"Drifting Cups on a Meandering Stream" in Japan

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Drifting Cups on a Meandering Stream (Kyokusui-no-En) is a Poetry Party that had its origin in ancient China, and was introduced to Japan passing through Korea. The flow of the meandering stream was made clear using the flow visualization techniques, surface floating method, PTV and the numerical simulation. At the same time, the motions of floating cup, the floating speed, rotating speed and the trajectory of the cup were also analyzed by using an originally developed image processing technique. Based on these researches, the model channel was considered. To make this party interesting the channel must has the characteristic that the drifting cups take the random pass and stagnant at the unexpected place. This model channel is satisfied with these conditions and the fluid mechanics consideration is performed on the both points of the experimental visualization and numerical simulation.

Key Words: Surface Flow on a Meandering Stream, Motion of Floating Cups, Numerical Simulation, Surface Floating Method, PTV, Model Channel for Poetry Party

1. Introduction

"Drifting Cups on a Meandering Stream" (Kyokusui-no-En) is a ceremony where a meandering ditch is made to let water flow and a several number of poets sitting on the banks of ditch are expected to make poems by the times when wine-filled cups pass in front of them. On finishing poem making, poets pick up cups to drink.

This poetry party was originated in ancient China in the 4th century. Recently, this poetry party was reappeared using the old actual channel in the Japan garden (Nakayama et al., 2001). The elegant movement of the floating cups in the water channel was generated by the meandering channel, the hollowed sidewall and the stone arranged with in the channel. At the poetry party, the cup movement and the flowing speed are very important factors to compose the poems.

In this paper, the flow of two actual channels was analyzed quantitatively using the flow visualization techniques and numerical simulation.

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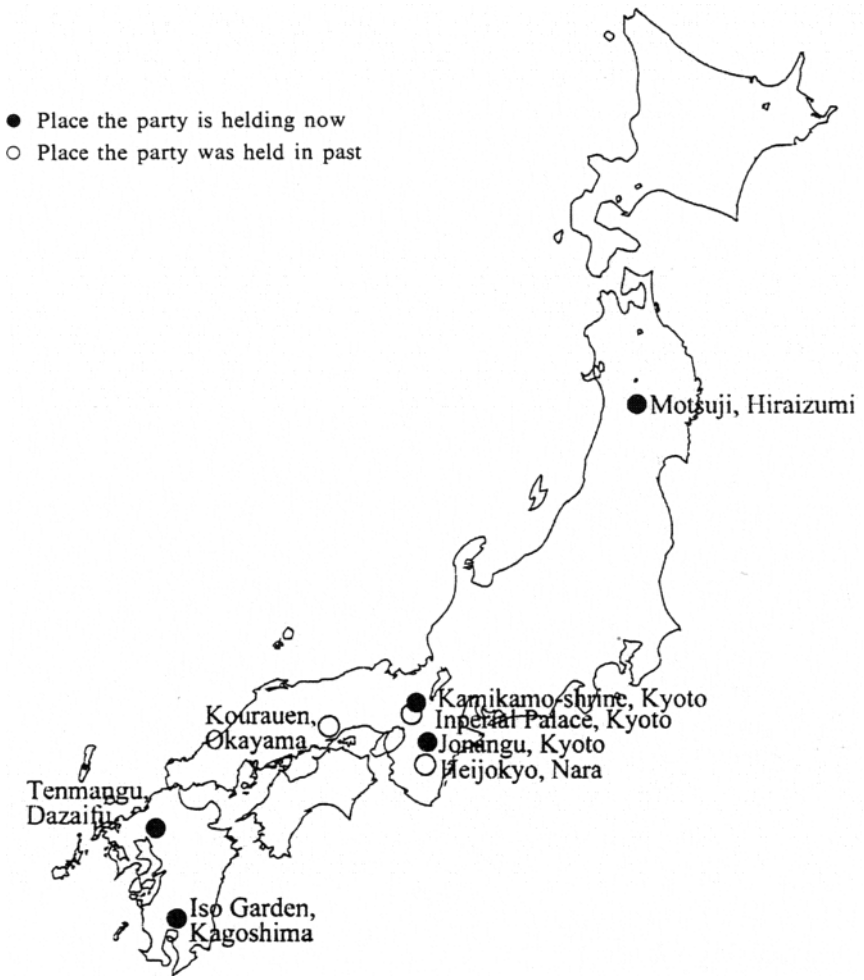


Fig. 1 Kyokusui-no-En in Japan

Fig. 2 Party of Jonangu (Dynasty style)

Fig. 3 Party of Iso Garden (Samurai style) (Shoko Shuseikan Museum, 1992)

The relationship between the cup motions and the surface flow conditions were made clear.

Based on these results, the model channel was considered and designed the new channel satisfied these conditions (Oki et al., 2001).

2. History

It is a famous story that on March 3 of 353 AD, Wang Xi-shi for the first time summoned 41 men of letters to Lanting (Orchid Pavilion Garden) to open a party by drifting cups on a meandering stream (Wei et al., 2001).

Later, this sort of party came over to Korea (Chang, 2001) and was introduced into Japan. In Japan, Nihon-Shoki (Chronicle of Japan) states that the party was held on the first day of Serpent in 485. In Nara Age (8th century) it was regularly held on March 3. In Heian Age (9th century and on) it became more popular and parties were held in the presence of emperor, and higher officials and men of letters presented their original poets under respective subjects. Even in this modern age, these sorts of parties are still held every year at 5 places in Japan as shown in Fig. 1. Two examples of these parties are shown in Figs. 2 and 3.

3. Meandering Stream

3.1 Actual channel

For actual channel, two places of the meandering stream were selected to experiment. One is Jonangu in Kyoto and the other is Iso Garden in Kagoshima City. The shapes of two streams are shown in Figs. 4 and 5. As shown in these figures, the meandering channels of Jyonangu and Iso Garden are respectively 105 cm and 165 cm in maximum width, 50 cm and 30 cm in minimum width, approx. 30m each in full length, and about 30 cm and 50 cm in head. On the banks of these streams, 7 poets for Jonangu and 8 poets for Iso Garden sit down to make poems.

The numerical simulation and the visualization experiments were made on the stream of the test part for Jonangu in Fig. 4, and on the stream of the test parts A and B for Iso Garden in Fig. 5.

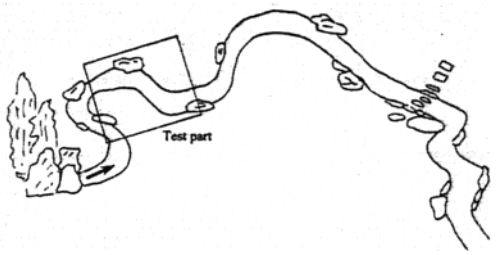


Fig. 4 Channel of Jonangu

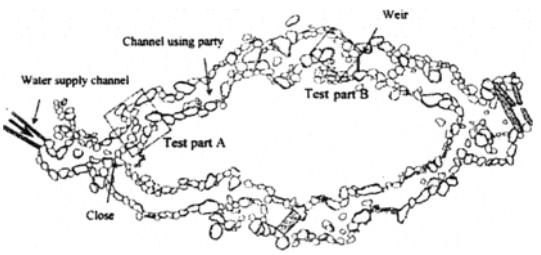


Fig. 5 Channel of Iso Garden

The stream draws a nice curve by the rocks and nooks at appropriate places, and generates, though unseen, vortices, stagnations and reversal flows, so that wine cups flown by children from the upstream pass most exquisitely in front of the poets. Indeed, this is a nice fruit of wisdom of the ancient people.

3.2 Model channel

To make this poetry party interesting, the channel must has the characteristics that the drifting cups take the random pass and stagnant at unexpected places. This model channel is planned to construct in Iwatsuki Park, Saitama Prefecture in Japan. To confirm the flow condition, 1/30 model is made and the fluid mechanics consideration is performed on the both points of the experimental visualization and numerical simulation.

As shown in Fig. 6, the model channel is made of wood, and has the width of maximum 123 mm and minimum 18 mm, and the length is about 1.83m, and the water depth is 2cm. The experiments and computation are performed about the whole length of the channel.

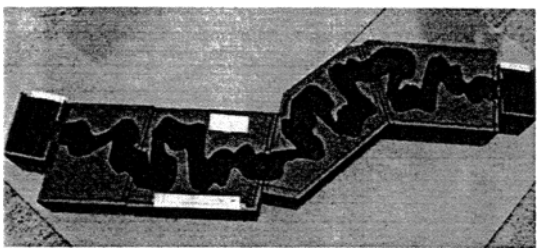


Fig. 6 Model channel

4. Numerical Simulation

For actual channel, the test parts in Fig. 4 and 5 were modeled, and on these regions, the numerical simulation was performed using the finite element method. The steady analysis was made on the fluid regarding it as a incompressible flow and also as the two-dimensional flow near surface. In Iso Garden, the turbulent analysis using the mixing length model was performed. As the inlet boundary condition, the actually measured uniform flow velocity 0.21m/s for Jonangu and 0.30 m/s for Iso Garden was used.

For model channel, the numerical simulation was performed by means of the finite volume method. The analysis was made in unsteady two-dimension turbulent flow. The RNG k-ε model (Yakhot and Orszag, 1986) was used as a turbulent model. As the inlet boundary condition, the actually measured uniform flow velocity 0.04 m/s was used.

5. Visualization Experiment

5.1 Surface floating method

In the visualization experiment, the surface floating method was used in order to visualize the whole flows on the test parts in Figs. 4, 5 and 6. As the tracer, the baby powder ("Siccarol") and cough powder ("Ryukakusan") were used. Each of the powders were wrapped in gauze and puffed evenly over the upper reach. The former is hard to scatter and develops into a film of relatively high density, while the latter is of fine particles and is evenly puffed developing a thin film.

5.2 PTV

On the test part in Fig. 5, the velocity measurement by PTV was performed. The surface flow of the channel is visualized by the polystyrene form particle whose mean diameter is about 7 mm, and the specific density is about 0.1. The surface flow velocity was measured by tracking of the particle using a set of four-time-steps of consecutive images (Kobayashi et al., 1989).

The cup motions were also analyzed. The cup model is a circular disk made of wood whose diameter and thickness are 50 mm and 30 mm respectively. The draft of the cup is 15 mm, which is coincided with the real cup filled in the wine. The motions of floating cup, the floating speed, rotating speed and the trajectory of the cup were analyzed by using the originally developed image processing technique (Kobayashi et al., 1997).

6. Results and Discussion

6.1 Actual channel

The calculated stream lines in Figs. 4 and 5 are shown in Figs. 7(a) and 8(a). The visualized results by the surface floating method of the same figure are shown in Fig. 7(b) and 8(b). From these figures the big vortices can be seen behind the stones and the stagnant regions occur in the alcoves of the stream.

The comparison of the PTV result of the flow velocity with the calculated result at the part A in Fig. 5 is shown in Fig. 9. From this comparison, both results are well agreeing with qualitatively as well as quantitatively.

Figure 10 shows the typical trajectories of the cup at the parts A and B in Fig. 5. Here, four different types of the cup trajectories were selected to show the typical cup motions. The cup T1 flows smoothly and floating speed is nearly equal the main flow speed. The changes of cup T2 motion in the part A were mainly raised up due to the impact of the cup to the rock. At the part B, the cup shows more complicated motions adding rotation.

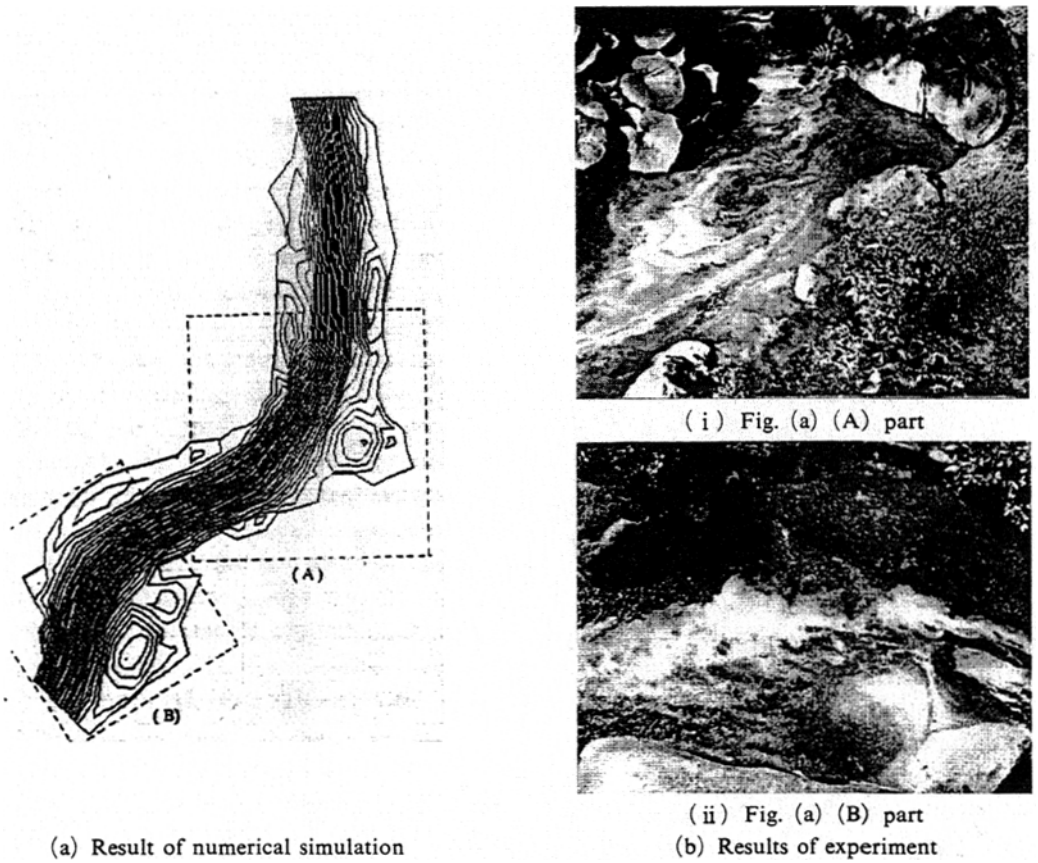


Fig. 7 Results of experiment and numerical simulation in Jonangu

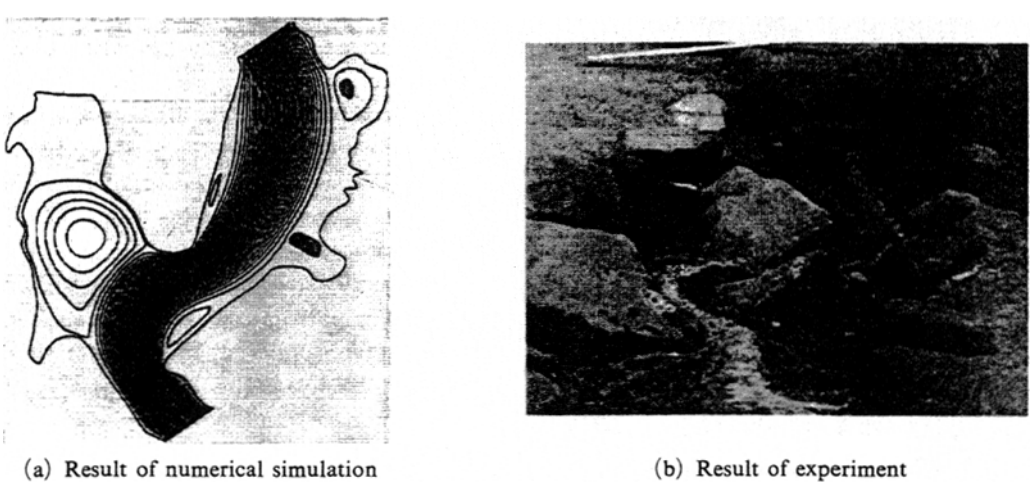
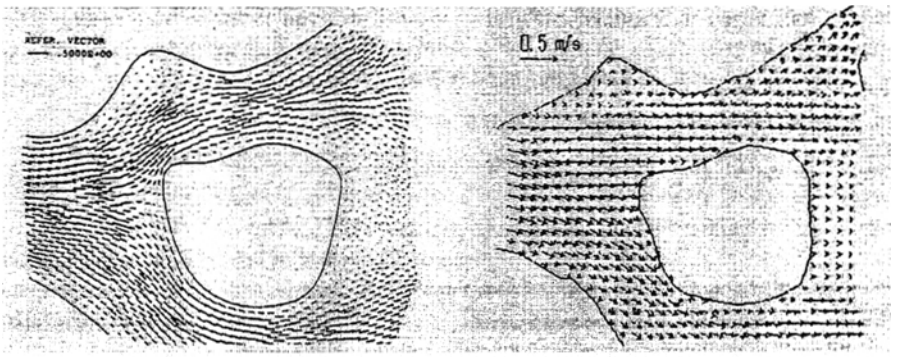


Fig. 8 Results of experiment and numerical simulation in Iso Garden (Part B)

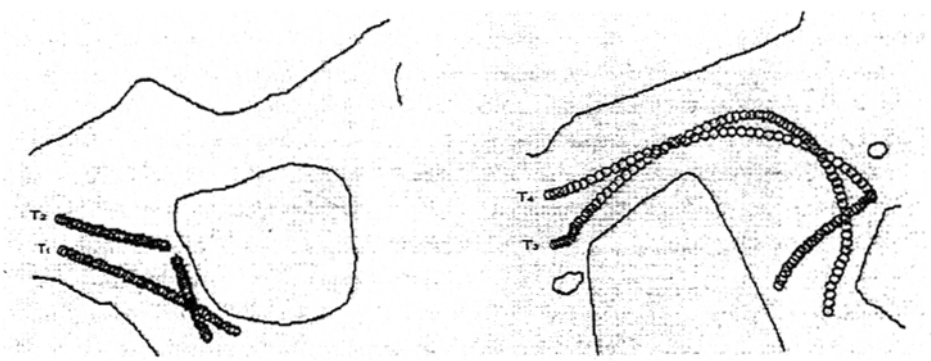
6.2 Model channel

One example of the calculated stream lines and the visualized result by the surface floating method are shown in Fig. 11. From these figures, the flow pattern by computation agree well with the visualized results. Thus it is found that the stream



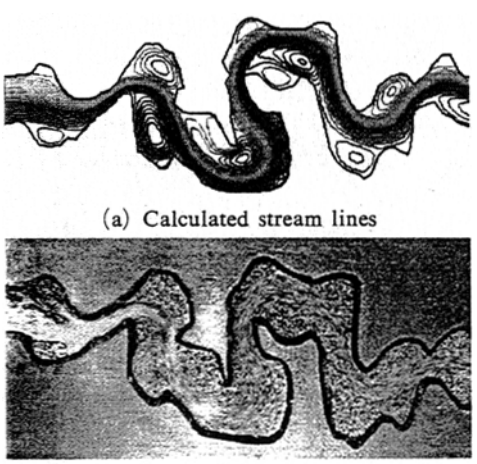
(a) Numerical simulation (b) PTV

Fig. 9 Results of velocity distribution in Iso Garden (Part A)



(a) Part A (b) Part B

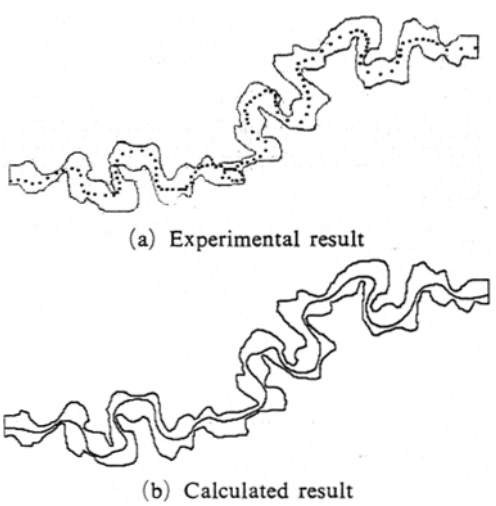
Fig. 10 Results of trajectories of the cup in Iso Garden



(a) Calculated stream lines

(b) Visualized result

Fig. 11 Comparison of calculated stream lines with visualized result



(a) Experimental result

(b) Calculated result

Fig. 12 Drifting path of the cup

of the model channel is so designed as to let vortices, reverse flows and stagnations develop everywhere for making the cup movement elegant.

Putting a model cup on the inlet of channel, the drifting path of the cup is examined by the

experiment, and compared with the path line by numerical simulation. The results are shown in Fig. 12. The both results almost agree with each other. These drifting styles of cup make the poetry party very elegant and interesting.

7. Conclusions

(1) On the channel flow of the complex shape, the experimental results on the flow pattern and velocity distribution agreed well qualitatively with those of numerical simulation. With regard to the measurement of PTV, both results also agreed well quantitatively at the places where the flow was not complicated.

(2) It was found that the stream of model channel was nicely designed for producing vortices, reversal flows and stagnations everywhere for making the flow of cups elegant.

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