Pressurize chimney annulus to avoid acid attack

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Chimney annulus pressurization is not uncommon in the power industry. Many new chimneys have pressurization fans already existing and operating; however, many older chimneys built with brick linings do not have an annulus pressurization system.

After years of service, these brick liners show signs of normal cracking, and flue gases under positive pressure tend to permeate through the brickwork into the annulus. This causes deterioration of mortar joints and corrosion of lining bands and other metal components within the annulus. It also can cause spalling of concrete on the inside face of the chimney column.

Obviously, the owners of a chimney wish to avoid damage in the annulus, since the repair cost will be very high and, for some chimneys with narrow airspace, repair may not even be possible. The answer to this problem is to pressurize the airspace before it is too late. The intent of this article is to review those factors that affect the design and selection of a pressurization system for existing chimneys.
Pressurization of a chimney annulus with an acid resistant brick lining will maintain a positive differential pressure between the annulus and the liner, thus preventing flue gas from permeating through the brick liner. An ideal solution would be to create a perfectly leak-proof brick liner, but there is no such thing. Even well-built, high-quality brick liners will show signs of cracking with time and allow flue gas to leak through. A properly designed, installed, and maintained pressurization system will provide much longer life for the brick liner and the accessories in the annulus.

Design guidelines

The design of the pressurization fan depends upon several parameters such as static fan pressure requirement, ambient air density, and total area of leakage. Starting from the general expression:

$$P = (\rho V^2) \div 2g$$

One can derive:

$$Q = (\sqrt{2gP/\rho}) \times A$$

where:

- Q = required fan output capacity, acfm
- ρ = ambient air density (use 0.07 to 0.08 lb/ft^3)
- A = total area of leakage
- P = required fan static pressure in inches of water

P is equal to the flue gas pressure inside the liner plus the desired pressure differential. For example, if the chimney pressure is +3 in. H_2O and 2 in. pressure differential is required, then $P = 3+2 = 5$ in. H_2O. It is recommended that the desired pressure differential and the flue gas pressure inside the liner be mentioned in the bid specification so that all bidders may design for the same pressure requirement.

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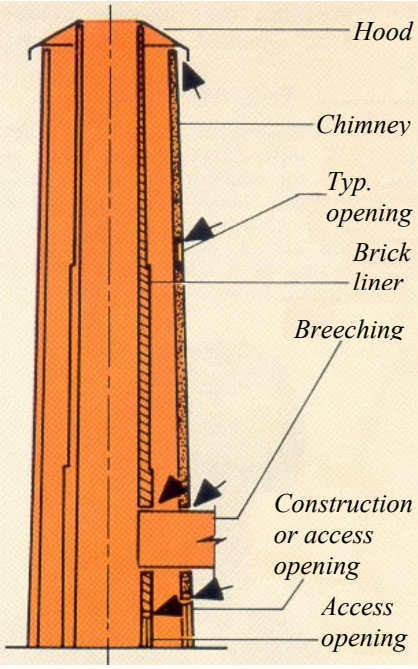

Figure 1. General areas in a typical chimney. These areas should be inspected frequently and any damaged seals should be repaired or replaced promptly

It is evident that the influence of leakage area A is significant in the fan output calculation. There could be many openings in the airspace, such as breechings, construction openings, roll-up doors, vents on chimney wall, top hood, hood vents, sampling probes, and probe access openings. Even though all these openings will be closed up and sealed for pressurization, as a practical matter all of the openings will develop some amount of leakage around the perimeter with time. The question is how to estimate this leakage so that the pressurization system is still effective and functional once these leaks develop. Proper judgment should be exercised in this estimate (Figure 1).

The following guidelines, based on actual field inspection of several chimneys, are considered reasonable:

1. For top hood with designed ventilation, use actual vent area.
2. For top hood without ventilation, use 0.1 in. all around the perimeter for a cloth seal. Use 0.2 in. for a metal or FRP seal.
3. For construction openings closed with metal doors use 0.125 in. around the opening.
4. For roll-up doors, use 0.25 in. around the perimeter.
5. For all other openings, use 0.1 in. around the perimeter.

In addition to the above guidelines, one should also consider some leakage through the concrete wall of the chimney which will develop hairline cracks with time. Here, leakage of 1 ft^2 for every 15,000 to 25,000 ft^2 of surface area, depending upon the condition of the chimney, is reasonable.

After determining the design leakage area, based on the above assumptions, one may consider a safety factor depending upon how often the airspace is inspected and maintained. Remember that any increase in the leakage area will increase the required fan size in direct proportion. Hence, it is recommended that the openings, leakage assumption around the perimeters, and leakage through the column wall should all be stated in the bid specification. This ensures that all bidders have the same design requirements and the owners of the chimney are able to make a valid bid comparison.

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Initially, these assumptions may seem over-conservative, since no appreciable leakage should occur in a newly installed pressurization system. But within a few months some leakage will develop due to normal service related movement of the liner, and, it is almost impossible to predict the actual area of leakage.
It is important to remember that the cost of an adequate pressurization system is only a fraction of possible repair costs to the annulus. So, it is much wiser to be conservative in designing the fan than to find out after subsequent inspections that the seals around the openings are no longer airtight, the leakage is greater than anticipated, and the fan system is undersized.

In a recent project, two different vendors proposed different fans for a chimney annulus pressurization, and the output ratio of these fans varied by as much as 2 to 1. Obviously, the important requirements, such as the desired pressure differential and the leakage area assumptions were not specified in the bid package. One vendor may have assumed very small pressure differential and minimal leakage since it was a new installation. The other may have considered 1 in. to 2 in. water pressure differential and a larger leakage area. Thus, the size of fan designed by the first bidder was considerably smaller and the price was more attractive. For cases like this, it is recommended that the owner should verify that the bidders' designs follow the specification requirements.

If design requirements were not clearly stated in the specification, then the owner should review the design and be satisfied that reasonable assumptions were made.

Accessories

Generally, the belt-driven fan is preferred over a direct-drive fan because of its low first cost option and the fact that it permits the flexibility of fine tuning the pressure at any time by means of a simple pulley change. It also makes motor selection and motor purchasing easier. However, it adds regular belt changing to the maintenance schedule.

For the pressure gage, our recommendation is to use a simple one that gives reliable reading of the annulus pressure above atmospheric and, since the flue pressure is known, the low pressure alarm is set accordingly. The gage should be located where it can be read instantly and be equipped with a low and high pressure alarm.

It is also desirable to have fan on/off switches at all entrances, both on the inside and the outside face of the chimney wall. Otherwise it may be difficult and dangerous to enter and exit the annulus while the blower is operating.

Air should be vented at the top to control leakage around the hood opening. This provides circulation and eliminates dead airspace where both heat and leak gas can build up. If an existing system lacks ventilation, it is wise to consider a retrofit.

Good maintenance program

Once a pressurization system is properly designed and installed, the most important factor that will keep it going is a good maintenance program. If a pressurization failure goes undetected, and acid condensate begins to corrode the steel in the annulus, the damages and the repair cost could be extremely high. The primary object should be to avoid repair costs entirely with a program that is about 90% inspection and 10% simple preventive maintenance.

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In general, preventive maintenance is a matter of visual inspection combined with operational tests. Operation of all door switches and locking devices should be checked at least once a month, together with the over- and under- pressure alarms. Seals around the doors, the ductwork and the electrical conduits may have to be repaired or replaced from time to time. The floor of the annulus must be constantly inspected for condensate in the annulus, fumes, fallen mortar or concrete chips-all signs of imminent trouble.

Wipers at the top of the annulus, fabric seal, lining bands, platforms, lighting and instrumentation should be checked at least once a month. This ensures that the pressurization system is working properly and that there is no leakage of flue gas into the annulus, which would cause the metal parts to corrode.

Structural considerations

The location of the fans and the size of the outlet duct may be very important for the structural integrity of the existing column. If the chimney already has large flue openings and another large opening is proposed for the fan outlet near an existing opening, considerations must be given for proper structural analysis to ensure that the chimney is not weakened by the installation of new openings.

In a recent project, a vendor told the owner that two openings for two separate fans could be installed in the chimney wherever the owner wanted them. It is recommended that the owner, in this case, ask for structural calculations showing that the chimney will not lose its structural integrity by the installation of these new openings.

The foundation requirement for the fan should be carefully reviewed. Generally, if the foundation for the chimney itself is large enough to accommodate the fan, there should not be much concern. However, the owner should insist that the vendor review the design of the foundation.

Conclusion

When a pressurization system for a chimney annulus is considered, all design requirements should be stated in the bid specification with as much detail as possible. It is not advisable to leave the design assumptions up to the vendors, since the proposals may vary considerably in price and the owner may find it difficult to make a decision.

It is never too early to design and install an adequate pressurization system for the annulus of a chimney, with an independent brick lining, that operates under positive pressure. In the present state of the art, this appears to be the most efficient and cost effective method of extending the life of the liner, the accessories in the annulus and the chimney wall.

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