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Experimental Investigation of Gas/Liquid Cylindrical Cyclone Separator

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INTRODUCTION

Producing mixed fluid from production wells must be separated before any transportation toward process facilities. Also, transportation under single phase condition is much easier than multiphase fluid stream [1,2]. Thus it is strongly recommended to consider high efficient separation vessels in flow lines. Moreover, conventional separators by settling down the multiphase inlet fluid in its container let the lighter phase (usually gas) separate from heavier phase. Moreover, gravity force has the main actor in this type of separation. However, sometimes, conventional separators are not an appropriate choice in places with especial conditions like offshore platforms [3,4]. Accordingly, the new generation of separators emerged as cyclone base separators. This kind of separators separates different phases with less space by using centrifugal force [5]. In addition, simplicity, compactness, low cost and weight, and easiness in installing and operation are their advantages which encourage oil and gas industry to use them instead of conventional separators [6]. Just for comparison it is interesting to know that a GLCC occupies one forth and one fifteenth of a vertical and horizontal separators respectively [7].

A gas liquid cylindrical cyclone separator (GLCC) consists of six main parts: multiphase inlet, main body, top outlet, bottom outlet liquid out leg and gas out leg. In other way, a GLCC is defined as a vertical pipe with a downward inclined tangential inlet located at the top and the bottom of the cylinder. After interring multiphase fluid into main body of gas liquid cylindrical cyclone separator, denser phase swirls on the body wall and phase with lower density stays in center of pipe and exits through top outlet, while denser phase flushes through bottom outlet [7,8]. Though, each production system has its singular condition which needs optimized separator design accordingly. Therefore, understanding the effect of any alteration in each mentioned part of as gas liquid cylindrical cyclone separator helps to reach proper design for any spectacular operation system [8].

Several studies have been done over vortex flow and the effect of cyclone body vessels on phase separation. Cyclone body separators were used for solid-solid mixture at first.

Then, because of their simplicity and compactness they were introduced in other industries as useful separation vessels [9,10]. The behavior of confined vortex flow in conical cyclones have been studied by Reydon and Gauvin studied, and they claimed that increasing the magnitude of the inlet does not change the shapes of vortex flow [11].

Then, the use of twin inlets in cyclone separators has been suggested by Millington and Thew [12]. In 1994, the mechanism of separating gas bubbles from a bulk liquid in a cyclone separator has been numerically investigated by Bandyopadhyah et al [13]. Then their simple mechanistic model which was capable to predict the general hydrodynamic flow behavior in a gas liquid cylindrical cyclone has been presented by Arpandi et al [8]. Also, other simplified models are presented based on CFD approach such as Mona et al model [14-16].

EXPERIMENTAL PROCEDURE

In this study, it is tried to make some changes in different specifications of an experimental version of GLCC separator and investigate the effect of any change in each part of that. Therefore, a mixer and separator set-up was built in Petroleum University of Technology research center to mix water and air and then conduct this two-phase fluid stream into GLCC test part. Following alteration are applied on this set-up section and separator performance is compared with normal version: reducing the inlet diameter, reducing the liquid outlet diameter, reducing the gas outlet diameter, reducing the gas column length, increasing the outlet leg length and reducing the column diameter.

RESULTS AND DISCUSSION

At first, normal GLCC separator was tested to determine its performance and possible operational flowrates. The liquid level is placed between inlet and bottom out let in the main body.

REDUCING THE INLET DIAMETER: Reduction in the inlet diameter increases the centrifuge force and make separation more efficient. Thus more domain of flowrate is acceptable for this separator. This fact shows reduction in inlet body is able to improve GLCC performance but further reduction could be against of separator performance.

REDUCING THE LIQUID OUTLET DIAMETER: It acts like a control valve which causes rising in liquid level. Therefore, higher gas flowrate is acceptable to enter in the separator main body to push liquid level down. This change can be useful in controlling liquid level in special situations.

REDUCING THE GAS OUTLET DIAMETER: This change acts like reduction of liquid outlet diameter, but it shows its effect only in high gas flowrates. Also, it is like another control valve in gas out line. Also, if the gas outlet diameter is decreased further, it can push down performance curve related to low gas flowrate like others.

REDUCING THE GAS COLUMN LENGTH: It does not change the GLCC performance so much, and it only increases the chance of liquid carry over in case of high column length reduction. This is a problem due to disturbing in the separator performance as well . Nonetheless, this change is helpful for compacting the separator.

INCREASING THE OUTLET LEG LENGTH: The only effect of this change is friction force rise in the system. What is more this force shows itself in high gas flowrates . This increases accumulated gas volume in the separator main body and pushes the liquid level down.

REDUCING THE COLUMN DIAMETER: Also, this change increases the centrifuge force and improve separation in the other hand increasing case it may become liquid level changes more sensitive. In addition, the nature of vortex may be threated under this condition.

CONCLUSIONS

Reducing the inlet diameter improves the GLCC separator performance. In addition, it allows more gas and liquid flowrates enter the separator for total separation by enhancing the centrifugal effect on liquid and gas phases. Reducing the liquid outlet diameter has a negative effect on GLCC flowrates domain, but this reduction can be used to control the equilibrium liquid level by a gate valve in liquid outlet leg. Furthermore, reducing the gas outlet diameter has a negative effect on GLCC performance. But in some situations controlling the amount of accumulated gas in GLCC can avoid liquid carry over in the system. Reduction in gas column length shows no effect on the separator flowrates domain. Finally, increasing the length of outlet legs increases the friction force and limited the separator performance. Also, reduction in separator body diameter raises the chance of liquid carry over and gas carry under and has negative effect on flowrates domain.

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