# USE OF AN AUTOMATIC L-VALVE WITH FCC GROUP A PARTICLES AT LARGE SCALE

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**Abstract** – The operation of a large cold flow model with FCC catalyst has been improved by replacing the external second stage dipleg discharge to a 1-m diameter fluidized bed (FB) with an automatic L-valve (140 mm in diameter). This device prevents the gas leakage from flowing back up the second stage dipleg. Cyclone performance was improved and the particle size distribution in the fluidized bed is maintained stable.

## INTRODUCTION

One of the major operational problems in fluidized bed processes is failure of solid circulation and feeding system (Knowlton and Hirsan, 1978). Therefore a good understanding and control of solid circulation is of extreme importance.

The non-mechanical valves are a category of solid flow control devices employing no mechanically moving part (Knowlton and Hirsan, 1997). They are simple in design, easy to operate and requires minimum maintenance (Knowlton, 1988; Yang and Knowlton, 1993). They can be operated in two different modes (Chan et al., 1988): the “valve mode” where the solid flowrate is controlled by the amount of aeration gas fed into it; and in the “automatic” solid flow-through mode. In the latter case, with constant aeration gas flow, if solid flowrate is changed, the non-mechanical valve pressure balance will automatically adjust to accommodate the flowrate modification. This type of transfer is very common in fluidized bed processing. However, there has been no systematic study in the literature on how such a device will respond to variations in system parameters. Moreover, most of the studies are done at small scale, for L-valve diameter lower than 50 mm (Yazdanpanah, 2011). The present study has been performed with a L-valve of 140 mm in diameter.

## EXPERIMENTAL SET-UP

In this study, a large cold flow model as shown on Fig 1, has been used with equilibrium FCC catalyst. The main mechanical characteristics of the solid are given in Table 1. The particle size distribution is given in Figure 4 (j0).

Table 1: Properties of FCC particles used in the present study

| | |
|---|---|
| Granulometry range (µm) | 20-300 |
| Sauter mean diameter, *dsv* (µm) | 71 |
| Particle density (kg/m3) | 1400 |

The cold flow model consists of a fluidized bed of 1 m in diameter and 7 m in height, a system of primary and secondary cyclones, and a bag filter, as shown in Fig 1. The internal first stage dipleg is sealed in the fluidized bed, the second one is external. It was initially connected to the fluidized bed through a flexible inclined pipe (roughy 45° inclination), with a bend in the dense zone. With this configuration, gas leakage back up to the second stage dipleg was observed and bad cyclone performance was observed with a lot of entrainment to the bag filter downstream the cyclone.

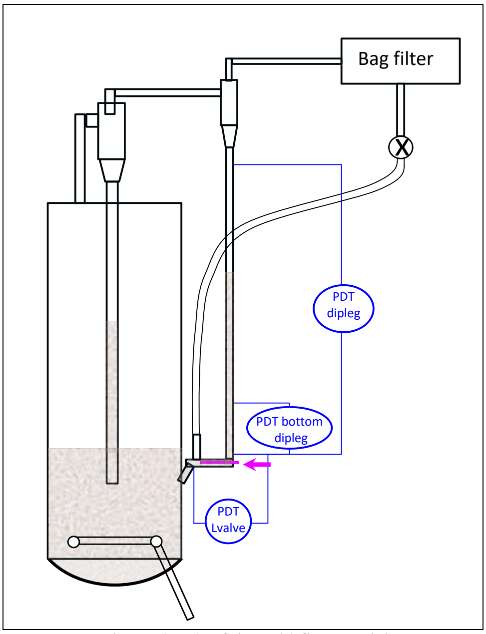

Fig 1. Sketch of the cold flow model

The operation of this large cold flow model has been improved by replacing the external second stage dipleg discharge to the 1-m diameter fluidized bed (FB) with an automatic L-valve. Since the aim is the transfer of solid from the external cyclone back into the fluidized bed, the L-valve is then used in the ‘automatic’ mode.

The L-valve is 140 mm in diameter and is designed with two aerations:

- a regular L-valve aeration, at 300 mm above the horizontal part axis (about twice the L-valve diameter), generating a superficial gas velocity of about 0.03 m/s in this vertical section,
- a lance aeration, placed on the axis of the horizontal part of the L-valve, drilled with five holes of 4 mm in diameter, generating a superficial gas velocity of about 0.1 m/s in this horizontal section.

Before starting the aeration in the L-valve, the solid needs to reach a certain height to ensure a proper seal through the L-valve. Therefore, fluidization air in the fluidized bed is put first, then entrained solid feeds the L-valve. When the solid height in the vertical part of the L-valve reaches a certain height, the L-valve aerations are switched on.

The dimensions of the L-valve and the aeration lance are given in the following figure. A photography of the L-valve is also given in this figure.

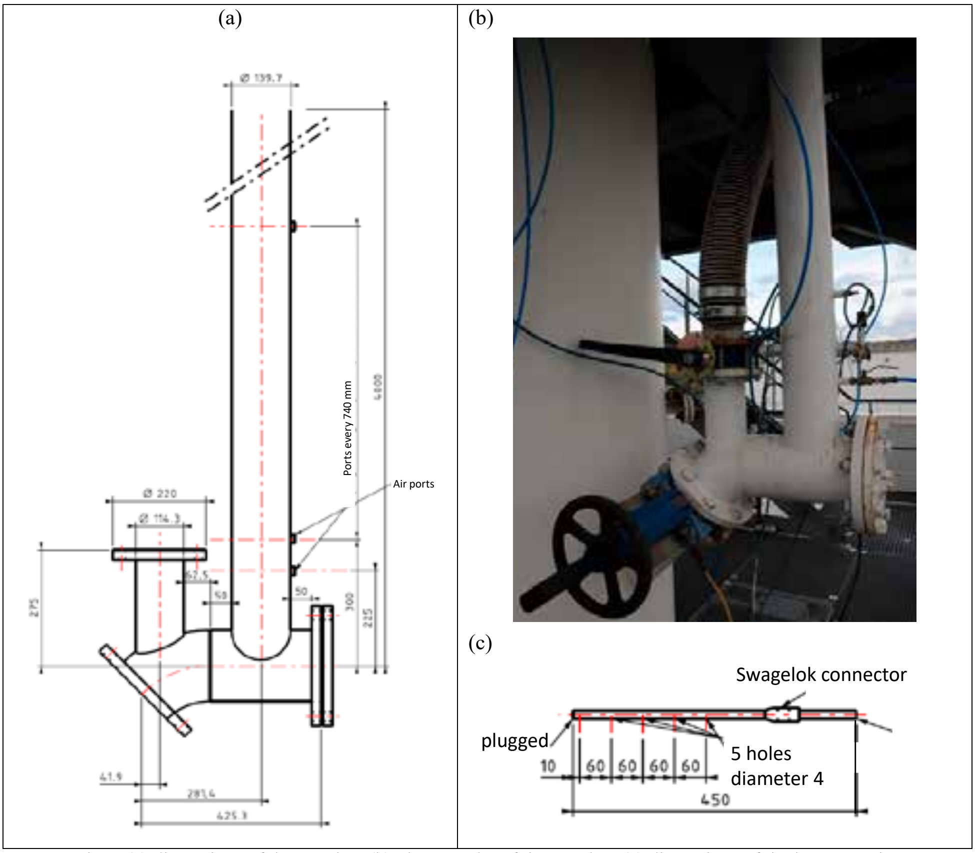

Fig 2. (a) dimensions of the L-valve, (b) photography of the L-valve, (c) dimensions of the lance aeration

Several taps allow the measurement of pressure drop in the horizontal and vertical parts of the L-valve and in the second stage dipleg, as indicated on Fig 1.

## RESULTS

At a constant L-valve aeration, the solid flow rate in the system was varied to determine how the L-valve responds. The gas velocity in the fluidized bed was increased in order to increase solid entrainment, and consequently the solid flow rate feeding the cyclones and then the L-valve. The following figure shows the pressure drops measured in the dipleg (PDT dipleg), at the bottom part of the dipleg (PDT bottom dipleg, characteristic of the bed density in the dipleg) and in the horizontal part of the L-valve (PDT L-valve), as a function of the gas velocity in the fluidized bed.

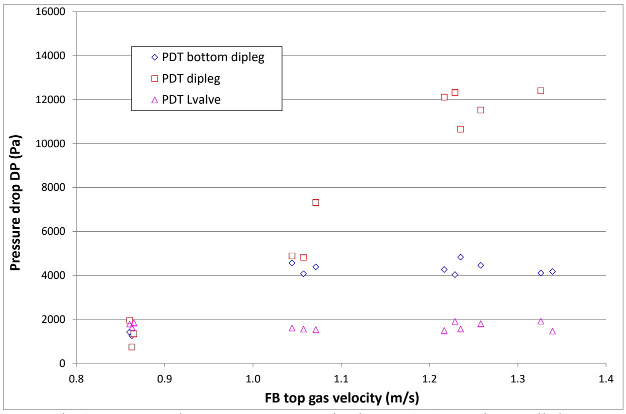

Fig 3. Pressure drop measurements in the DN150 L-valve & dipleg

As expected, when gas velocity in the fluidized bed increases, the solid entrainment increases, generating an increase of solid flowrate in the L-valve. An increase of the solid level in the dipleg is then observed, related to the overall cyclone pressure balance. Indeed, the whole dipleg pressure drop increases, while the dipleg bed density remains constant around 600 kg/m3 (height between pressure taps is 0.74 m). Note that, at gas velocity lower than 0.9 m/s, the pressure drop measured at the bottom of the dipleg is lower because solid level in the dipleg is lower than the higher pressure tap at this stage.

In fact, when the solid flowrate from the second stage cyclone increases, the solid level in the dipleg initially rises because solid is fed to the L-valve faster than it was previously. The increased height of solid in the dipleg causes the increase of the pressure at the aeration points. Since the aeration flowrate is maintained constant, a greater fraction of the aeration gas will now flow around the elbow, causing an increase in the solid flowrate through the L-valve. Since enough aeration gas is injected to the L-valve, the system reaches equilibrium at an increased solid height in the dipleg and the system is balanced. Gas flowing in the vertical section is self-adjusted to respect the pressure balance in the circulating system (Yazdanpanah, 2011 & 2012).

Thanks to the dense phase build up, the L-valve device prevents the gas leakage from flowing back up the second stage dipleg. Cyclone performance was improved and the particle size distribution (psd) in the fluidized bed is maintained stable as shown in the following figure (psd measured by laser diffraction). Values of Sauter mean diameter and fines contents smaller than 44 µm are reported on Table 2. The dates are indicative only.

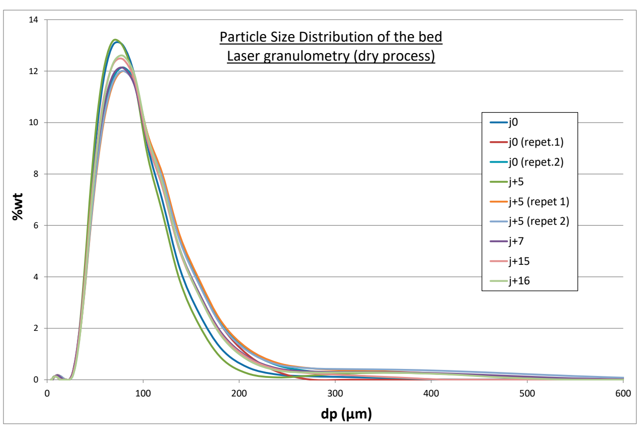

*Fig 4. Particle size distribution of the fluidized bed over time*

Table 2: Sauter mean diameter and fines contents smaller than 44 μm over time

| | j0 | j0 (repet1) | j0 (repet2) | j+5 | j+5 (repet1) | j+5 (repet2) | j+7 | j+15 | j+16 |
|---|---|---|---|---|---|---|---|---|---|
| dsv (μm) | 70.9 | 72.7 | 73.7 | 69.9 | 75.1 | 74.7 | 72.9 | 72.9 | 74.3 |
| < 44 μm | 15.2 | 14.9 | 14.3 | 16.3 | 13.7 | 13.9 | 15.2 | 14.7 | 13.7 |

These data also compared the psd measured several times on the same catalyst sample (repet. 1 and 2). It shows that the evolution of the fluidized bed psd over several days of cold flow model operation remains inside the repeatability gap.

Thanks to the modification, severe fluidization conditions were achieved in the fluidized bed over long time periods in the range of 1-1.3 m/s and the inventory remained constant in the bed. During the test period extending over 16 days, no significant fine accumulation was observed.

When varying operating conditions (bed level range between 2.3 and 2.9 m, gas velocity range between of 0.8 and 1.3 m/s), it was not necessary to adjust the automatic L-valve operation by changing aeration.

## CONCLUSION

An automatic L-valve was installed on an external secondary dipleg of a FCC fluidized bed operating at very high fluidization velocities. Operation of such device is very simple and flexible. Dipleg hydrodynamics was greatly improved with suppression of gas leakage and generation of a large pressure build up. Measured dipleg density based on pressure transducer indication is in the range of 600 kg/m3. Based on this modification, cyclone performance was improved and no significant losses were observed over the testing period.

## NOTATION

| | | | |
|---|---|---|---|
| DP | differential pressure, Pa | psd | particle size distribution |
| PDT | differential pressure tap | *dp* | particle size, m |
| FB | fluidized bed | | |
| *dsv* | Sauter mean particles diameter, m | | |

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