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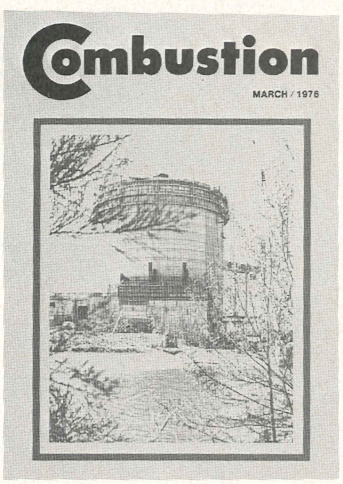

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Mechanical draft fans for today's modern balanced draft steam generators are the second largest consumers of station power. Our paper examines the aerodynamic, mechanical, physical, maintenance, sound control, and flow control aspects of axial mechanical draft fans compared to airfoil centrifugal fans presently in popular use. Axial fans may be a better investment for many users, when energy and material conservation are important factors.

Axial Mechanical Draft Fans for Energy Conservation *

C. E. WAGNER K. H. JOHNSTONE

Buffalo Forge Co.

Mechanical draft fans for today's modern balanced draft steam generators are the second largest consumers of station power, following only boiler feed pumps. The application of forced draft, induced draft, and primary air fans will be the subject of this paper.

Centrifugal and axial flow types of fans will be compared.

A typical airfoil blade centrifugal fan rotor is shown in Fig. 1. A typical adjustable pitch axial flow fan impeller is shown in Fig: 2.

There are three energy conservation reasons for the United States utilities companies to review design and application criteria for their mechanical draft fans.

(1) Increasing cost and decreasing availability of fossil fuels.

(2) Increasing construction costs and scarcity of basic material.

(3) Physical size factors.

This paper will endeavor to present, by comparison of centrifugal and axial flow fans, a cogent argument to justify the claim that axial flow mechanical draft fans should be used for energy conservation.

Aerodynamic Comparison of Centrifugal and Axial Fans

In the aerodynamic comparison which follows, fan flow rates and pressure rises, typical of those expected for a 600-mw balanced draft, pulverized coal fired steam generator are presented. Table 1 gives the required duty for each of the fans.

For forced draft and primary air fans, airfoil blade centrifugal fans with variable inlet vane control will be compared to adjustable pitch controlled axial flow fans. For induced draft, the comparison will be between airfoil blade centrifugal fans with hydraulic coupling control versus adjustable pitch controlled axial flow fans. Table 2 summarizes the power consumption of each fan.

The totals are shown in Table 3 together with an expression of total mechanical draft fan consumption as a percent of unit design.

Mechanical Comparison of Centrifugal and Axial Fans

While the aerodynamic comparison of centrifugal and axial flow fans illustrates energy conservation, there are also significant mechanical and structural advantages when using axial flow fans. Table 4 summarizes the total mass of each fan and required driving motor for the aforementioned example.

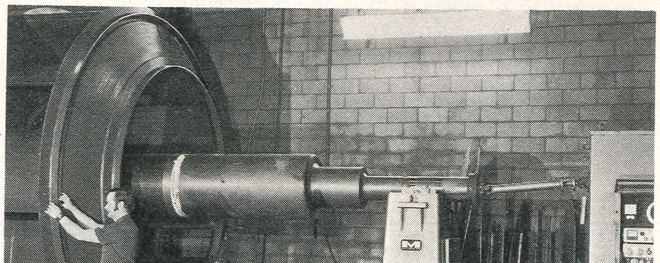

Fig. 1. Airfoil blade centrifugal rotor for mechanical draft service

* Presented at the Winter Annual Meeting, New York, N. Y., November 17–22, 1974. ASME Paper 74-WA/PWR12

TABLE 1

Load	Design	100%	88%	44%
Two Forced Draft Fans each				
Fan Flow Rate, m^3/s	343	254	222	147
Fan Total Pressure, mm wg	651	463	354	239
Two induced Draft Fans each				
Fan Flow Rate, m^3/s	688	518	454	272
Fan Total Pressure, mm wg	590	361	300	156
Two Primary Air Fans each				
Fan Flow Rate, m^3/s	105	84	80	51
Fan Total Pressure, mm wg	1862	1483	1336	1224

TABLE 2

Load	Design	100%	88%	44%
Two Forced Draft Fans each				
Centrifugal Power, kW	2284	1782	1427	1087
Axial Power, kW	2466	1318	927	517
Two Induced Draft Fans each				
Centrifugal Power, kW	4653	3108	2521	1234
Axial Power, kW	4530	2418	1848	769
Two Primary Air Fans each				
Centrifugal Power, kW	2163	1608	1526	1106
Axial Power, kW	2087	1389	1196	738

TABLE 3

Load	Design	100%	88%	44%
Unit Output, kW		600000	528000	264000
Power Total Six Centrifugals, kW	18200	12996	10948	6850
Power for Cent, % of unit output		2.17	2.07	2.59
Power Total Six Axials, kW	18166	10250	7942	4048
Power for Axials, % of unit output		1.71	1.50	1.53
Total Power Savings, kW		2746	3006	2803
Total Power Savings, % of unit output		.46	.57	1.06

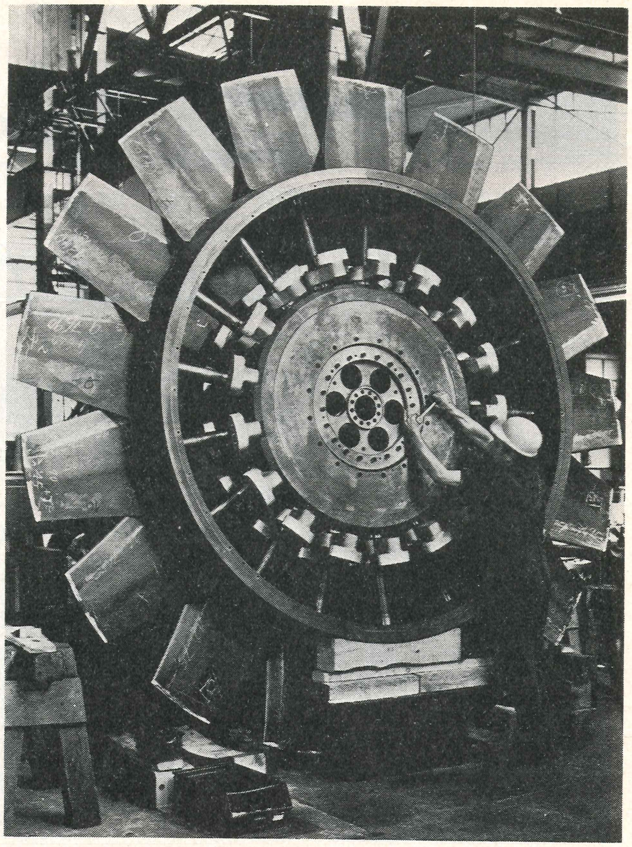

Fig. 2. Large mechanical draft axial impeller as viewed from entering air side

TABLE 4

Fan Application	FD	ID	PA	6 Fans Total
Weight each Cent. Fan, kg	47900	86300	10000	288400
Weight each Axial Fan, kg	17800	51300	12700	163600
Weight each Cent. Motor, kg	11800	14500	6000	64600
Weight each Axial Motor, kg	8400	13600	6000	56000

It is apparent from Table 4 that, not only can 133,400 kg of basic material be saved by use of axial fans, but less mass of structure is required to support the fans and their motor. An accepted rule of thumb is that the foundation mass should be three times the mass of the supported rotating machinery. By making this assumption, we realize a possible reduction of 400,000 kg in foundation mass with axial flow fans.

One other aspect of the mechanical comparison is the flywheel effect of centrifugal and axial flow fans. Table 5 summarizes the WK^2 values for each of the fans of the example. The resulting advantages in acceleration and deceleration times are obvious and the first cost savings of motors with the lower WK^2 values can be documented.

Physical Size Comparison of Centrifugal And Axial Fans

A typical cross-sectional drawing of a double inlet, airfoil blade, forced draft fan is shown in Fig. 3. Likewise, a typical cross-sectional drawing of an axial flow forced draft fan is shown in Fig. 4.

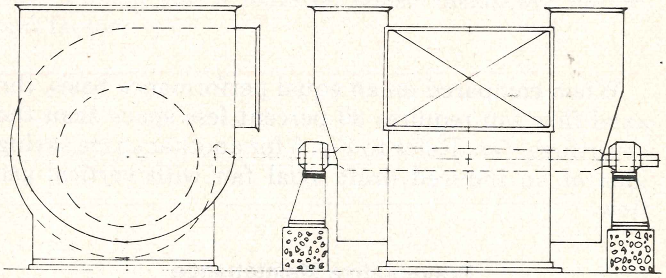

Fig. 3. Sectional of an airfoil centrifugal mechanical draft fan

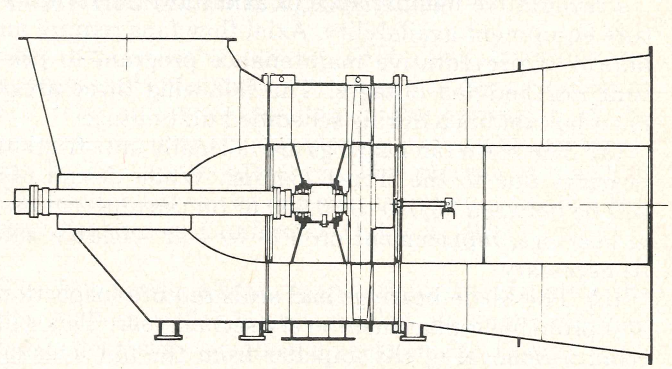

Fig. 4. Sectional of an horizontal installation mechanical draft axial flow fan

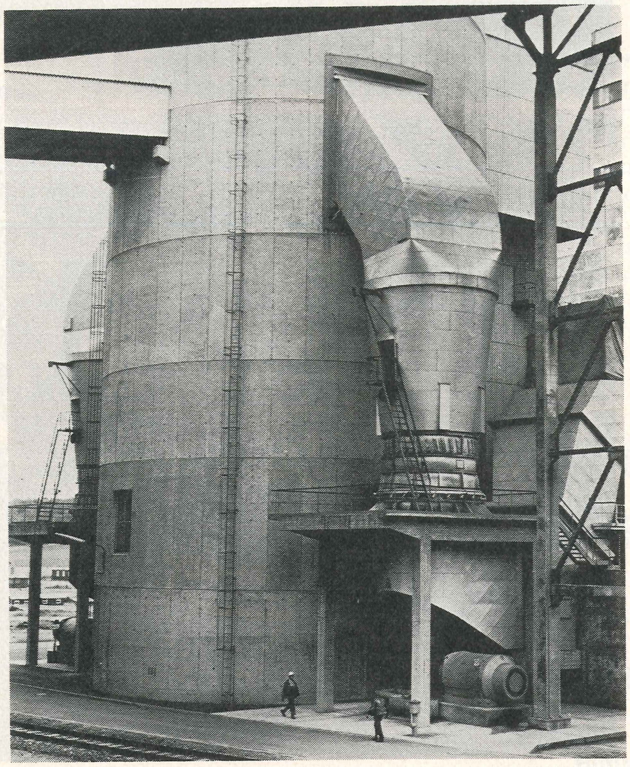

Fig. 5. Single-stage vertical mechanical draft axial fan for induced draft service

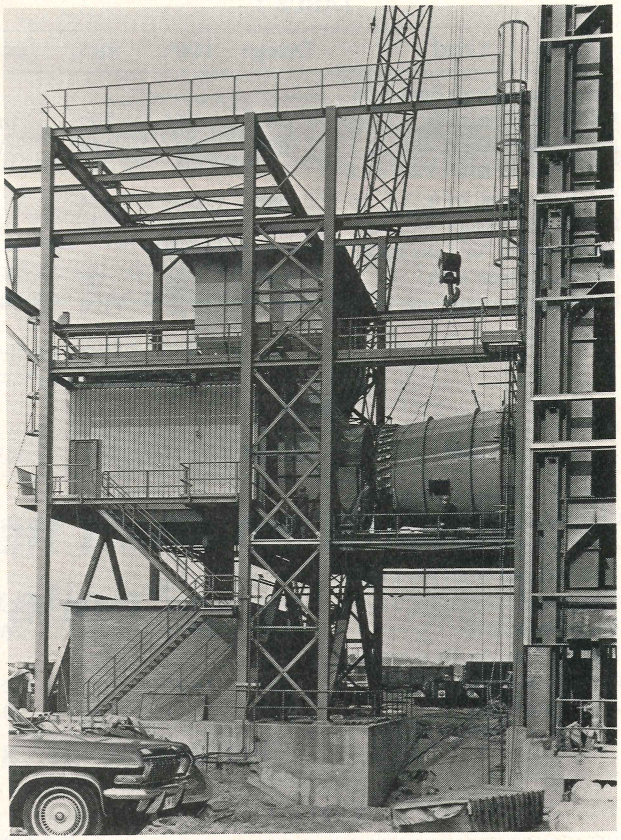

Fig. 6. Single-stage mechanical draft axial fan used for forced draft service with sound attenuator installed

TABLE 5

Fan Application	FD	ID	PA
Centrifugal WK^2, kgm^2, Lb (pound)	9000	24000	400
Axial WK^2, kgm^2	720	5200	760

When compared on an equal performance basis, the axial flow fan requires 30 percent less space than the centrifugal fan. Refer to Fig. 5 for another space saving idea of an induced draft axial fan with vertical gas flow.

Preventative Maintenance

Preventative maintenance of axial flow fans will insure equipment availability. Axial flow fans require an improved preventative maintenance program to prevent unscheduled outages. The following three areas must be examined during scheduled unit outage.

(a) The main fan bearings are normally anti-friction bearings due to the thrust loading. While design life will be between 30,000 to 60,000 hr on the antifrictional bearings, replacement on a 3- to 4-yr schedule will be necessary.

(b) The blade bearings and seals require inspection and probable replacement every second year. This will require removal of the impeller from the fan housing to a clean shop where the work can be accomplished.

(c) In induced draft fan service, abrasive erosion of the blades and the guide vanes is possible. Should replacement be required, a new set of blades and/or guide vanes can be replaced in an 8- to 16-hr time period.

Sound Control

OSHA has established design criteria for allowable noise levels at various work stations in the power plant. When compared on the basis of equal performance axial flow fans will generate higher sound power levels than centrifugal fans. However, complicance with OSHA is possible at comparable costs due to the following:

(a) Axial flow fans often have 23 blades compared to 10 blades for airfoil centrifugal fans. Axial flow fans will operate at the same or higher relative speeds, therefore, the resulting blade frequency will be in a higher octave band where adsorptive silencers have their maximum attenuation.

(b) Fig. 6 shows the typical compact arrangement of an adsorptive silencer on an axial flow forced draft fan.

(c) As shown in Fig. 7, less sound protective covering is required to prevent the casing component of the fan noise from emanating into the area immediately surrounding the fan due to smaller fan size.

Flow Control

With the continued increase of the physical size of

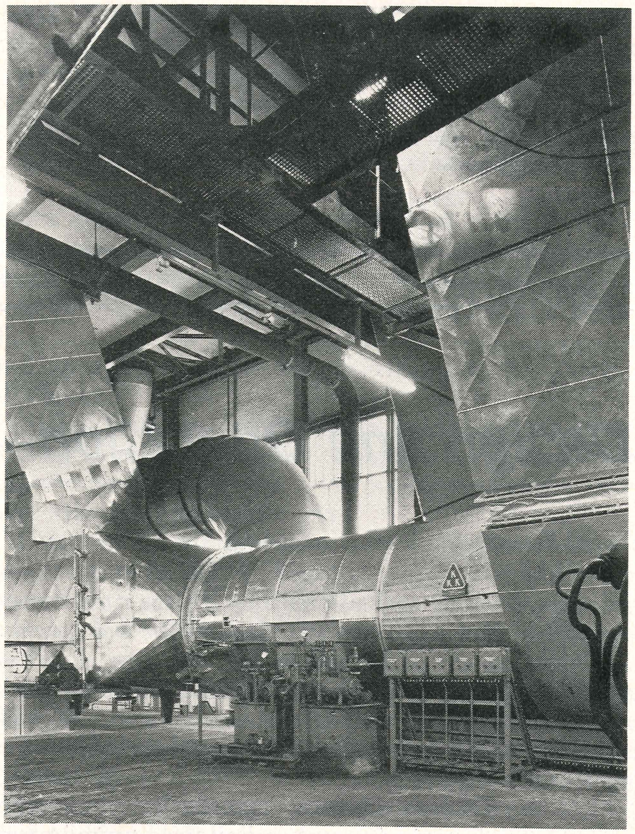

Fig. 7. Two-stage mechanical draft axial fan used for induced draft service with fan housing covered for noise and temperature controls

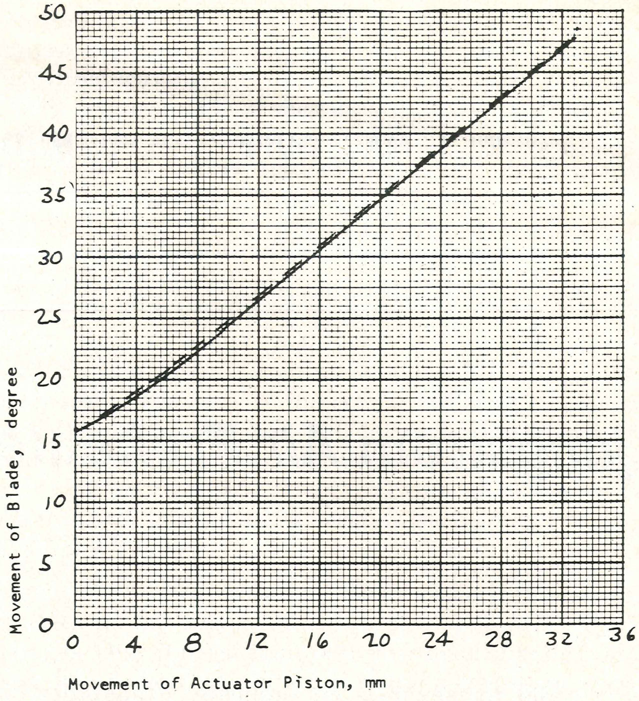

Fig. 8. Axial flow hysteresis curve

centrifugal mechanical draft fans, fan flow rate control by variable inlet vanes or inlet box dampers has become more difficult.

Axial flow fans with blade pitch control offer more reliable modulation with assured repeatability. The hysteresis curve shown in Fig. 8 demonstrates the maximum deviation to be about 1.4 percent.

This produces a steadier flow of air and assures efficient combustion of the fuel.

Summary

The comparison of the aerodynamic aspects, mechanical aspects, and physical size of axial flow fans with airfoil centrifugal fans clearly demonstrates that axial flow fans may be a better investment especially when energy and a material conservation are important factors.

Third Energy Technology Conference/Exposition

The sponsors of this Conference are again three of the world's leading trade magazines: *Research/Development, Power Engineering* and *Pollution Engineering*—each of which is devoted to a special segment of the energy technology field and Government Institutes, Inc., publishers devoted to the energy and environmental fields. These four have been assisted by many key energy organizations in formulating this public service endeavor to communicate needed information of present efforts and plans for the future in Energy Technology. This Conference is intended as a not-for-profit endeavor.

These same sponsors conducted the successful 1st Energy R&D Conference in 1974. The favorable responses and constructive comments of the attendees at the 1st Conference resulted in the expansion of the program to cover the broader subject at the 2nd Energy Technology Conference. The success of the 2nd Conference led to the decision to conduct the 3rd Energy Technology Conference (ET3) in 1976.

The Exposition offers organizations interested in the new trillion dollar energy market an opportunity to reach over 2000 decision-makers in the Energy field. The attendees from this unique Conference will be able to visit the exhibits on all 3 days of the meeting.