Evaluation of FF Pulse Cleaning Valves

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ABSTRACT

Three FF cleaning valves were compared with the reference valves "D" and "E" by measurement of bag pulse pressure. In addition to this, an indicative life time test was performed to study the durability and type of failure for the valves.

Test results regarding pulse pressure and long-time durability are presented. A comparison is made between existing membrane valves on the market, model "A", "B" and "C" and the reference valves "D" and "E", both of piston type.

Keywords

Fabric filter, pulse cleaning valve.

INTRODUCTION

To investigate the current status of FF cleaning valves regarding performance, with regard to bag cleaning capacity and life time, a comparison was made between the dominating products on the market.

CLEANING SYSTEM

The performance of the bag cleaning system is an essential part of successful high ratio fabric filter (HRFF) operation.

The quality of the cleaning system has a great influence on:

- bag life
- gaseous and particulate emission
- pressure drop across filter bags
- total energy consumption

In HRFFs, the bags are cleaned by means of a pulse of compressed air that is fired axially into the top, open end of the bag. The distribution of compressed air in short pulses is performed by selectively firing a pulse valve, connected to a tank containing compressed air. The pressurized air pulses are supplied to a row of bags by a tube provided with small orifices or nozzles, which direct the jets of compressed air at a high velocity into the tops of the bags. As the air burst travels down and through the bags, the normal flow of flue gas through the bags is stopped (provided on-line cleaning), and a pressure and shock wave is transmitted down the length of the bags. The bags expand, and as their shape changes rapidly from concave to convex, the fabric flexes and the ash layer cracks. As the bags expand to their full circumference and rapidly decelerate, the particles in the ash layer are partly dislodged, due to inertia forces. The dislodged ash cascades down the length of the bags and eventually settles into the hopper located below the bags. See Figure 1.

The main variables affecting the separation force between the ash layer and the fabric is the

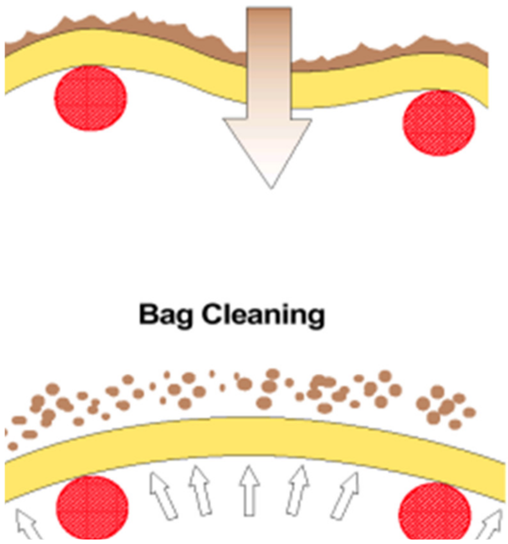

Figure 1: Gas cleaning and bag cleaning mode.

fabric acceleration force generated by internal pulse pressure, and the fabric movement distance. The most important design criteria for the cleaning system is to quickly produce a high pressure inside the filter element, by rapidly injecting a large volume flow of pressurizing air against the resistance offered by the filter fabric [1]. A very high rate of volume flow injected into the filter element is essential to achieve the large cleaning forces required for efficient on-line cleaning of long bags.

In the Alstom Power (AP) pulse system design; these requirements are met by using components with low pressure loss, large flow cross section areas, and an optimum geometry, see Figure 2. This is a well-balanced system between pulse valve, volume of air in the pulse tank, pulse distribution pipe and pressure in the pressure tank.

The cleaning system has been developed and continuously improved by AP during the last 30 years, utilizing e.g. a full-scale pulse test rig, see Figure 2.
The cleaning system produces a large flow rate of cleaning air. Peak pressure in the bag is reached in about 10 ms. The high cleaning energy can be utilized in several ways, for example:
- cleaning very long bags and many bags at same time
- on-line cleaning is no problem
- cleaning flexibility as required for process changes

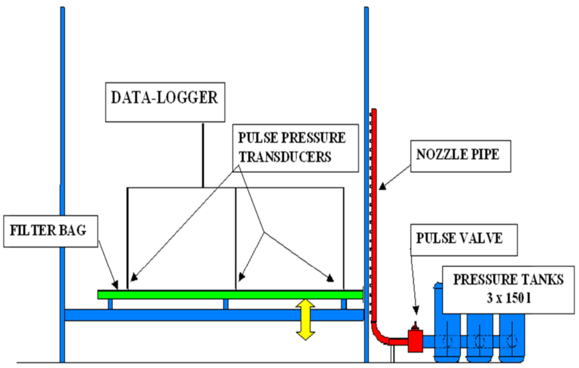

Figure 2: AP full-scale pulse test rig, Växjö, Sweden.

The fast action results in a minor stretch of the fabric when it is expanded to the circular form. At the same time no bending of the fabric or friction against the cage occurs in this expanded circular form. Hence, the fast, efficient cleaning will have no negative effect on the bag life. On the contrary, it prolongs the bag life by keeping the fabric clean and in full operation throughout the life of the bag.

When the pulse pressure across the filter bag decreases to a value less than the differential pressure across the filter bag, the return of the bag towards the bag cage starts. The return force is of the same magnitude as the previous cleaning force if the pulse is cut off in a fast manner (short pulse), and will result in an aggressive landing on the cage, with abrasion and increased local stress in the bending zones of the felt.

PULSE VALVE EVALUATION

Test rig set up

The pulse pressure inside the filter bag was measured with a differential pressure transducer, see Figure 3. The sensor attachment is located close to the inner surface of the filter bag. It is fixed to the Alstom standard 16 wire bag cage. This position gives the most relevant measure of pressure acting on the fabric since the pulse pressure varies over the cross section of the filter bag.

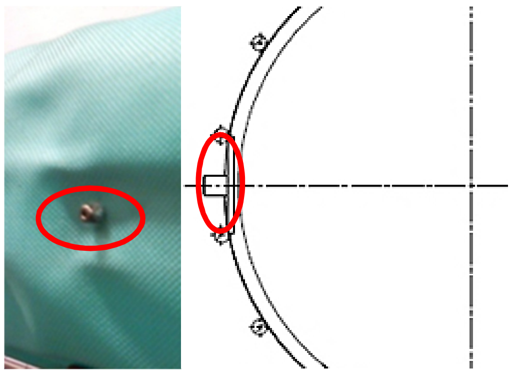

Figure 3: Bag pressure sensor attachment.

For testing purpose, a specially prepared filter bag is used. It has similar resistance to flow as a filter bag in use. This makes the measurement as realistic as possible, ensuring cleaning capacity also at the end of bag lifetime.

The pulse pressure also varies along the bag and the lowest value is critical to cleaning performance. Therefore the sensor was positioned 5000 mm from top of bag (bag plane).
For all valves, pulse pressure was measured with a pressure tank volume of 300 dm^3. This

corresponds to the general requirement of air per area of fabric.

For the life time test a volume of 150 dm^3 was used to reduce time since the volume not is expected to influence the result.

Tank pressure was varied from 3 to 6 bar to cover the full range of operation for both types of valves, membrane and piston. The valves were all open for 300 ms to reduce the tank pressure to 0.5 bar.

Nozzle pipe used

In the test rig previously described, two types of nozzle pipes were used. For the larger valves (“A”, “B” and “E”), pipe inner diameter was 116 mm and distance between the 30 nozzles was 160 mm. With 10 m long bags, this gives a bag filter area of 120 m^2.

For the smaller valves (“C” and “D”), pipe inner diameter was 106 mm and distance between the 22 nozzles was 160 mm. With 10 m long bags this gives a bag filter area of 88 m^2.

Pulse valves tested

The larger piston valve “E” was compared with “A” and “B”, both of membrane type. The smaller piston valve “D” was compared with the membrane type of valve “C”, with similar outlet dimensions.

Pulse valve comparison, new valves

Pulse pressure values are measured at nozzle # 5 on a standard pipe of totally 30 nozzles for “A”, “B” and “E” (Figure 4). For “C” and “D” (Figure 5), a pipe with 22 nozzles is used due to the lower capacity. The selection of nozzle (#5) represents the average pressure value for the pipe.

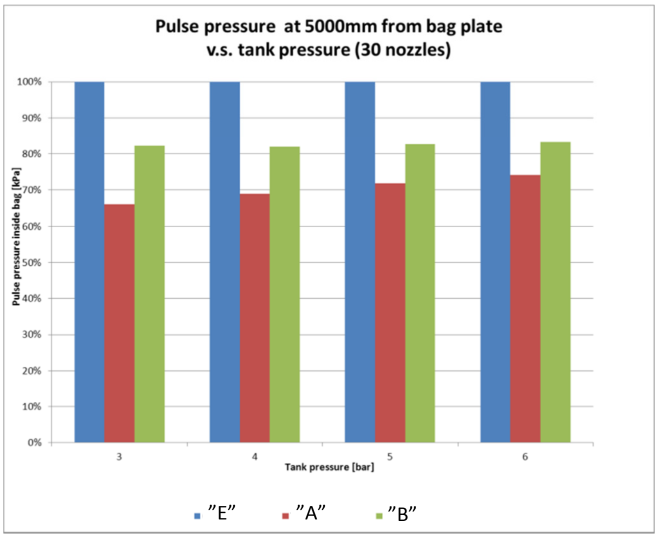

Figure 4: Comparison of pulse pressure of the valves “A” and “B” (new valves). New valve “E” as reference.

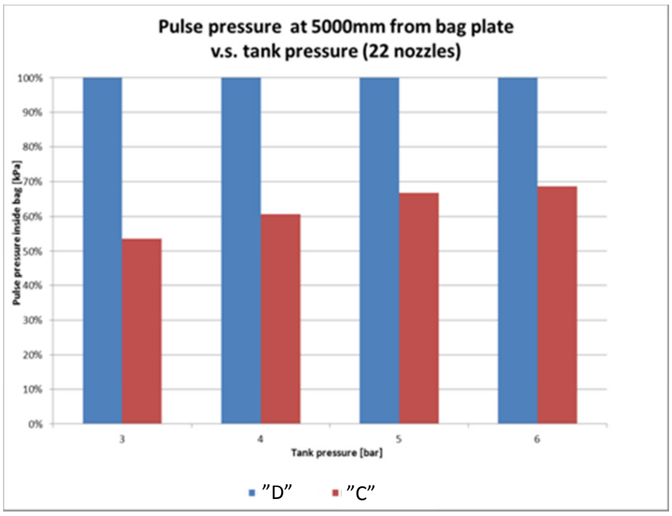

Figure 5: Comparison of pulse pressure of the valve C (new valve). New valve “D” as reference.

Pulse valve comparison, valves after life time test

The requirement for life time was set to >150 000 pulses, corresponding to >5 years of continuous operation. Customer requirement on high availability and low maintenance cost must both be met. In addition to this, no significant degradation of cleaning performance must occur.

The pulse pressure measurements are also presented in Figure 6 and Figure 7, for new valves as well as for valves having completed the life time test. No obvious effect from the life time test can be seen on the pulse performance for “A “or “B”. But for “C”, pulse pressure is reduced between 7 to 10 % for tank pressure 3 to 6 bar.

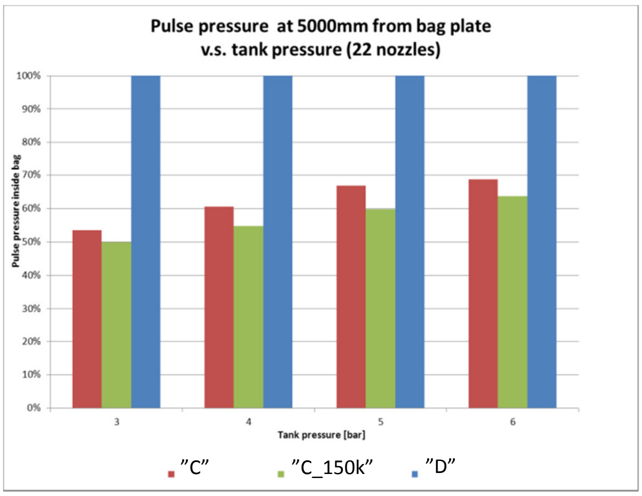

Figure 6: Comparison of pulse pressure for the ”C” valve, new and after (“_150k”) completed life time test. New valve “D” as reference.

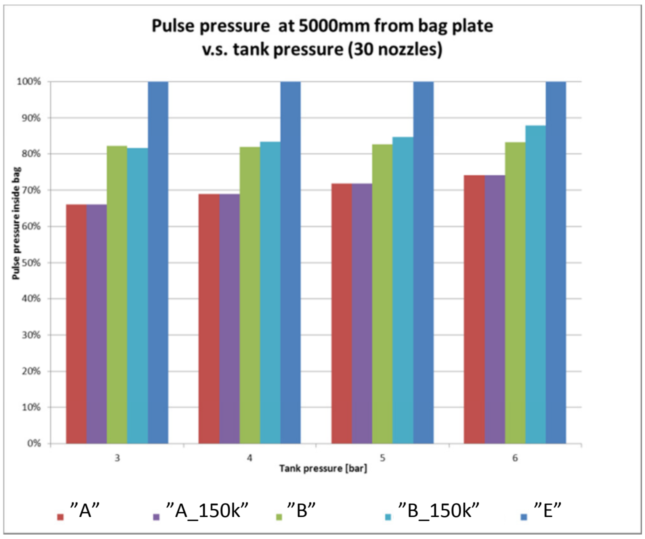

Figure 7: Comparison of pulse pressure for "A" and "B" valve, new and after ("_150k") completed life time test. New valve "E" as reference.

Life time test

Valve "A"

150 000 pulses were completed without any interruptions. The wear of the membrane seemed reasonable (Figure 8) and one can expect longer operation than the number tested.

Figure 8: "A", wear pattern of membrane, support side.

Valve "B"

128 979 pulses were completed until the test was stopped. The pressure decrease (opening time) and the ability to open were both affected by the wear holes that were found in the membrane (Figure 9).

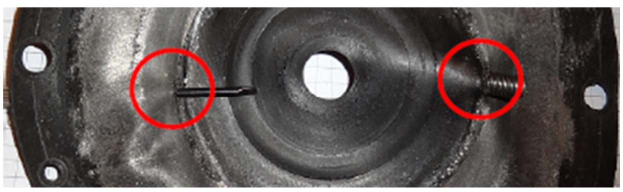

Figure 9: "B", holes found (left Ø 5 mm, right Ø 8mm).

Metal particles were found on top of the membrane (solenoid side) and both the metal disc and the valve body was deformed (Figure 10).

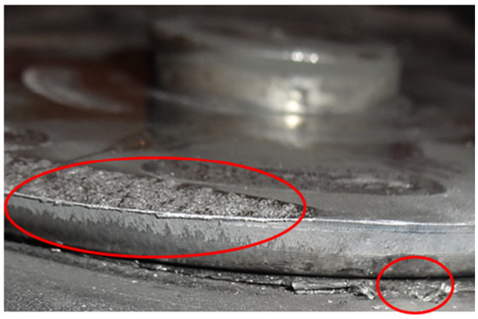

Figure 10: "B", bending wear of membrane caused holes. Excessive wear of membrane metal disc by contact to valve body.

Valve "C"

After 150 000 pulses the membrane looked OK, no damages were noted.

Note that the piston valves "D" and "E" not were tested with respect to life time performance. From experience, no noticeable wear or decrease in pulse performance can be expected.

RESULTS

"A" succeeded well in the life time test, in contrast to "B". On the other hand, "B" showed slightly better pulse performance, fulfilling the pulse pressure criteria up to 30 bags/valve, 10 m long bags (120 m^2). The upper limit for "A" regarding pulse pressure is 28 bags/valve, 10 m long (112 m^2). These figures are valid for max system pressure (6 bar) and measured in the test rig. For process conditions, additional pressure-margins have to be included in the sizing, reducing the actual limits of maximum cleanable bag area per pulse valve. "C" demonstrated such poor cleaning performance, that it might not be considered at all for installation in large FFs with 22 bags /valve, 10 m long (88 m^2).

DISCUSSION

The life time test was only performed for one valve of each type, apart from "B", where the membrane was replaced once. This limits the analysis of life time performance. The results presented are more indicative than typical, and the values of life time cannot be taken as absolute figures. The deviation in quality for material, production and assembly has not been taken into account. Nor that the conditions at site (filter installation) hardly can be fully simulated. Factors like temperature, dust and process gases are left out. A larger number of valves with longer test period need to be analysed (preferably at site-like conditions), for making any statement of this kind.

CONCLUSION

The tests performed have shown the difference between the valves, both in cleaning performance and design. An indication of life time performance has also been given.

“A” is ahead of “B” in terms of life time (less wear) but “B” has better pulse performance (performance limit up to 30 bags/valve, 10 m long bags (120 m^2). “A” is limited to 28 bags/valve, 10 m long (112 m^2). These figures are valid for maximum air supply pressure (6 bar) and measured in the test rig. For process conditions, additional margins of air pressure supply have to be included in the sizing using membrane valves, reducing the actual limits of maximum cleanable bag area per pulse valve.

The reference valves “D” and “E”, both of piston type, perform similar but at a lower tank pressure. This gives additional margins in the sizing, taking process variations into account, as well as lower stress on other system components like pressure vessel, piping etc.

“C” shows such poor cleaning performance that it does not seem to be of interest for any application. Even if the lifetime is long enough, this valve is the only one that shows a significant reduction in pulse pressure after life time test.

At the same tank pressure, the pulse pressure of “A” is approximately 80 %, and the pulse pressure of “B” is approximately 65 – 70 % relative reference valve “E”.

“C” produces a pulse pressure in the range of 55 – 70 % relative reference valve “D” at the same tank pressure.

The valve “D” fulfils the pulse pressure criteria for 22 bags, 10 m long (88 m^2) and valve “E” for 30 bags, 10 m long (120 m^2). This is valid for tank pressure 4 bar and higher.

REFERENCES

1. Löffler, Dietrich and Flatt. Dust collection with bag filters and envelope filters.