isbn 978-979-96152-8-2

Mathematical Harmony in Science and Technology

SEACMA 2013

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2013

PROCEEDING

South East Asian Conference on Mathematics and Its Applications

"Mathematical Harmony in Science and Technology"

1960 - 2013
ITS KREATIF ETOS UNGGUL

November, 14-15 2013

PROCEEDING

SOUTH EAST ASIAN CONFERENCE ON MATHEMATICS AND ITS APPLICATIONS

SEACMA 2013

"Mathematical Harmony in Science and Technology"

Published by:

MATHEMATICS DEPARTMENT

INSTITUT TEKNOLOGI SEPULUH NOPEMBER SURABAYA, INDONESIA

PROCEEDING

SOUTH EAST ASIAN CONFERENCE ON MATHEMATICS AND ITS APPLICATIONS

SEACMA 2013

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Prof. Dr. M. Isa Irawan, MT.
Dr. Subiono
Subchan, Ph.D
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ISBN 978-979-96152-8-2

This Conference is held by cooperation with
Mathematics Department, ITS

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Mathematics Department
Kampus ITS Sukolilo Surabaya 60111, Indonesia
seacma@its.ac.id

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Message

from the

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On behalf of the Faculty of Mathematics and Natural Sciences, Institut Teknologi Sepuluh Nopember, it is a great honor and sincere to welcome all participants to the second of South East Asian Conference on Mathematics and Its Application (SEACMA 2013).

This year, Department of Mathematics, Institut Teknologi Sepuluh Nopember, have honor to organize this meaningful conference. I believe that the purpose of this conference is not only sharing knowledge among the mathematician and scholars in related fields but also to hearten new generation of expertise in mathematics to realize the science and technology advancement.

It is undeniable that there is mathematical harmony in science and technologies. Many disciplines like engineering, computer science, information technology, operational research, logistics management, risk management and many others are all the products of mathematics. Thus, it is essential that we must hold this annual conference as a stage for all scholars in finding new ideas and applications on Mathematics.

Greatly thank to all supportive session including organizing committee, keynote speakers, invited speakers, paper reviewers, participants and sponsors. This event will not achieve without you all. Finally, I hope that the outcome of SEACMA 2013 will be pleasing and most useful to everybody.

Sincerely yours,

Prof. Dr. R.Y. Perry Burhan
Dean

Message *from the*
Chairman
Organizing Committee

On behalf of the organizing committee it is my pleasure to welcome you to the South East Asian Conference on Mathematics and Its Applications. The conference aims to provide a forum for academics, researchers, and practitioners to exchange ideas and recent developments on mathematics. The conference is expected to faster networking, collaboration and joint effort among the conference participants to advance the theory and practice as well as to identify major trends in mathematics.

We are also very pleased to welcome keynote speakers of the conference: Prof. Dr. Ir. Arnold W. Heemink, from Delft Institute of Applied Mathematics, Netherlands, Prof. Dr. Muhammad Isa Irawan, MT, from Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia, and Dr. Said Munzir, M.EngSc, from Syiah Kuala University, Indonesia, Dr. Nguyen Van Sanh, from Department of Mathematics, Faculty of Science, Mahidol University, Thailand.

We will spend about a day together for the conference. This conference is attended delegates and contributors from Indonesia, Malaysia, Thailand, and Netherlands Such a spread of participation from around the world confirms the appropriateness of the “National” label of this conference. There are 35 papers to be presented orally. Papers presented in the conference will be included in the conference proceeding to be published at the conference.

The organizing committee would like to express our deepest appreciation to ITS Rector, keynote speakers, head of departments of Mathematics of ITS, and sponsors for the support, without all mentioned this conference may not be happened. Furthermore, my appreciation goes to the members of the committee for their hard work and cooperative teamwork in the preparation of the conference. Finally, we wish all participants enjoy a fruitful scientific and human discussion.

Subchan, PhD
Conference Chairman

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Tentative schedule

Thursday, 14 November 2013

07.30 – 08.00 : Registration

08.00 – 08.30 : Opening Ceremony

08.30 – 09.00 : Keynote Session 1 by Prof. dr. ir. Arnold W.Heemink (Netherland)

09.00 – 09.30 : Keynote Session 2 by Dr. Said Munzir, M.EngSc (Indonesia)

09.30 – 10.00 : Discussion Session

10.00 – 10.15 : Break

10.15 – 10.45 : Keynote Session 3 by Dr. Nguyen Van Sanh(Thailand)

10.45 – 11.15 : Keynote Session 4 by Prof. M. Isa Irawan(Indonesia)

11.15 – 11.45 : Discussion Session

11.45 – 13.00 : Break

13.00 – 16.00 : Parallel Session

 ISBN 978-979-96152-8-2

Mathematical Model of Drag Coefficient of Tandem Configuration on $R_e = 100$

Chairul Imorn[1], Suhariningsih[2] Basuki Widodo[3], and Triyogi Yuwono[3]

[1] Post Graduate Student of Universitas Airlangga (Unair) and
Lecturer of Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia
imron-its@matematika.its.ac.id,
[2] Universitas Airlangga (Unair), Surabaya, Indonesia
[3] Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia

Abstract. Numerical simulation of a tandem configuration of both *I*-shape and circular cylinder at two-dimensional. Diameter of circular cylinder is D as the bluff body and I-shaped cylinder has diameter of d with a cutting angle 53^o as passive control, that is located in front of the bluff body. Navier Stokes equations are used to solve this problem and solved with a finite difference method. When we put the Reynolds number of $R_e = 100$, the domain distance between bluff body and passive control is a $S/D = 0.6, 1.2, 2.4$ and 3.0 then we obtain profile streamline around the bluff body, pressure distribution, separation point on the top around the 125^o and on the bottom around 225^o, and mathematical models of drag coefficient.
Mathematics Subject Classification: 76D05, 65D05

Keywords: Passive control, drag coefficient, wake, streamline.

1 Introduction

Research carried out carefully to produce advanced technology and will change of human behavior towards the technology itself. Research carried out with experimental or simulated manner, will result in a profitable thing for humans. In the field of fluid dynamics research, research on fluid flow through a circular cylinder as bluff body and I-type cylinderas as passive control in front of the bluff body. Research carried out by numerical simulations will produce a drag coefficient, pressure distribution, the point of separation, and streamlined around bluff body.

In fact, many found the interaction between fluid flow with some objects. Some examples that often we find, among others, offshore building, overpass structures and other engineered products are often designed in the group. The construction will receive loads from above and around. The object is usually called a bluff body or body in which geometric shapes was varied and usually in groups. Geometric shapes are the main factors that must be considered in designing an object, because the flow of fluid through the different objects will produce different characteristics, so the object is a stand-alone or in groups.

Laminar and turbulent flow through the surface of the object, the surface around the particle will move slowly due to the viscous force, so that the particle velocity is relatively zero. While others try to flow to move slowly as a result of the interaction between fluid motion faster and slower flows. It's a phenomenon that can increase the strength or shear stress. Shear stress will affect the speed at each layer, it is called the boundary layer.

Research on the phenomenon of fluid flow on the surface of an object growing fast. The concept of the boundary layer manages to uncover some answers to the influence of shear stress plays an important role on the characteristics of a drag around the object[13]. For example, several studies have been done that the fluid flow through a single circular cylinder[12], which is modified into either D-shape cylinder or I-shape cylinder [8, 10]. In addition,this is also an example, i.e. the fluid flow through more than one cylinder of different sizes and tandem configuration[3, 4, 6, 7].

Flow across a circular cylinder will produce adverse drag. The amount of drag is influenced by several parameters, one of which is the drag coefficient C_D. One way to reduce the drag on a circular cylinder is to add a small circular cylinder in front of a circular cylinder called passive control cylinder. Experiments have been done in that way, which can reduce the drag coefficient of 48% compared with the no passive control[3]. It has also been done with varying Reynolds number and result in minimum pressure coefficient $C_{P_{min}}$ is lower [4].

Characteristics of flow through the D-type and I-type cylinder, indicating that the cutting angle (θ_s) to reach 53^o, the coefficient of drag (C_D) reached 50% of C_D cylinder circular. If $theta_s > 60^o$, then C_D will be greater than C_D when $\theta_s > 60^o$[8]. I-type cylinder with angle 65^o as a passive control with $R_e = 3.8 \times 10^4$ provide a drag reduction of 7% smaller than the circular cylinder without cutting[6]. I-type cylinder with a cutting angle $\theta_s = 65^o$ has a drag coefficient is greater than I-type cylinder with a cutting angle $0^o \leq \theta_s < 65^o$, having formed in the passive cylinder control with cutting angles $\theta_s = 65^o$ is greater[2]. All the above results based on experimental research.

I-shape cylinder with cutting angle $\theta_s = 53^o$ has most width wake than the other cylinders. The shear layer formed is also suspected to be more wider width and stronger disturbing flow on walls of bluff body. Therefore, the transition from laminar into a turbulent boundary layer will occur more quickly, so the momentum of the turbulent flow are better able to resist the adverse pressure gradient and friction along the walls of the bluff body, the result of those will delay separation flow. When the separation flow delay, then the wake formed on a bluff body becomes narrower. This is obtained in a reduction in drag on a bluff body.

Based on the above results, and the passive control is a I-shape cylinder with $\theta_s = 53^o$ and Reynolds number $R_e = 100$ which causes a turbulent flow [1] and the tandem arrangement can be seen in Figure 1. Rasio S/D varies from 0.6 to 3, which is S is distance center of bluff body and center of passive control,

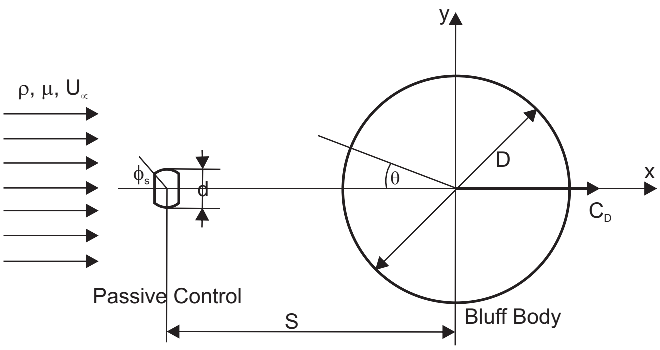

Fig. 1. Schematic of passive control and bluff body

and D is diameter of bluff body. By using these parameters it will be sought from the mathematical model of drag coefficient of the bluff body, in which the wake behind the bluff body and the location of separation point are also take consider.

2 Numerical Method

Let see Navier-Stokes equations for unsteady incompressible fluid,

$$\frac{\partial \mathbf{u}}{\partial t} + \nabla \cdot \mathbf{uu} = -\nabla P + \frac{1}{Re}\nabla^2 \mathbf{u} \tag{1}$$

$$\nabla \cdot \mathbf{u} = 0. \tag{2}$$

where $\mathbf{u}$ is the velocity, P is the pressure, and Re is the Reynolds number. To solve the above equations using numerical solution technique, it needs to do the following steps. The first step to ignore the pressure, so equation becomes

$$\frac{\partial \mathbf{u}}{\partial t} = -\nabla \cdot \mathbf{uu} + \frac{1}{Re}\nabla^2 \mathbf{u} \tag{3}$$

This equation further is solved and it is obtained $\mathbf{u}$, then

$$\frac{\partial \mathbf{u}}{\partial t} = \frac{\mathbf{u}^{**} - \mathbf{u}^{*}}{\triangle t} = -\nabla P \tag{4}$$

We now put divergence on both sides, the result

$$\frac{\nabla \mathbf{u}^{**} - \nabla \mathbf{u}^{*}}{\triangle t} = -\Delta P \tag{5}$$

and since $\nabla \mathbf{u}^{**} = 0$, then the equation turns into

$$\frac{\nabla \cdot \mathbf{u}^{*}}{\triangle t} = -\Delta P \tag{6}$$

This equation is called the Poisson equation and we will obtain the P. The last step is a correction velocity, ie.:

$$\frac{\partial \mathbf{u}}{\partial t} = -\nabla P \tag{7}$$

3 Result and Discussion

Numerical simulations of the Navier-Stokes performed with the following conditions, the Reynolds number of 100, velocity in the horizontal direction $U = 1.0$ and in the vertical direction $V = 0.0$, the grid size is 400×800, bluff body diameter D and passive control diameter d. To obtain the data, four variations of S/D is $0.6, 1.2, 2.4$ and 3.0. Pressure distribution on the bluff body with a range of 10^o, starting from the front of the bluff body and rotates clockwise. Numerical simulations are run as much as $99,999$ iterating and iterating each $1,000$ numerical results are stored in a file. Because $R_e = 100$, then the flow is turbulent flow, so that the vortex[1]. Therefore, the flow through the bluff body is unbalanced. The comparison of the drag coefficient (C_D) with some previous studies in Tabel 1.

Table 1. The Comparison of Average Drag Coefficient of $R_e = 100$

Authors	Present Study	Lima[5]	Zulhidayat[9]	Sintu[11]
C_D	1.358	1.39	1.4	1.431

3.1 Pressure distribution

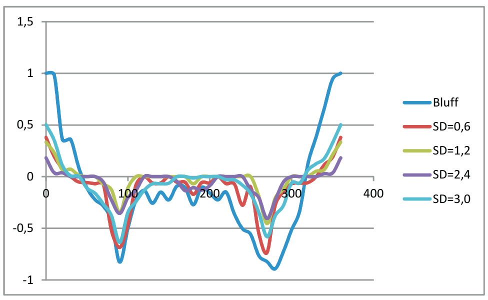

Fig. 2. Pressure Distribution on Bluff Body

Coefficient of pressure distribution C_p on bluff body with $R_e = 100$ for four different ratios (S/D) is shown in Figure 2. Coefficient of pressure distribution on the front area of the bluff body of passive control is always smaller than the bluff body without passive control. It is caused by obstruction of the flow by passive control, has been described by Tsutsui and Igarashi[4]. Coefficient of pressure distribution on the bluff body has a max or min values, can be seen in Table 2.

Table 2. Pressure Distribution

S/D	0.6	1.2	2.4	3.0
$C_p max$	0.3789	0.333	0.1818	0.5016
$C_p min - upp$	-0.6858	-0.3466	-0.356	-0.6363
θ	90^o	90^o	90^o	90^o
$C_p min - low$	-0.7346	-0.4542	-0.4056	-0.5812
θ	270^o	270^o	270^o	270^o
Separation point up	129.5^o	135.5^o	132^o	139^o
Separation point low	231.5^o	224.5^o	233^o	223^o

The pressure coefficient C_{p-max} of bluff body without passive control is 1.0, and minimum pressure coefficient of upper area of -0.8267 locates at position 90^o, and lower area of -0.8226 locates at position 280^o. Upper separation point occurs at the angle of approximately 128^o and bottom separation point at the angle of about 233^o

3.2 Streamline

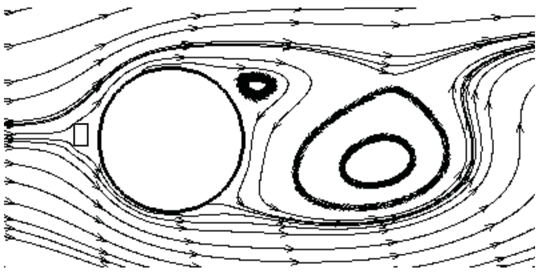

Fig. 3. Streamline of $S/D = 0.6$

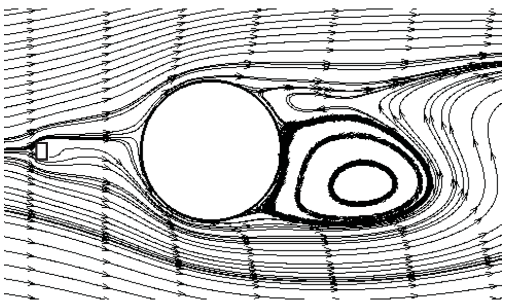

Fig. 4. Streamline of $S/D = 1.2$

The results of numerical simulations of the Navier-Stokes equations to produce a streamlined bluff body with a passive control in front of main cylinder are depicted, in Figure 3 and 4. In accordance with the above explanation, the $R_e = 100$, the flow hits an object and produces, vortex behind the object. The vortex behind objects occur periodically. Vortex away from the object, it will be smaller and finally disappears into the surging stream at a slower rate. Flow velocity behind the passive control depends on the distance between the passive control and the bluff body.

Behind the passive flow control in which lower speed will hit the front of the bluff body, the flow moves to the top of all, down all, or part of the upper portion of the bluff body down and meets with the free flow. If the velocity of the flow at the top and the bottom respectively has the same speed and the vortex that occurred just behind the bluff body, the wake formed symmetric. However, if the flow rate is not balanced, and the vortex is formed behind the main cylinder is not directly, then behind the main cylinder wake formed is nearly symmetric.

3.3 Mathematical Modeling of Drag Coefficient

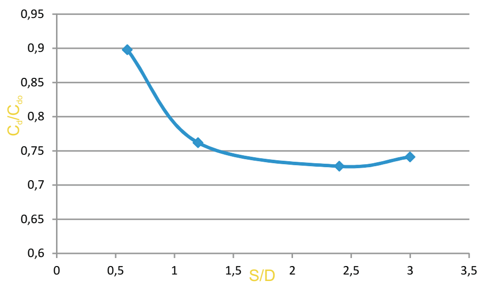

Fig. 5. Variation of C_D/C_{D0} towards S/D

Numerical simulation results will be obtained when the pressure distribution on the wall of the bluff body. Five numerical calculations have been conducted when $S/D = 0.6, 1.2, 2.4, 3.0$. It is therefore obtained drag coefficient, see Table 3.

Table 3. The Value of Drag Coefficient when Variates

S/D	0.6	1.2	2.4	3.0
C_D	1.2195	1.0349	0.988	1.0066

With five drag coefficient data from the Table 3 and by using an approximation, in which the drag coefficient is a function of S/D, we obtain equation,i.e.

$$y = -0.046\ x^3 + 0.342\ x^2 - 0.808\ x + 1.591 \tag{8}$$

We obtain minimum drag coefficient of the bluff body is 0.9748 when $S/D = 1.9428$. This equation is obtain by assuming

$$y = a_0x^3 + a_1x^2 + a_2x + a_3 \tag{9}$$

by letting y as the drag coefficient C_D and x as S/D. We further put the five data, it is obtained

$$\begin{aligned} 1.2195 &= 0.216\ a_0 + 0.36\ a_1 + 0.6\ a_2 + \ a_3 \\ 1.0349 &= 1.728\ a_0 + 1.44\ a_1 + 1.2\ a_2 + \ a_3 \\ 0.988 &= 13.824\ a_0 + 5.76\ a_1 + 2.4\ a_2 + \ a_3 \\ 1.0066 &= 27.0\ a_0 + 9.0\ a_1 + 3.0\ a_2 + \ a_3 \end{aligned} \tag{10}$$

The equations system has five equations and five unknowns, namely a_i with $i = 0, \cdots, 3$. Solve the Equation 10 by using the Gauss-Jordan method, it is obtained a polynomial equation, i.e. Equation 8.

4 Conclusion

Pressure coefficient on the bluff body with passive control is better than without passive control $S/D < 3.0$, the upper separation point around 125^o and lower separation point around 225^o.

Streamline is happened around the bluff body, vortex will occur behind the bluff body on upstream rounds from upper or lower, then moving to the rear vortex that moves up and down. Therefore, the wake is happened allowing near balanced.

Mathematical models of the drag coefficient of a bluff body with the passive control type-I, is

$$y = -0.046\ x^3 + 0.342\ x^2 - 0.808\ x + 1.591$$

From this equation, it can be found that the smallest drag coefficient obtained when $S/D = 1.943$ and $C_D = 0.9748$.

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