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ELSEVIER

A Pilot-Scale Study of the Design and Operation Parameters of a Pulse-Jet Baghouse

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ABSTRACT. Filtration curves and pulse-jet cleaning performance of different design and operating conditions of a pilot-scale pulse-jet baghouse are investigated. The effective residual pressure loss is used as an index of bag cleaning effect, while the average pulse overpressure inside the bag is used as an index of bag cleaning intensity. It is found that filtration curves vary with the initial tank pressure and the nozzle diameter of the bag cleaning system. The filtration time increases with increasing initial tank pressure or nozzle diameter. However, a critical value of the tank pressure exists for an effective bag cleaning. It is also found that a critical effective residual pressure loss value exists for the pulse-jet cleaning system. Too large an initial tank pressure and nozzle diameter result in a waste of cleaning energy. The addition of a venturi increases the average pulse overpressure appreciably, hence increasing the cleaning effect. A venturi is suggested to be installed to increase the bag cleaning effect and maximize cleaning energy in this study. AEROSOL SCIENCE AND TECHNOLOGY 29:510–524 (1998) **© 1998 American Association for Aerosol Research**

INTRODUCTION

The basic researches for fabric filtration and bag cleaning performance of the baghouse have been reported by many previous investigators (Dennis and Klemm, 1980; Ellenbecker and Leith, 1979; Humhpries and Madden, 1983; Koehler and Leith, 1983). Many design and operating parameters influences the performance of pulse-jet baghouse, including tank size, tank pressure, blow tube diameter, discharge characteristics of diaphragm valve, nozzle diameter, venturi type, pulse duration, and dust properties etc.

The filtration time that increases with an increasing bag cleaning efficiency is correlated with the cleaning intensity. From the economic point of view, the bag cleaning performance of a baghouse is more effective for a longer filtration time. Many previous investigators (Humphries and Madden, 1983; Morris, 1984; Ravin et al., 1988; Sievert and Löffler, 1989) pointed out that a critical cleaning efficiency exists for different indices of cleaning intensity, such as the peak pulse overpressure, the average pulse overpressure inside the bag, and the fabric acceleration. If the index of cleaning intensity exceeds the critical value, the cleaning efficiency improves only slightly. Thus, the

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amount of the cleaning energy that exceeds the critical value is an energy waste.

In this study, a pilot-scale pulse-jet baghouse was tested for investigating the performances of bag filtration and bag cleaning. The objective of the pilot-scale pulse-jet baghouse test is to determine the filtration curves under different operating conditions and obtain the critical cleaning indices. The influence of various nozzle-venturi assemblies, i.e., jet pump (Bakke, 1974), on the index of cleaning intensity was also investigated.

PREVIOUS WORK

The Influence of Cleaning Intensity on the Bag Cleaning Effect

Many different indices of bag cleaning intensity such as pulse pressure, initial pressure rise rate, fabric acceleration, and pressure impulse in the fabric bag have been claimed to be responsible for dust cake release by different investigators (Dennis et al., 1981; Ellenbecker and Leith, 1981; Humphries and Madden, 1983). Dennis et al. (1981) demonstrated that significant cake release only occurs when the pressure pulse has an initial pressure rise rate greater than 600 Pa/ms. Rothwell (1988, 1990) used the same criteria in the study of the pulse-jet fabric filtration systems. Other authors (Ellenbecker and Leith, 1981; Humphries and Madden, 1983) claimed that the fabric acceleration is the main cleaning mechanism and reverse airflow plays only a minor role.

Many investigators studied the relationship of the bag cleaning effect with the fabric acceleration. Dennis et al. (1981) predicted that an acceleration of 200 g is required to achieve a complete dust dislodgment during pulse-jet cleaning. However, Morris's experiment (1984) demonstrated that the pulse jet fabric system can operate steadily when the acceleration ranges from only 30 g to 60 g. From Bustard's observation (1992), the acceleration of 100–200 g is necessary to dislodge the dust effectively. The magnitude of acceleration required to remove the dust effectively was found to be related to the fabric material (Sievert and Löffler, 1987). It was found that the dust removal efficiency increases with fabric acceleration and only an acceleration exceeding 30 g was needed to dislodge dust effectively when the flexible polyester fabric was used. However, if an inflexible fabric was tested, the fabric acceleration must reach 200–500 g to dislodge the dust effectively (Sievert and Löffler, 1987).

Klingel and Löffler (1983) pointed out when air pressure impulse (PI) in the fabric bag was greater than 50 Pa · sec, dust removal efficiency would not increase further. Air pressure impulse PI is defined as the integral of pressure versus time over a pulse duration, or $PI = \int_0^{T_{pd}} p(t)\,dt$ where T_{pd} is pulse duration. Humphries and Madden (1983) found that there is a minimum pulse pressure of about 0.3 kPa in the fabric bag that removed about 60% of the dust cake from the fabric. Increasing the pulse pressure beyond this minimum value results in only a slight increase in the amount of dust dislodged. Sievert and Löffler (1989) also showed that it is necessary to reach a critical static overpressure of 400–500 Pa at all locations along the length of a bag in order to achieve a good fabric cleaning efficiency. The overpressure is defined as pulse pressure minus the bag pressure drop. Along the fabric bag, cleaning mechanisms responsible for dust release may be different. The strong acceleration/deceleration in the upper bag regions was found to be responsible for cake dislodgment, while in the lower bag regions the dust removal was due to the reverse airflow (Sievert and Löffler, 1987, 1989).

In this study, the peak pulse overpressure, average pulse overpressure, and acceleration of bag were used as indices of cleaning intensity to evaluate the pulse-jet cleaning effect.

Filtration Performance

In filtration process, the dust accumulates on the fabric to from a dust cake. The pressure drop is a common measure for evaluating filtration performance. When the dust accumulated on the fabric bag, the filter drag is described by the following basic filtration equation (Donovan, 1985).

$$\frac{\Delta p}{v_f} = S_f = S_E + K_2(w - w_R) = S_E + K_2 w_0 \quad (1)$$

$$\Delta p = (S_E + K_2 w_0) v_f = R_f v_f \quad (2)$$

Where Δp is the pressure drop across the filter bag, v_f is the filtration velocity, K_2 is the specific resistance coefficient of dust cake, S_f is the filter drag, S_E is the effective drag, w is mass areal density of the dust cake, w_R is the residual dust areal mass density, w_0 is just the dust mass areal density added during the filtration cycle rather than the total mass areal density, and R_f is filter's final resistance coefficient.

Dennis and Klemm (1980) have proposed that the filter drag for a single pulse jet unit can be described by the relationship:

$$S_f = S_E + (K_2)_c w_c + K_2 w_0 \quad (3)$$

The new term added in Eq. (3) is $(K_2)_c w_c$, which represents the drag contribution of the cycling portion of the dust mass areal density on the fabric. In Eq. (3), $(K_2)_c$ is the specific resistance coefficient for the cycling fraction of the total dust mass areal density that is alternately dislodged and redeposited on the fabric, w_c is the cycling portion of the dislodgeable dust mass areal density.

Dennis et al. (1981) rewritten Eq. (3) as:

$$\Delta p = (p_E)_{\Delta w} + K_2 w_0 v_f$$
$$= (p_E)_{\Delta w} + C K_2 v_f^2 \Delta t = R_f v_f \quad (4)$$

Where the fresh added dust areal density, w_0, during the filtration interval, Δt, is expressed as $C v_f \Delta t$, with C the dust inlet concentration. The variable, $(p_E)_{\Delta w}$, herein is defined as the effective residual pressure loss. The $(p_E)_{\Delta w}$ can be obtained from the intercept of the linear extrapolation of the pressure-time curve with the vertical axis at the resumption of filtration. The slope of the pressure-time curve equals $C K_2 v_f^2$, where K_2 is easily obtained from the slope when the inlet dust concentration and filtration velocity are constant. The similarity between Eq. (4) and the basic filtration equation (Eq. [2]) is obvious and, in limit of negligible w_c, Eq. (4) becomes identical to the basic filtration equation. However, Eq. (4) can be applied to the on-line pulse-jet filtration.

When the filtration process reaches steady state, the effective residual pressure loss and the specific resistance coefficient of dust cake will keep constant (Dennis and Hovis, 1984). For a constant filtration velocity and inlet dust concentration, lower effective residual pressure loss represents a longer filtration time and a better cleaning effect. The magnitude of $(p_E)_{\Delta w}$ is related to the cleaning energy. In this study, the effective residual pressure loss is used as an index to evaluate the bag cleaning effect.

Jet Pump Performance

When the pressure drop across the fabric bag is greater than a designated value, a short burst of compressed air is discharged from a nozzle and usually directed through a venturi into the filter bag to increase the pulse pressure within the bag. The nozzle-venturi assembly system converts the velocity energy into pressure energy. Therefore, the sudden increase of the air pressure in the bag leads to the acceleration of the bag cloth and creation of reverse air through the bag, resulting in the removal of dust cake. This nozzle-venturi system is so-called jet pump (Bakke, 1974; Morris et al., 1991; Ravin et al., 1988).

Figure 1 shows a typical jet pump curve, pulsing power curve, and bag operating lines of a pulse-jet fabric filter (after Bakke, 1974). A jet pump characteristic curve varies with the initial tank pressure, nozzle size, venturi configuration, and the distance between the nozzle and venturi. The maximum pulse pressure developed in the bag by the jet pump is obtained at zero flow rate. Conversely, the maximum flow rate through the venturi is obtained at zero pulse pressure, or when the bag has zero resistance. The jet pump curve can be obtained easily by measuring the pulse pressure developed in the bag by the jet pump at various airflow rates using bags of different resistance.

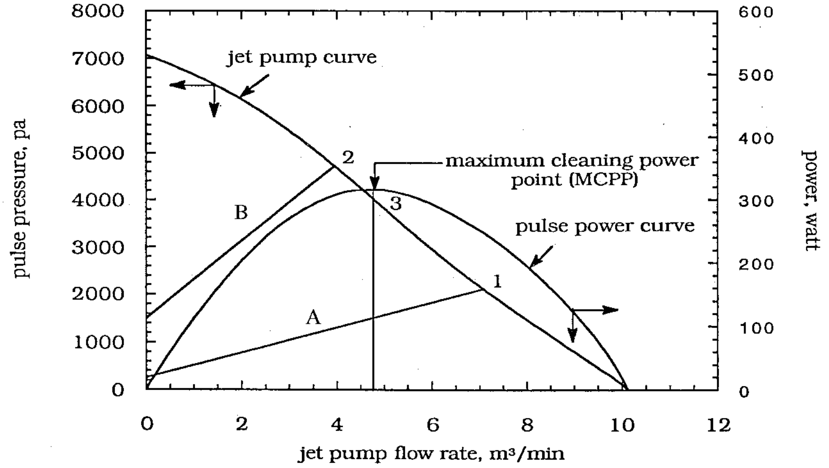

FIGURE 1. Typical jet pump and pulse power curves.

When the dust accumulated on the fabric bag, the relationship between the pressure drop and filtration velocity is described by Eq. (4). If the effect of the airflow to pressure drop is the same in both the forward filtration and reverse bag cleaning processes, and the filter's final resistance coefficient keep constant during cleaning, then the bag operating line will be linear and its slope equals the ratio of filter's final resistance to filter area, R_f/A_c, as described by Eq. (4).

In Fig. 1, different bag operating lines are shown as solid straight lines A and B. The intercept of bag operating line with the vertical coordinate is the filtration pressure drop. When the bag is cleaned on-line, the pulse pressure of the bag cleaning process must exceed the filtration pressure drop in order to remove the dust cake. If the bag is cleaned off-line, the pulse pressure must be zero at zero flow rate, hence the line passes through the origin. It is possible to predict the average pulse pressure inside the bag from the operating point, which is the intersection of a bag operating line and the jet pump curve during pulse-jet cleaning.

Also shown in Fig. 1 is the pulsing power curve, which is calculated from the product of the jet pump flow rate and the developed pulse pressure. The pulsing power curve is located between the maximum pressure at zero flow and zero pressure at the maximum flow rate. A maximum cleaning power point (MCPP) exists between the two zero values. The point can be seen in the Fig. 1.

The shape of jet pump curve depends on the venturi configuration, nozzle size, and initial tank pressure, which are the most important parameters influencing the jet pump performance. There are three commonly used pulse-cleaning designs, classified by the tank pressure including low pressure (LP), intermediate pressure (IP), and high pressure (HP) baghouses (Bustard et al., 1992). In the LP configuration, the tank pressure reaches approximately 12 psi, and no venturi is installed at the bag top. In the HP configuration, a venturi is installed at the bag top to induce the secondary airflow. The EPRI report (Lanois and Wiktorsson, 1982) compared the performance of the "advanced" and "traditional" fabric filter designs. The "advanced" system utilizes 15–30 psi compressed air to clean the filter bag and no venturi is used, while the "traditional" system utilizes 70–90 psi compressed air and a venturi is installed at the bag top. It was found that the "advanced" system design requires a lower cleaning energy for an equivalent cleaning efficiency. However, Morris

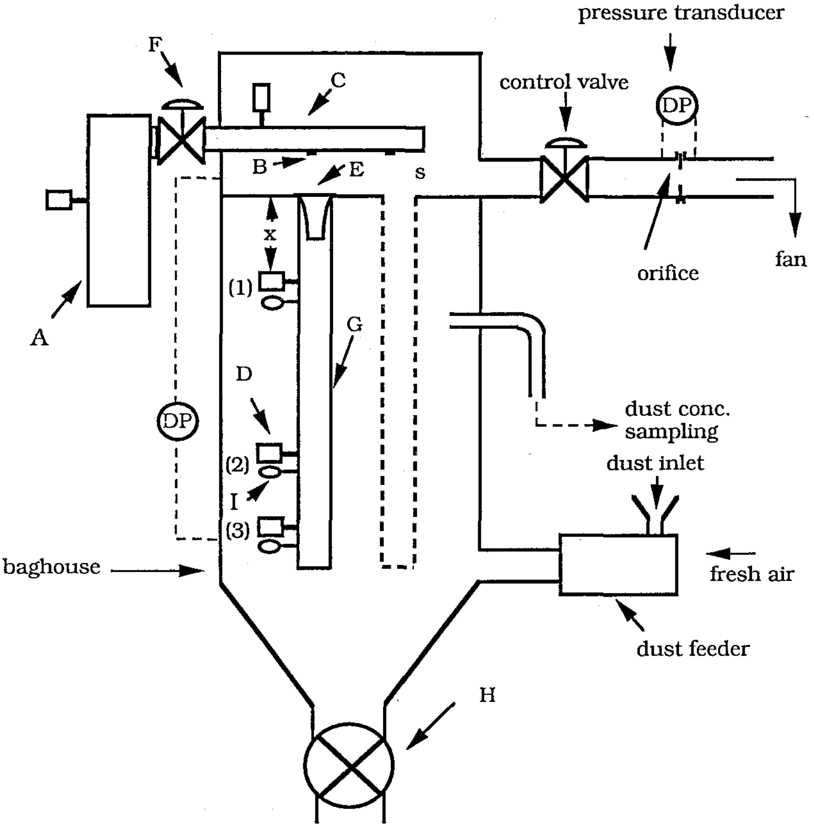

FIGURE 2. Schematic diagram of the pilot-scale pulse-jet baghouse. A, pressure tank; B, nozzle; C, blow tube; D, pressure transducer; E, venturi; F, diaphragm valve; G, fabric bag; H, rotary valve; I, accelerometer; x, distance of measured point away from bag opening; and, s, distance between nozzle and bag opening.

(1984) pointed out that the energy needed for the stable operation of a pulse-jet baghouse was reduced by about 30% on average by the addition of venturis. Whether a venturi is required at the bag entrance can't be decided by the previous experimental data in the literature. There are situations where venturis are required to increase pressure pulse inside the bag, and there are also situations where venturis are not necessary.

The jet pump curve can demonstrate the potential cleaning performance of a nozzle-venturi assembly system. An appropriate nozzle-venturi system not only reduces the consumption of pulse energy but also increase the bag cleaning effect. In this study, a pilot-scale pulse-jet baghouse is tested for determining whether a venturi is required under various operating conditions.

EXPERIMENTAL METHOD

The schematic diagram of the pilot-scale pulse-jet bag filter for testing the performance of dust filtration and bag cleaning is shown in Fig. 2. The equipment consists of a compressed air reservoir, diaphragm valve, air blow tube, nozzles with or without venturi, fan, dust feeder, and a baghouse compartment. The compressed air tank volume was 0.08 m^3; blow tube diameter was 8.3 cm. The venturi configurations used in the ex-

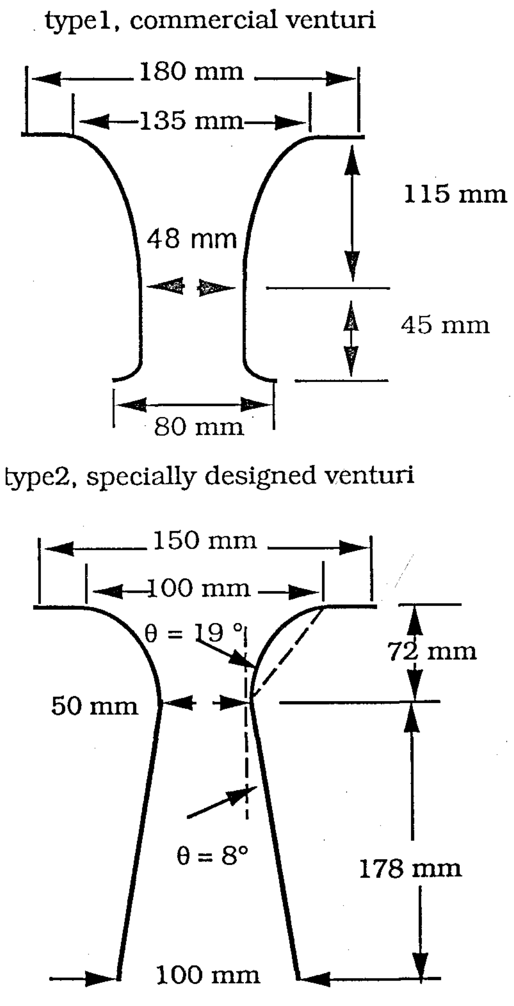

FIGURE 3. Configuration of type 1 and type 2 venturi.

periment are shown as Fig. 3. Type 1 venturi is a conventional design and type 2 venturi is a better design, which minimizes the flow separation in the divergent section. Inside the baghouse compartment, two 1.5 meter long and 127 mm diameter fabric bags made by polyester with acrylic coating were installed. A cylindrical cage supported the bags. A flow rate control device including an orifice, a pressure transducer, and a control valve was set downstream of the baghouse to measure the airflow rate during filtration and maintain a constant filtration velocity at 2 cm/sec for each test. The test dust was fly ash, which was obtained from a local coal fire power station. The MMAD (mass median aerodynamic diameter) and σ_g (geometric standard deviation) of the test dust was measured in the baghouse by a MOUDI (Model 100, MSP Inc., St. Paul) to be 6.0 μm and 2.1, respectively. The dust was fed into the baghouse from a homemade screw-type dust feeder located before the gas inlet duct and dispersed by a 40 psi compressed air. There was a speed control device to control the output dust concentration of the dust feeder. Dust mass concentration inside the compartment was determined by gravimetric method for each test during filtration.

Conditioned bags were used. The bags were conditioned by running the baghouse using the test dust for many filtration cycles until the filtration time and residual pressure drop became nearly constant. For the current experiment, this conditioning process lasted for over 50 hours. During filtration, the pressure drop Δp across the bag and the volume flow rate Q_f were measured continuously. The pressure drop vs. time curve can be used to decide the effective residual pressure loss, $(p_E)_{\Delta w}$, and the specific resistance coefficient, K_2, of dust cake. After attaining a pressure drop of 6 in. of H_2O, the diaphragm valve opened and the compressed air was discharged into the bag from the nozzle to remove the dust accumulated on the bag. The dislodged dust fell down to the hopper and was removed by the rotary valve. The tank pressure, the nozzle diameter, and the venturi were varied for the pulse-jet cleaning system to obtain different operating conditions. In order to determine the cleaning conditions inside the bag when the compressed air was released, the pulse pressure and the fabric acceleration/deceleration at various positions along the bag had to be measured simultaneously. For this purpose, high-frequency pressure transducers (Model R22-01505, MODUS instruments Inc., USA) and piezoelectric accelerometers (Type 4393, Bruel & Kiaer Inc., Sweden) were installed on the bag. Both, pulse pressure and fabric acceleration were measured

TABLE 1. Design and Operation Parameters of the Pulse-Jet Baghouse Used in This Study

Design and Operation Parameters	
Number of bags	2
Bag length	1.5 m
Bag diameter	127 mm
Bag fabric	polyester with acrylic coating
Venturi	type 1, type 2 and no venturi were tested
Nozzle diameter, d_n	8, 13 and 20 mm
Distance between nozzle and venturi, S	72 mm
Filter Operating Condition	
Filtration velocity, v_f	2 cm/sec
Inlet dust concentration, C	$9.5 \sim 11.8$ g/m^3
Cleaning pulse duration, T_{pd}	150 msec
Initial tank pressure, p_{tk0}	39.2 to 588 kPa (or $0.4 \sim 6.0$ kg/cm^2)
Dust	fly ash, MMAD $\fallingdotseq$ 6.0 μm, $\sigma_g \fallingdotseq 2.1$

at three positions, referred as points (1)~(3). These positions were located from the bag opening at 20, 100, and 140 cm, respectively. The pulse pressure and fabric acceleration were recorded simultaneously by computer.

All tests were performed at a constant filtration velocity of 2 cm/sec. When the pressure drop across the fabric reached 6 in. of H_2O, the bag cleaning was initiated. The design and operation conditions are shown in Table 1.

RESULTS AND DISCUSSION

Filtration Curves for Various Operating Conditions

Figures 4a–c show the filtration curves for no venturi condition under various initial tank pressures. It is seen that the filtration curves are influenced by the initial tank pressure and nozzle diameter. When the initial tank pressure increases, the residual pressure drop decreases while the slope of filtration stays almost constant. The experimental data of Dennis et al. (1981) showed the same results. With the initial tank pressure exceeding a critical value, the filtration curves will overlap and the residual pressures drop remains the same. For example, it is seen in Fig. 4c that the filtration curves for p_{tk0} = 147 kPa (or 1.5 kg/cm^2) and p_{tk0} = 294 kPa (3.0 kg/cm^2) are almost the same, with the residual pressure drop of about 199 Pa (0.8 in. of H_2O). This fact indicates that a critical value of tank pressure exists for the most effective bag cleaning. When the initial tank pressure exceeds this critical value, the pulse-jet cleaning effect increases only slightly.

From the filtration curves under different operating conditions, the effective residual pressure loss, $(p_E)_{\Delta w}$, and the specific resistance coefficient of dust cake, K_2, can be calculated by Eq. (4). The calculated results are shown in Table 2. It is seen that the K_2 value is nearly constant at the same filtration velocity of 2 cm/sec. The average of K_2 value in this experiment is 4.79 N · min/g-m. The effective residual pressure loss decreases with increasing initial tank pressure and nozzle diameter. In this experiment, the effective residual pressure loss reaches a value of about 249 Pa (or 1 in. of H_2O) eventually under various operating conditions, when the initial tank pressure and nozzle diameter are large enough. This fact indicates that high initial tank pressure (high pressure-low air volume) or large nozzle diameter (low pressure-high air volume) provides comparable cleaning results.

Figures 5a–c show the filtration cycle of the cleaning system for three different nozzle diameters without the venturi and p_{tk0} = 196 kPa. When the pressure drop across the fabric bag reaches 1494 Pa (or 6 in. of H_2O), the diaphragm valve opens and the bag cleaning process begins. The filtration time

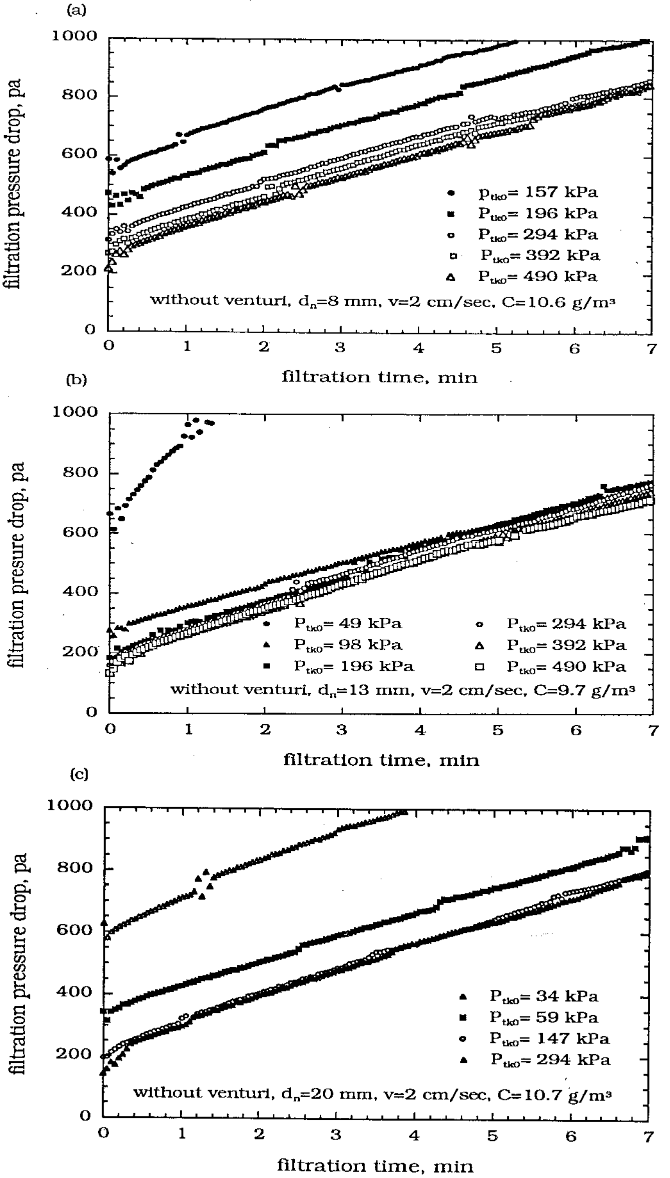

FIGURE 4. Filtration curves for bag cleaning system without venturi under various initial tank pressure: (a) d_n = 8 mm; (b) d_n = 13 mm; (c) d_n = 20 mm.

of one cleaning cycle for nozzle diameter of 8, 13, and 20 mm is about 11 min, 13 min, and 13.6 min, respectively. The filtration time for 8 mm nozzle diameter is shorter than that for 13 and 20 mm; the time for the last two nozzle is very close. This discrepancy is caused by the effective residual pressure loss. The effective residual pressure losses for 8, 13, and 20 mm nozzle diameter are 486, 237, and 262 Pa (or 1.95, 0.95, and 1.05 in. of H_2O), which are found from Table 1. The lower effective residual pressure loss value represents a longer filtration time and a better cleaning effect. The higher effective residual pressure loss for 8 mm nozzle diameter results in the shorter filtration time per

TABLE 2. The Calculated Values of K_2 and $(P_E)_{\Delta w}$ from Filtration Curves under Various Operating Conditions

Venturi type	Nozzle Diameter (mm)	Initial Tank Pressure, p_{tk0} (kg/cm^2)*	Effective Residual Pressure Loss, $(p_E)_{\Delta w}$ (in. of H_2O)**	Residual Pressure Drop, p_R (in. of H_2O)	K_2*** ($N \cdot min/g\text{-}m$)
no venturi	8	1.6	2.48	2.17	4.81
		2.0	1.95	1.73	4.78
		3.0	1.58	1.26	4.43
		4.0	1.37	1.00	4.81
		5.0	1.23	0.87	4.89
		6.0	1.17	0.73	4.85
	13	0.5	3.88	2.47	5.42
		1.0	1.26	1.11	4.60
		2.0	0.95	0.74	5.63
		3.0	1.01	0.64	4.61
		4.0	0.85	0.54	5.43
		5.0	0.93	0.53	5.03
	20	0.5	1.62	1.27	4.47
		0.7	1.13	1.09	4.57
		1.5	1.08	0.79	4.93
		2.0	1.05	0.7	5.20
		3.0	1.1	0.58	4.95
type 1 venturi	8	1.0	2.78	3.4	4.50
		2.0	1.62	1.42	5.31
		3.0	1.43	1.18	5.26
		4.0	1.34	1.06	5.12
	20	0.5	1.65	1.41	4.96
		1.0	1.40	1.16	4.64
		2.0	1.11	0.84	4.93
		3.0	1.09	0.76	4.64
type 2 venturi	13	1.0	1.67	1.41	5.09
		2.0	1.38	1.08	4.80
		3.0	1.34	1.09	5.57
		4.0	1.22	0.92	4.86

* 1 kg/cm^2 = 98 kPa; ** 1 in. H_2O = 249 pa; *** average K_2 = 4.79 $N \cdot min/g\text{-}m$

cycle. Thus, the effective residual pressure loss can be used as an index of bag cleaning effect. The filtration time can then be estimated from the effective residual pressure loss by Eq. (4) providing K_2 is known.

The Influence of Various Operating Conditions on Bag Cleaning

The pulse overpressure equals the difference of the pulse pressure inside of the bag and the pulse pressure outside of the bag. The pulse overpressure is the driving force to dislodge the dust accumulated on the bag. In this experiment, the pulse overpressure is used as an index for cleaning intensity.

Figures 6a–c show the pulse overpressure profile at different positions along the bag, while Figs. 7a–c show the fabric acceleration profile at the same positions. It is seen from Fig. 6 that the pulse overpressure profile varies along the bag. Fast oscillation of negative pulse overpressure occurs near the top of bag (point (1). At the middle and bottom portions, point (2) and point (3), of the bag, both pulse overpressure profiles are nearly the same. This fact shows that the pulse pressure distribution is uniform in the middle and bottom parts of the bag. From the profile of the fabric acceleration, it is seen that the maximum acceleration/deceleration occurs at the point (1). When the amplitude of pulse overpressure increases, the absolute magnitude of acceleration/deceleration also increases.

The effective residual pressure loss is an index to evaluate the bag cleaning effect. More effective bag cleaning will result in a

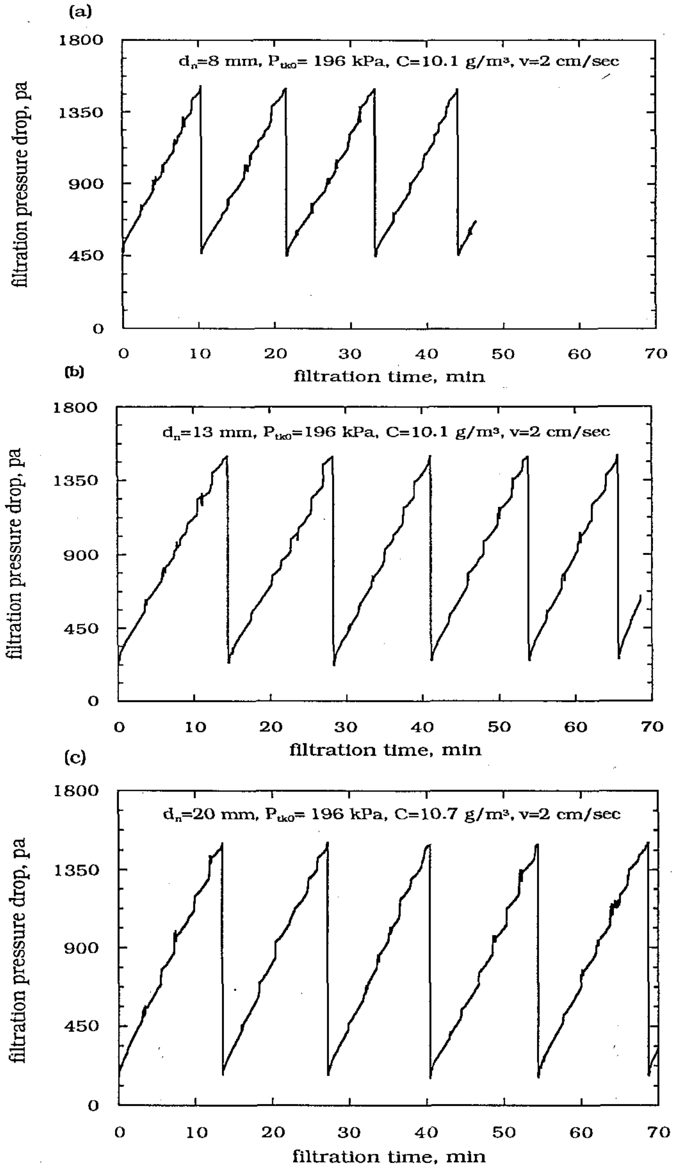

FIGURE 5. Filtration cycles for bag cleaning system without venturi at p_{tk0} = 196 kPa (or 2.0 kg/cm^2) (a) d_n = 8 mm; (b) d_n = 13 mm; (c) d_n = 20 mm.

smaller effective residual pressure loss. The average and peak pulse overpressures and maximum absolute fabric acceleration are used as indices of bag cleaning intensity. Figures 8a–c show the relationship between the effective residual pressure loss and the cleaning intensity index. Figure 8a shows the relationship between the average pulse overpressure and the effective residual pressure at point (2). When the average pulse overpressure exceeds about 600 pa, the effective residual pressure stays nearly constant. This fact indicates that when the average pulse overpressure exceeds 600 pa, the dust cake removal efficiency increases only slightly. This critical value is very close to the value of

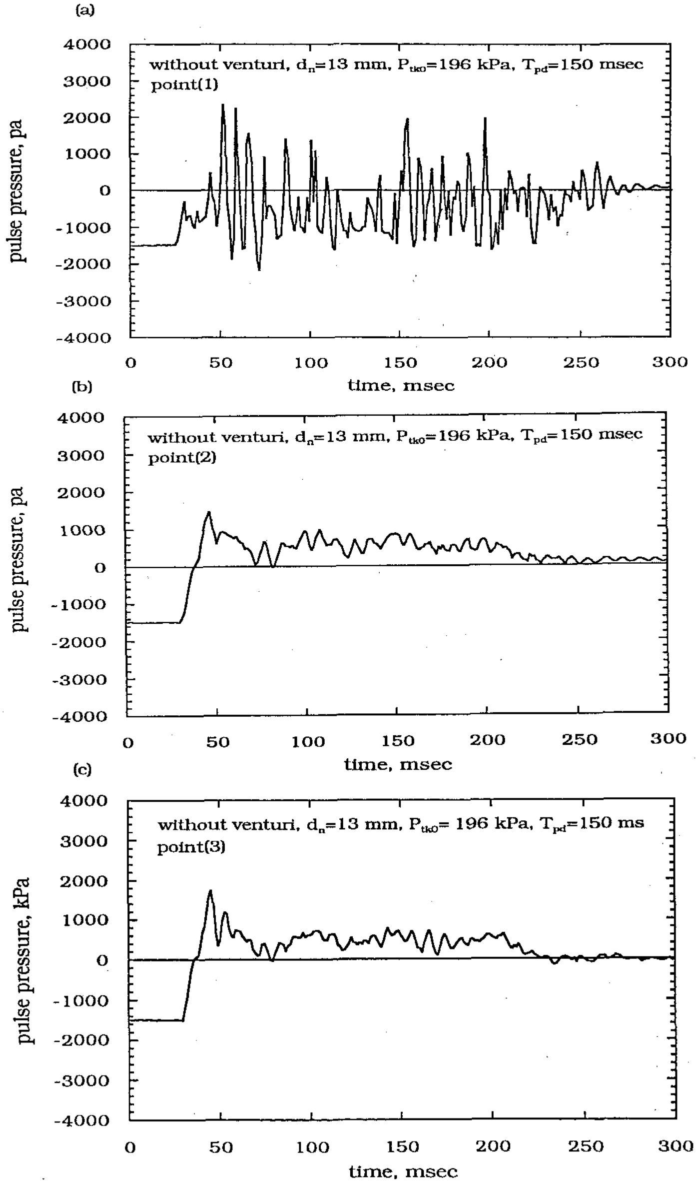

FIGURE 6. Pulse overpressure profile of different positions along the bag when d_n = 13 mm, p_{tk0} = 196 kPa (or 2 kg/cm^2) (a) 20 cm; (b) 100 cm; (c) 140 cm.

400~500 Pa obtained by Sievert and Löffler (1989).

Figure 8(b) shows the relationship between the peak pulse overpressure and the effective residual pressure at the point (2). From Fig. 8b, the critical peak overpressure value of about 1200 Pa is obtained. Figure 8c shows the relationship between the maximum absolute acceleration/deceleration and the effective residual pressure at the point (1). From Fig. 8c, the critical value of fabric acceleration/deceleration is found to be about 30 g. This value agrees with the result of Morris (1984). These facts show that a critical cleaning effect exists for a pulse-jet cleaning system. Too large of an initial tank

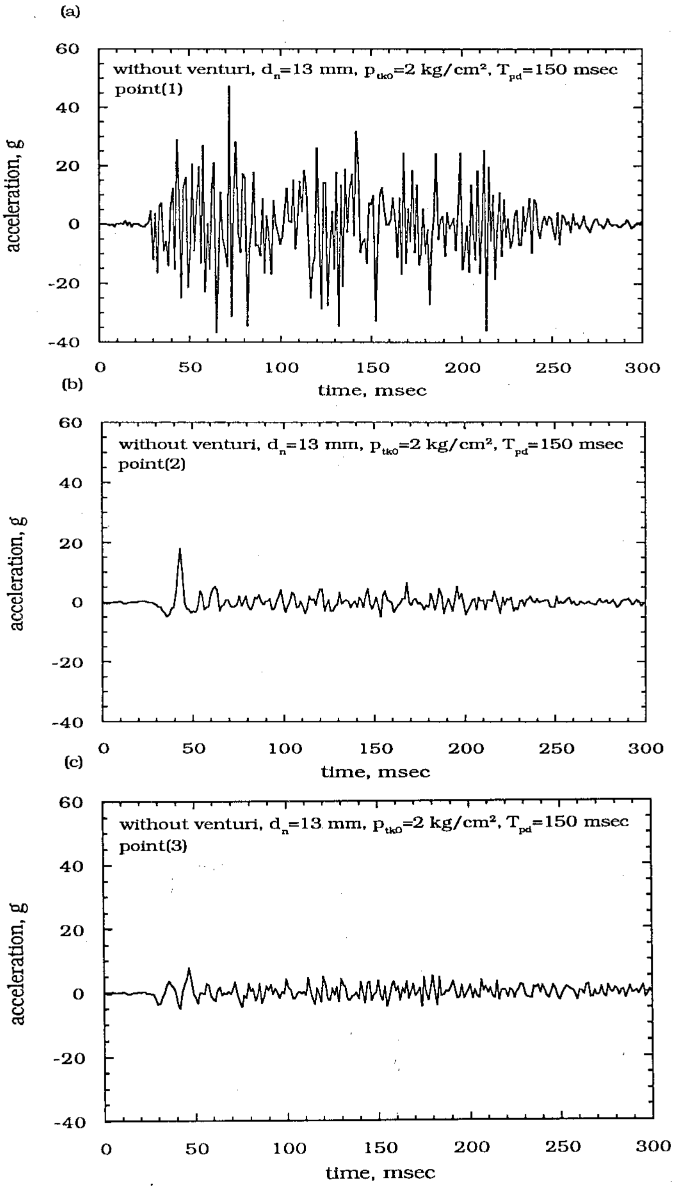

FIGURE 7. Fabric acceleration profile of different positions along the bag when d_n = 13 mm, p_{tk0} = 196 kPa (or 2 kg/cm²) (a) 20 cm; (b) 100 cm; (c) 140 cm.

pressure and nozzle diameter result in a waste of cleaning energy. When designing a baghouse, the critical cleaning force intensity must be taken into consideration.

Figure 9 depicts the relationship between the initial tank pressure and average pulse overpressure for no venturi and type 1 venturi conditions. A horizontal line representing a critical average pulse overpressure of 600 Pa is also indicated. The average pulse overpressure increases with the initial tank pressure linearly. To create an average pulse overpressure higher than the critical value, 600 Pa, the initial tank pressure must be higher for the system using smaller nozzle diameters. For the nozzle diameters of 8 mm

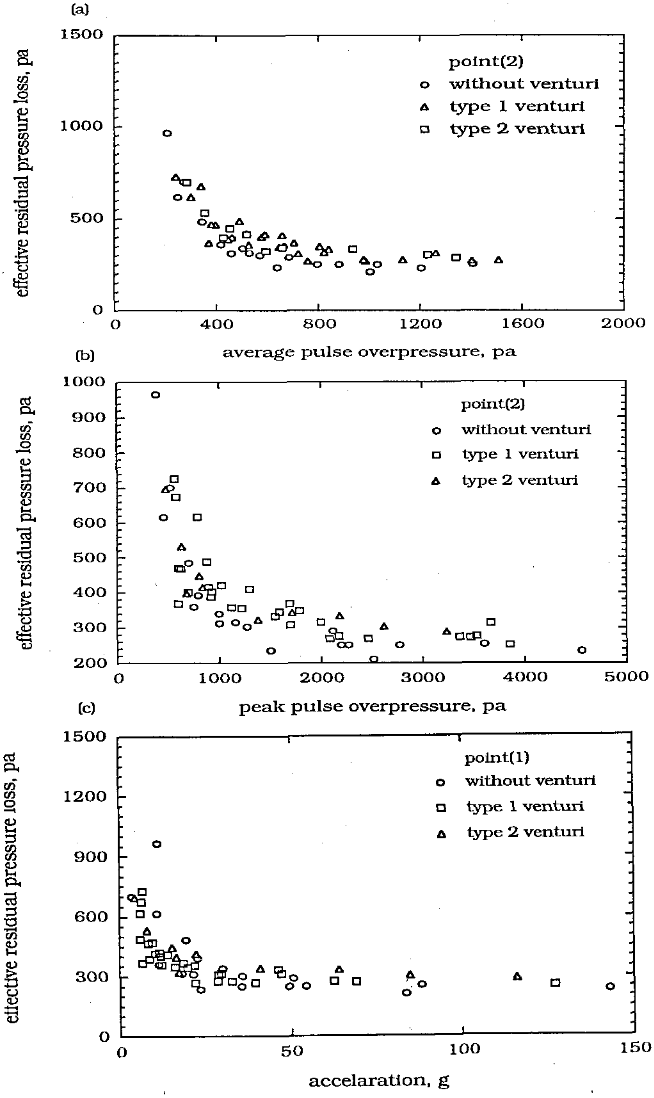

FIGURE 8. The relationship between the effective residual pressure loss and cleaning force indices: (a) $(p_E)_{\Delta w}$ vs. average pulse overpressure at point (2); (b) $(p_E)_{\Delta w}$ vs. peak pulse overpressure at point (2); (c) $(p_E)_{\Delta w}$ vs. maximum absolute acceleration at point (1).

and 13 mm, the pulse-jet cleaning system with type 1 venturi generates a higher pulse overpressure. For the nozzle diameter of 20 mm, the average pulse overpressure is similar for the no venturi and type 1 venturi conditions. This fact shows that when no venturi is installed, a larger nozzle diameter is more effective to achieve a higher pulse overpressure. In this experiment, a venturi is suggested to be installed to increase the cleaning effect and reduce cleaning energy waste.

Figure 10 shows the relationship between the energy consumption of pressure tank and average pulse overpressure. The horizontal line in the figure represents the critical average pulse overpressure. For no venturi condition, a small nozzle diameter consumes more energy while achieving the same average pulse overpressure. For the type 1 venturi condition, the energy consumption to obtain the same average pulse overpressure for 8 mm and 13 mm is very close. For no venturi condition, a larger noz-

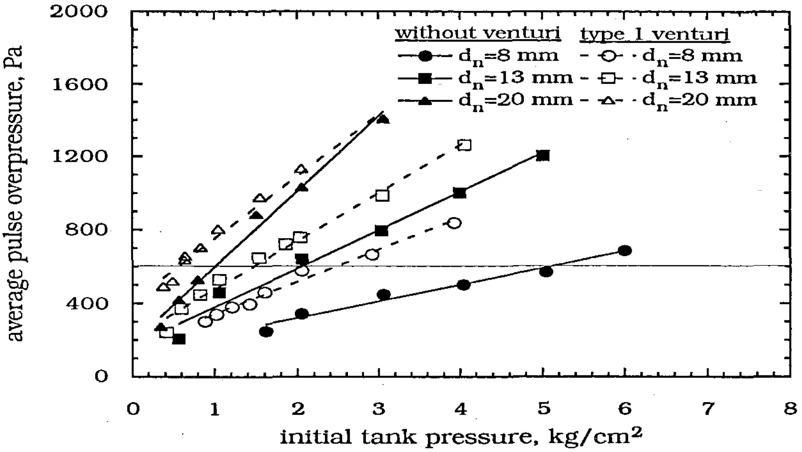

FIGURE 9. **The relationship between the average pulse overpressure and initial tank pressure with type 1 venturi and without venturi condition under various nozzle diameters.**

zle diameter causes more air to be discharged into the bag, resulting in a more effective pulse overpressure. When a venturi is installed, a larger nozzle also causes a higher pulse overpressure. However, since a venturi throat constrains the airflow into the bag, an increase of the nozzle diameter will not increase the effective pulse overpressure appreciably.

CONCLUSIONS

This study has investigated the filtration curves and pulse-jet cleaning effect for different design and operating conditions of a pilot-scale pulse-jet baghouse. It is found that filtration curves vary with the initial tank pressure and nozzle diameter of the bag cleaning system. The filtration time increases with the increasing initial tank pres-

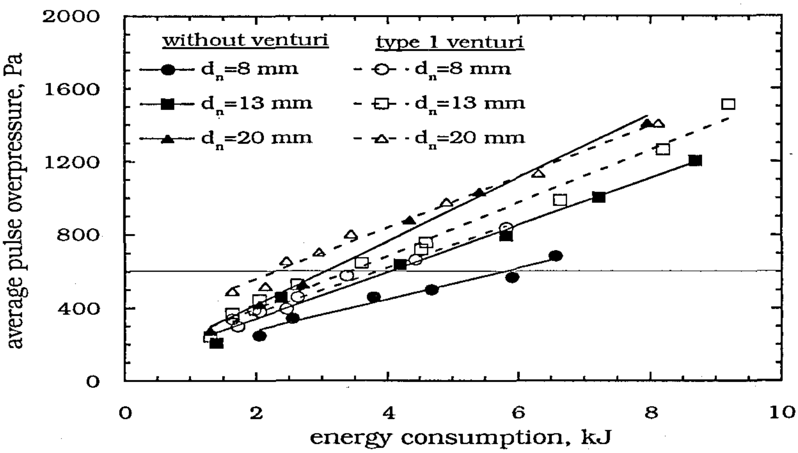

FIGURE 10. **The relationship between the average pulse overpressure and tank pressure energy consumption with type 1 venturi and without venturi condition under various nozzle diameters.**

sure or nozzle diameter. However, a critical value of the tank pressure exists for an effective bag cleaning. It is found that a critical effective residual pressure loss value of about 1 in. H_2O and a critical cleaning average overpressure of 500–600 pa for an effective bag cleaning exist for the pulse-jet baghouse investigated in this study.

The addition of the venturi increases the average pulse overpressure appreciably, hence increasing the cleaning effect. In this study, a type 1 venturi with a small nozzle is shown to be a preferred configuration for an effective bag cleaning.

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