5	220
2	100	90	50	5	220
3	100	70	50	5	220
4	100	50	50	5	220

III. RESLUTS AND DISCUSSION

The base case of these variations is a diameter of 100 mm., and the range is from 100 to 50 mm. The diameter of the distribution manifold (D1) is kept fixed at 100 mm, and the angle at which the flow enters the manifold is perpendicular to the cross section. the inlet water flow rate is 790 l/min. for all cases.

The result of flow ratio of this methodology is illustrated in Fig. 3. From the figure, it is seen that the use of inlet diameter (Di) different from that of manifold leads to a clear change in flow distribution through lateral pipes. When the inlet diameter (Di) is decreased to 90 mm, the difference in flow ratio between first and last lateral pipe is 58% compared with 59% of the base case. This means that there is no improvement in flow uniformity.

Figure 4 shows that the relationship between the inlet diameter and the non-uniformity coefficient (Φ). From this figure, it is seen that the decrease in the diameter of the inlet does not give rise to improvement in performance where the standard deviation from uniformity increases sharply.

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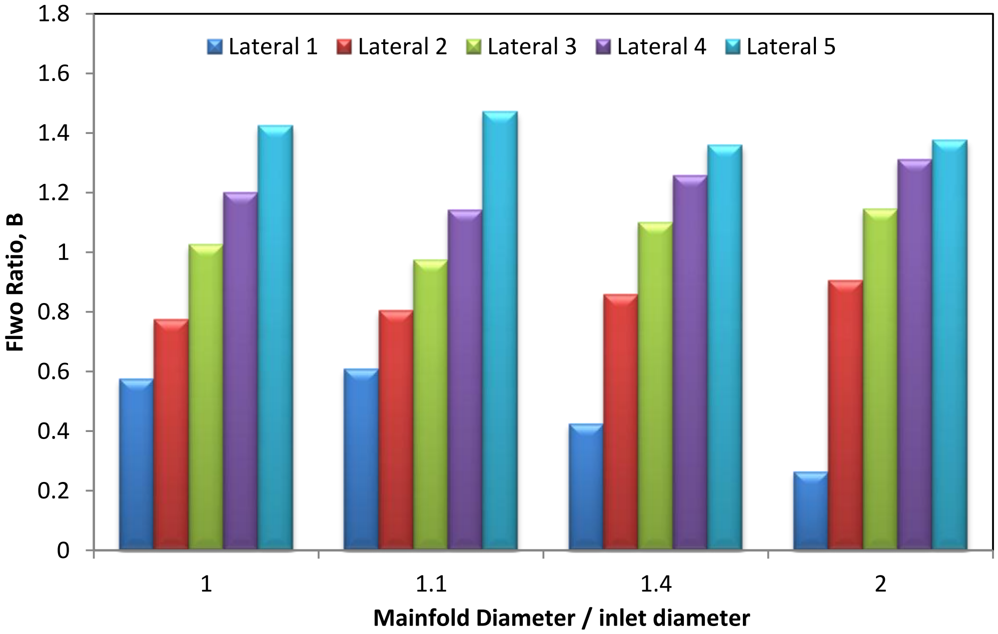

Figure 3: Flow ratio (β) at different inlet diameters.

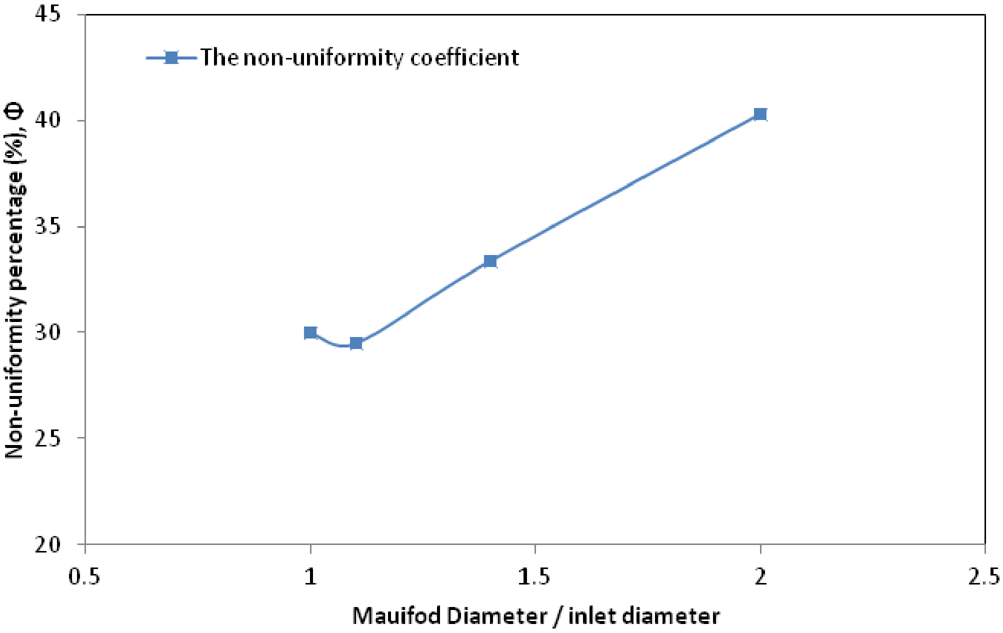

Figure 4: Effect of inlet diameter on the outflow lateral flow rates uniformity.

IV. CONCLUSION

The methodology of changing cross-section area of main pipe to the header is a negative step in the quest for flow uniformity as the coefficient of non-uniformity increased from 0.3 to 0.401.

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