

Technical Paper:

Flow Analysis in Pipe of a Manifold Block

Osamu Abe*, Tetsuhiro Tsukiji*, Takeshi Hara*, and Kazutoshi Yasunaga**

*Sophia University

7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-8554, Japan

E-mail: t-tukiji@sophia.ac.jp

**TOKYO KEIKI INC.

1-1 Sakae-cho, Sano-shi, Tochigi 327-0816, Japan

[Received February 1, 2012; accepted April 19, 2012]

Manifold blocks are recently used to connect hydraulic components in hydraulic system, which has flow channel inside. They are useful for reducing the size and weight of hydraulic systems. This paper deals with solid manifold block and laminated manifold block. They are different from machining. We investigate pressure drops of their pipe flow with Computational Fluid Dynamics (CFD) and compare those of two types. And then, we conduct experiment, measuring pressure and visualization, to validate the results of CFD analysis. By using these results, we are intended to obtain guidelines for pipeline design in laminated manifold block.

Keywords: manifold block, pipe flow, CFD, pressure drop, cavitation

1. Introduction

Hydraulic machines have many valves and piping parts. So there are problems that much space is needed and plumbing is more troublesome. Recently, as one of the methods to reduce the space and piping parts, manifold system is developed. This system is the method of connecting valves and actuators by using steel blocks that have pipelines inside. These blocks are called ‘Manifold Block.’ It is said that pressure drop of pipe flow in the block because it has many curved section. However, pipe flow in the block has hardly been researched ever though curved pipe flow such as bend or elbow is researched by many workers [1, 2].

Manifold block is generally classified into two types by way of machining. One is a solid manifold block (solid type) that has some holes by drilling as shown in Fig. 1. The other is a laminated manifold block (laminated type) that is composed of some blocks grooved and drilled in advance. In solid type, design of pipeline is relatively simple since its pipeline only connects some holes, but it is impossible to design pipeline freely. On the other hand, in laminated type, it is possible to design pipeline freely because it has pipes of rectangular groove, but it is difficult to weld blocks. So it takes much time to manufacture

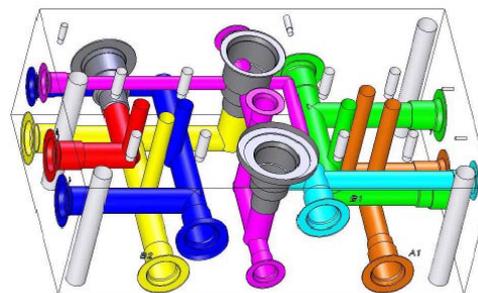
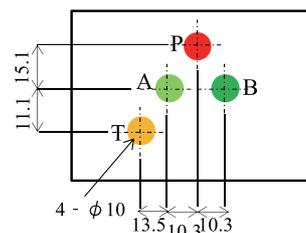
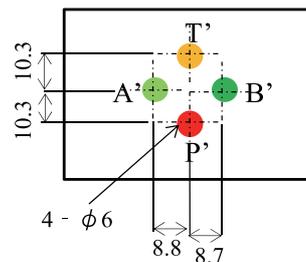


Fig. 1. Solid manifold block.



(a) Ports of one valve



(b) Ports of another valve

Fig. 2. Port standards of valves.

laminated type.

This study focuses on estimating pressure drop of pipe flow in two types as follows with CFD. And by using these results, we aim obtainment of guidelines for pipeline design in a manifold block. Furthermore, we also verify the validity of the CFD results by comparison of CFD results with pressure measurement. In this paper, however, we deal with a manifold block as port converter in case of substituting a valve as shown in Fig. 2(a) for another valve as shown in Fig. 2(b) when we compare two types.

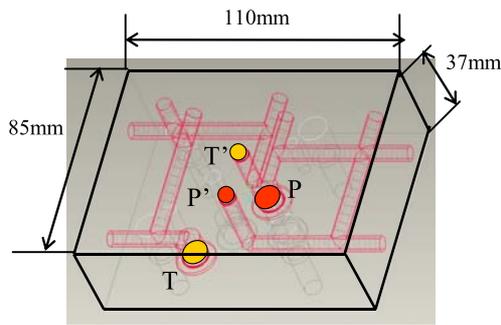


Fig. 3. Port converter of solid manifold block.

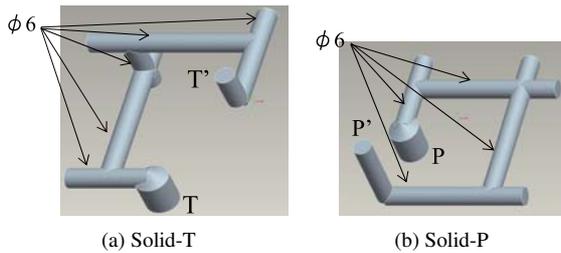


Fig. 4. Flow channels in solid manifold block.

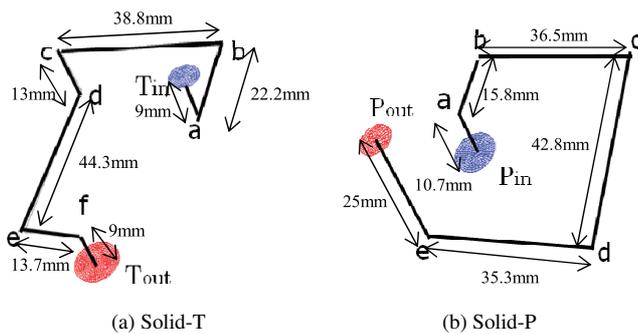


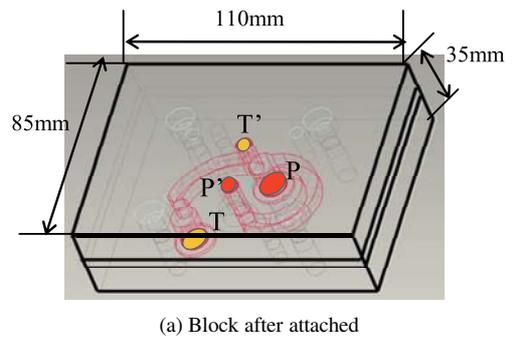
Fig. 5. Central axis of solid type.

2. Comparison of Two Types

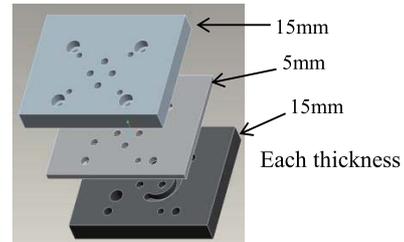
2.1. Objects of Analysis

Figure 3 shows a port converter of solid type. And Figs. 4(a), (b) show flow channels in the block connecting the port T with T' (solid-T) and P with P' (solid-P). These channels go around because they must avoid tapped holes for attachment and other channels. Central axis of solid type is shown in Figs. 5(a), (b). Fig. 6(a) shows a port converter of laminated type (laminated 1). This is composed of three blocks as shown in Fig. 6(b). In the same, Figs. 7(a), (b) show flow channels in the block (laminated 1-T and laminated 1-P, respectively). Unlike solid type, it is possible to connect ports by curved channel. To compare with solid type, we deal with flow channels that are the same length of central axis as solid type channel as shown in Figs. 8(a), (b) (laminated 2-T and laminated 2-P, respectively). Cross section of groove is 6 mm square.

Analysis objects are the above six flow channels. In this paper, we analyze them by FLUENT12.0. SST $k - \omega$



(a) Block after attached



(b) Three blocks before attached

Fig. 6. Port converter of laminated manifold block (laminated 1).

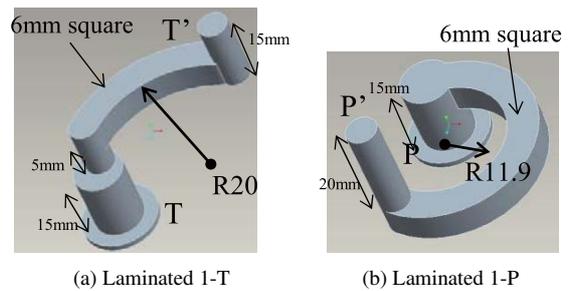


Fig. 7. Flow channels in laminated 1.

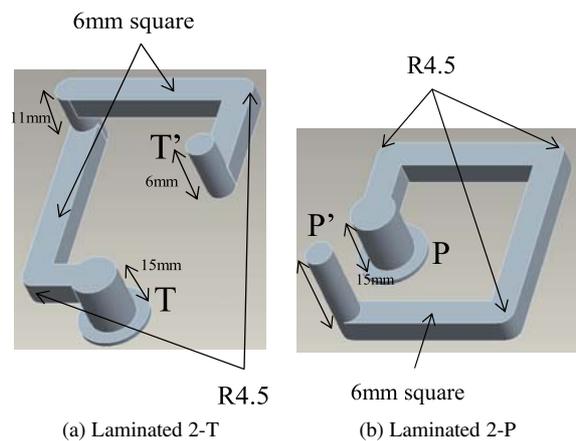


Fig. 8. Flow channels in laminated 2 (Like solid type).

model is used for turbulence model along the lines of the study in past times [3]. Inflow boundary condition is set to velocity inlet (uniform flow), and outflow boundary condition is set to pressure outlet (0 MPa). Those flow channels contain tetrahedral and hexahedral cells. Properties of working fluid is $\rho = 870 \text{ kg/m}^3$, and $\nu = 32 \text{ mm}^2/\text{s}$ where $T = 317 \text{ K}$ (40 degrees Celsius).