CHAPTER

3

UNSTEADY SEPARATED HYBRID STAGNATION NANOFLUID FLOW

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3.1 INTRODUCTION

The investigation of hybrid stagnation nanofluid flow has emerged as an intriguing research topic due to its various applications. Hybrid nanofluid; is a brand-new kind of heat transmission fluid that employs more than one nanoparticle and claims to provide superior thermal conductivity than conventional fluid. Numerous researchers were captivated by this cutting-edge type of heat transfer fluid because of its track record in advancing and increasing thermal properties in engineering applications past a stagnation region.

A stagnation point flow is a fluid flow that is close to reaching a state of stagnation on a moving or stationary solid surface (refer to Figure 3.1). A stagnation point, according to Clancy (1975), is a location in a flow field with zero local velocity. Borrelli et al. (2015) in turn described stagnation point flow as a jet of water colliding on a rigid body. The temperature at the stagnation point is referred to as the stagnation temperature, and the static pressure of a fluid reaches its maximum there, known as the stagnation pressure (Pritchard & Mitchell, 2011).

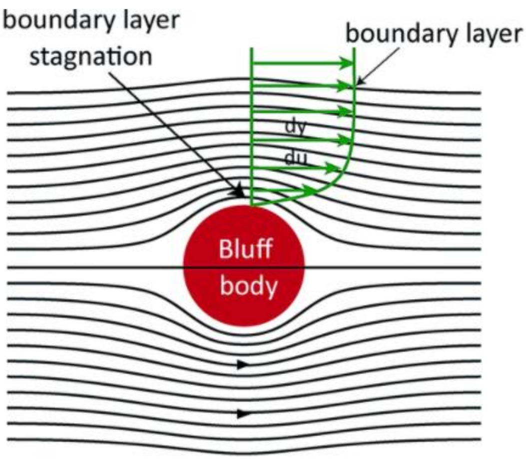

Figure 3.1 Stagnation flow schematics in boundary layer flow

3.1.1 Stagnation Point Flow

Hiemenz (1911), pioneered the theoretical study of stagnation point flow in two dimensions on solid surfaces in moving fluids. He used similarity transformations to derive the Navier-Stokes equation in the form of a nonlinear ordinary differential equation. Meanwhile, Homann (1936) studied the coaxial symmetric stagnation point flow problem. Continuing from the problems considered by Hiemenz (1911) and Homann (1936). Howarth (1951) expanded the investigation of three-dimensional (3D) coaxial symmetric flow at the stagnation point. Proudman and Johnson (1962) and Robins and Howarth (1972) conducted boundary layer research on posterior stagnation point flow in two-dimensional (2D). Davey (1963) examined the rotational flow near an anterior stagnation point, while Howarth (1975) investigated the study of 3D posterior stagnation point using the boundary layer approximation.

According to Schlichting and Gersten (2016), Eckert extended Homan's (1936) problem by taking into account energy equations for analysing heat transfer at stagnation point flow and has been successful in resolving the system of equations with obtaining precise solution. These days, a lot of research has been done on the fluid flow and heat transmission in stagnation zones near the boundary layer using a variety of fluid types and geometries, including those by Waini et al. (2022).

Theories and concepts involving stagnation point flow are nothing new in industrial and engineering applications. This interrelated relationship encourages the researchers to actively investigate the stagnation point flow under various industrial applications so that it would benefit the intended industries. For instance, Gadgil (1993) elaborated on the design optimisation of stagnation point flow reactors for chemical vapor deposition of organic metals through flow imaging. Ariel (2010), studied problems related to fluid dynamics and aerodynamics flow at stagnation point. The role of stagnation point flow in the controlled cooling process of filaments pulled through a stagnation fluid following extrusion from a mould was examined by Chakraborty et al. (2017). Apart from that, according to Vajravelu and Mukhopadhyay (2015), engineering and industrial processes such as polymer extraction process, nuclear reactor cooling, electronic equipment cooling process using a fan, papermaking, fiberglass manufacturing, and wire pulling process also involved in this region of fluid dynamics flow.

3.1.2 Hybrid Nanofluids in Thermal System

Heat transfer systems are crucial for creating sustainable energy systems for a variety of reasons, for example, reducing emissions and pollutants. In general, various studies and experiments are conducted by researchers to achieve thermodynamic cycle processes with high efficiency, low emission, and cost savings included in heat transfer technology. Amano and Sundén (2008), state that three parallel strategies may be used to accomplish sustainable energy development: Employing renewable energy sources, lowering final energy consumption, and increasing total heat transfer efficiency. Additionally, by lowering radiation and pollutants, the process of heat transfer is essential for environmental protection. This clearly shows that the application of heat transfer provides great influence and impact in the formation of human civilisation. Thus, the ongoing initiative in providing efficient and competent heat transfer systems is a real challenge.