International Journal of Research and Review
www.gkpublication.in E-ISSN: 2349-9788; P-ISSN: 2454-2237

Review Article

A Review on Research and Studies on Boundary Layers and Its Affecting Parameters

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Received: 07/08/2016 *Revised: 26/08/2016* *Accepted: 26/08/2016*

ABSTRACT

The boundary layer formation plays major role in momentum, mass and heat transfer. The concept and understanding of boundary layer is important to know the transfer phenomenon in fluids. In flow past immersed bodies, the formation of boundary layer is predominant phenomenon. Formation of boundary layer and its thickness depends on roughness, velocity of flow and fluid properties. The current review emphasizes importance of boundary layer and research and studies on boundary layers.

Key words: Stokes draft, flows, separation, shock wave, pressure, turbulence, roughness.

INTRODUCTION

The flow past immersed bodies depends on geometry, fluid properties and velocity. The drag coefficient is ratio of drag force to the shear due to velocity. There are two types of drags, skin drag and form drag. Skin drag occurs when flow passes the solid. Form drag is generated because of pressure differences along the body. This may be due to the irregular shape of the body also. Many investigators have carried out studies and research on boundary layers for different systems. Current review summarizes research and studies on boundary layers.

BOUNDARY LAYERS: AN INSIGHT INTO RESEARCH AND STUDIES

Paskyabi et al. carried out an investigation on effect of waves on surface boundary layers in ocean. [1] Their included the parameters such as surface wave stress, wind energy input, wave dissipation, and Stokes drift. They conducted a series of model experiments for testing the wave-modified model. Their studies indicated that the Stokes draft plays major role in surface current and boundary layer behavior. Pirozzoli et al. carried out an investigation aimed at analyzing the unsteady effects in shock/boundary layer interactions. [2] Kumar and Kim carried out investigation on wall roughness effects on shock boundary layer interaction flows. [3] These shock boundary layer interactions are observed in devices such as turbine blades, air wings, intake systems for ram jet engines, etc. They drew various conclusions like boundary layer thickening, boundary layer separation and reattachment, shock unsteadiness. They simulated the flow characteristics produced by the interaction of shock wave on boundary layer over a rough wall. They compared characteristics of separation bubble and shock strength for roughened wall with smooth wall simulation. They observed that, as the wall roughness increased, the shock location moved upstream. Also the rough wall produces much higher turbulent kinetic energy along the wall surface. Studies were carried out by Gupta et al. on the boundary layer studies for rough plates under negative pressure. [4] They carried out studies on boundary layers for different objects, which helped them to design streamline object. They used inclined flat plate to create negative pressure. Hamad et al. carried out an investigation on boundary layer flow near the stagnation point on a stretching/shrinking sheet. [5] They studied effects of the effects of thermal jump and variable thermal conductivity on flow and heat transfer near the stagnation point. They observed that with increase in Deborah number, a small increase in wall temperature was observed by them. Also the wall temperature and heat transfer coefficient decreased with an increase in the ratio of specific heats. With increase in stretching parameters, the skin friction decreased.

Direct numerical simulations (DNS) were applied by Schlatter et al., while studying structure of a turbulent boundary layer. [6] They considered a boundary layer with zero pressure gradients and allowed the boundary to develop and grow. They observed that the statistics was in very good agreement with experimental measurements. Gryning et al. carried out an investigation on Long-term boundary layer profiles of wind and weibull distribution parameters. [7] They carried out the studies in rural coastal area. In their studies they found that the wind speed and direction changes with height. According to their studies, nudging reduced the scatter between the simulated and measured wind speeds. An investigation was carried out by Wang et.al on the effects of initial conditions on interaction between a boundary layer over a flat plate. [8] They observed that base vortex enhanced with increase in boundary layer thickness. Filho carried out an investigation on the boundary layers subjected to high free-stream turbulence effects. [9] They tested and modified an active turbulence generator for creating high free-stream turbulence intensities in the wind tunnel. In their investigation, they observed that when the two-dimensional turbulent boundary layer was subjected to high free-stream turbulence effects, the skin friction coefficient increased by 10.5%. Bo et al. conducted an experimental study on cascade boundary layer under different inlet conditions. [10] They changed incidence angle and inlet Mach number for acquiring total pressure in both suction and pressure surfaces. The change in inlet Mach number had very little effect on boundary layer. Tsai et al. carried out investigation on effect of external turbulence on wall jet boundary. [11] The experiments carried out by them indicated that the velocity fluctuation changes the velocity profile. According to these studies, the effect of the grid oscillations causes interactions between the external turbulence and shear layer. According to them, more complex models are needed when the external turbulence contains large intense eddies.

Brandt et al. studied transition in boundary layer subject to free stream turbulence. [12] They performed experiments by varying incoming perturbations. Montague et al. carried out work on simulation of effects of intrinsically dense boundary layer. [13] According to these studies, higher thermal diffusivity due to enrichment in metals acts to suppress internal convection in the models. Lagha et al. carried out an investigation on compressible turbulent boundary layers. [14] They used Navier Stokes equation for analyzing Compressible turbulent boundary layers. They studied the effect of Mach number on turbulence statistics and near-wall turbulence structures. This study revealed that supersonic/hypersonic boundary layers at zero pressure gradients had similarities to incompressible boundary layers. There was significant variation in the probability density function of the velocity dilatation as the Mach number was increased. Satyanarayana et al. carried out an investigation on boundary layer characteristics over a semiarid region in northwest India. [15] According to him, the atmospheric boundary layer and land surface play important role and effect environmental and ecological phenomenon such as monsoon. According to Simens and Gungor, surface roughness plays major role in deciding the boundary layer properties. [16] They found that the type, height, and location of the roughness element affect laminar separation and turbulent transition. They also observed that the transition of the separated boundary layer with wakes was placed at approximately the same stream wise place as that induced by the three-dimensional roughness element.

CONCLUSION

The boundary layer flow and thickness are affected by velocity gradient and physical properties of fluids. Also the nature of surface and shape has significant effect on boundary layers. It was observed by researchers that as the wall roughness increased, the shock location moved upstream in case of roughness effects on shock boundary layer interaction flows. The type, height, and location of the roughness element affect laminar separation and turbulent transition. Few investigations also revealed the atmospheric boundary layer and land surface play important role and effect environmental and ecological phenomenon such as monsoon.

REFERENCES

1. Mostafa Bakhoday Paskyabi A,N, Ilkerfer A, Alastaird. Jenkins, "Surface Gravity Wave Effects on the Upper Ocean Boundary Layer: Modification of A One-Dimensional Vertical Mixing Model", Continental Shelf Research, 2012, 38, 63-78.
2. S. Pirozzoli, J. Larsson, J. W. Nichols, M. Bernardini†, B. E. Morgan And S. K. Lele, "Analysis Of Unsteady Effects In Shock/Boundary Layer Interactions", Center For Turbulence Research Proceedings Of The Summer Program 2010, 153-165.
3. Arun Kumar R, H.D Kim, "Wall Roughness Effects On Shock Boundary Layer Interaction Flows", Proceedings Of International Conference On Energy And Environment-2013 (Icee 2013), On 12th To 14th December Organized By Department Of Civil Engineering And Mechanical Engineering Of Rajiv Gandhi Institute Of Technology, Kottayam, Kerala, India, International Journal Of Innovative Research In Science, Engineering And Technology, 2013, 2(1), 387-394.
4. Vivek Gupta, "Boundary Layer Studies On Rough Flat Plates under Negative Pressure Gradient", Department of Civil Engineering, National Institute of Technology, Rourkela, 2014, 1-75.
5. M. A. A. Hamad, S. M. Abdel-Gaied, Andw. A. Khan, "Thermal Jump Effects On Boundary Layer Flow Of A Jeffrey Fluid Near The Stagnation Point On A Stretching/Shrinking Sheet With Variable Thermal Conductivity", Hindawi Publishing Corporation, Journal Of Fluids, Volume 2013, Article Id 749271, 8 Pages Http:// Dx.Doi. Org/10.1155/2013/749271.
6. Philipp Schlatter, Qiang Li, Geert Brethouwer,Arne V. Johansson, Dan S. Henningson, "Structure Of A Turbulent Boundary Layer Studied By DNS", Http://Www.Springer.Com/978-94-007-2481-5
7. Gryning, S-E., Batchvarova, E., & Floors, R. " A Study On The Effect Of Nudging On Long-Term Boundary Layer Profiles Of Wind And Weibull Distribution Parameters In A Rural Coastal Area", Journal Of Applied Meteorology And Climatology, 2013,52 (5),1201-1207.Doi: 10.1175 /Jamc-D-12-0319.1
8. H. F. Wang, Y. Zhou, C. K. Chan, K. S. Lam, "Effect Of Initial Conditions On Interaction Between A Boundary Layer And A Wall-Mounted Finite-Length-Cylinder Wake", Physics Of Fluids,2006, 18, 1-13
9. Edgar Orsi Filho, "An Experimental Study Of Turbulent Boundary Layers Subjected To High Free-Stream Turbulence Effects", Thesis Submitted To The Faculty Of Virginia Polytechnic Institute And State University In Partial Fulfillment Of The Requirements For The Degree Of Master Of Science In Aerospace Engineering, 2005, 1-112.
10. Xiangfeng Bo, Bo Liu, Pengcheng Zhao, Zhiyuan Cao, "Experimental Investigation Of Boundary Layer Characteristics On Blade Surface Under Different Inlet Flow Conditions", Energy And Power Engineering, 2010,

2, 313-319.
11. Y. S. Tsai & J. C. R. Hunt & F. T. M. Nieuwstadt and J. Westerweel & B. P. N. Gunasekaran, "Effect Of Strong External Turbulence On A Wall Jet Boundary Layer", Flow Turbulence Combust, 2007, 79, 155-174.
12. Luca Brandt, Philipp Schlatter and Dan S. Henningson, "Transition in Boundary Layers Subject To Free-Stream Turbulence", J. Fluid Mech., 2004, 517, 167-198.
13. Nancy L. Montague, Louise H. Kellogg, "High Rayleigh Number Thermo-Chemical Models Of A Dense Boundary Layer In D00", Geophysical Research Letters, 1998, 25(13), 2345-2348.
14. M. Lagha, J. Kim, J. D. Eldredge, And X. Zhong, "A Numerical Study Of Compressible Turbulent Boundary Layers", Physics Of Fluids, 2011, 23, 1-12.
15. A.N. V. Satyanarayana, V. N. Lykossov, U. C. Mohanty, E. E. Machul'skaya, "Parameterization Of Land Surface Processes To Study Boundary Layer Characteristics Over A Semiarid Region In Northwest India", Journal Of Applied Meteorology, 2003,42,528-540.
16. Mark P. Simens, Ayse G. Gungor, "The Effect of Surface Roughness on Laminar Separated Boundary Layers", Journal of Turbomachinery, March 2014, 136, 1-8.

How to cite this article: Kulkarni SJ. A review on research and studies on boundary layers and its affecting parameters. Int J Res Rev. 2016; 3(8):23-26.

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