Core Flow

How to save over 70% on your FPD conveyor system's energy costs

CoreFlow's highly-efficient SmartNozzle™ technology reduces OPEX and accelerates ROI

Executive Summary

CoreFlow's SmartNozzle™ air-floating technology provides highly-reliable conveyance of flat-panel display substrates over a stage surface, at power consumption levels that are significantly lower than those of alternative technologies, resulting in significant cost savings:

- 87% lower than porous material air bars
- 77% lower than drilled-hole air bars

Introduction

This paper is aimed at comparing the energy requirements of non-contact conveying systems that are commonly employed in the flat-panel display (FPD) manufacturing sector.

These systems utilize air bars that float glass substrates over the conveyor's stage surface. The most widely used technologies in the fabrication of air bars are drilled holes and porous material. This paper will discuss the performance of these technologies from a power-consumption perspective, and will compare their efficiency to that of CoreFlow's SmartNozzle™ technology.

Technology Overview

In non-contact conveying systems, power is consumed to compress the gas that is used to float the substrate. The power consumption levels are determined by the following parameters:

- The mass flow rate (MFR) of the compressed gas. The MFR determines the height at which the substrate floats over the stage surface. A faster flow rate increases the equilibrium height of the floating substrate, reducing the possibility of contact with the surface.
- The pressure level to which the gas supply is compressed. The supply pressure determines the system's ability to avoid contact between the substrate and the stage surface. Higher pressure levels increase the resistance forces inherent in the air cushion when the substrate is close to the surface.

Porous Material

When using porous material air bars to elevate substrates, an air compressor is used to supply a compressed dry air (CDA) system that is required to move a sufficient flow of air through the pores in the material. This high-potential solution provides very high levels of pressure – up to 0.4 MPa – at a relatively low flow rate. In the event of a sudden loss of height, the high-pressure flow easily restores the substrate to its equilibrium height.

Porous material systems were optimized for use as air bearings for rotating shafts, due to the high pressure required to maintain precise positioning during rotation. This technology was adapted for use in the FPD sector, despite the lack of efficiency. CDA systems provide pressures of 0.6-1.0 MPa, and in order to reduce the pressure to the 0.2~0.4 MPa level that is required to operate the air bars, most of the power used to compress the air is wasted.

Drilled Holes

In the drilled-hole implementation, an air pump or blower is used to deliver air through holes that are drilled in the air bars.

This low-potential model requires from 1.0 to 3.0 kPa of pressure in order to achieve a "reasonable" air-gap height, but this pressure level is too low to maintain satisfactory contact resistance between the glass substrate and the stage surface, and can lead to substrate instability. In order to achieve the necessary level of contact resistance, an increase in pressure is required, causing the flow to increase to rates that raise the gap height to extreme and unnecessary levels of a millimeter or more.

SmartNozzle™

CoreFlow's SmartNozzle™ technology adopts the best characteristics of both the above models – requiring reduced air flow rates at lower pressures – without their disadvantages. On one hand, SmartNozzle™ requires a relatively low-pressure supply of 20 kPa, allowing the use of economical blowers for air compression, thus providing higher energy efficiency when compared with CDA systems. On the other hand, the pressure is high enough to ensure excellent non-contact performance.

The self-regulating SmartNozzle™ uses resistance to accommodate dynamic changes in the air gap during moments of substrate instability. The formula below illustrates the relationship between higher pressure levels and increased resistance.

$$\textbf{Resistance} = \frac{\textbf{Pressure Drop}}{\textbf{Flow Rate}}$$

When the floating height suddenly decreases due to a reduced flow rate, the local exit pressure is increased. As a result, the required air gap for glass substrates can be lowered, thus reducing power requirements. This is accomplished without any moving parts or PLC control.

As mentioned previously, the required air flow is closely related to the target air gap. Coreflow's SmartNozzle™ was optimized to float glass substrates at a height of 500 µm or less (typically, 300 µm), and requires only 15 kPa to achieve this height. The 500 µm air gap needs only 1/3 the airflow of a 1000 µm gap required by drilled holes.

The SmartNozzle™ can be manufactured in a variety of sizes and resistance factors, allowing its deployment in a wide array of conveyance applications.

Energy-Use Comparison

The table below provides an energy-use comparison of the above-described technologies when handling a 0.5 mm thick Gen. 6 glass substrate on a 30 meter conveyor. The parameters that are crucial in estimating energy use are:

- **Floating height.** The floating height required by the technology in order to ensure non-contact handling of the substrate, in µm.
- **Required flow rate.** The flow rate needed to achieve the necessary floating height, in standard liters per minute. The flow rate required is highly sensitive to the floating height. In the 0-500 µm range, for every x% increase in the floating height, the flow rate must be increased by x3%.
- **Supply pressure.** The air pressure supply needed in order to maintain the required flowrate, in kPa.
- **Power consumption.** The rate of power consumption required in order to supply the above-specified air pressure, in kilowatts.

As shown in the table, CoreFlow's SmartNozzle technology consumes less power than the alternative models:

- 87% less than porous material
- 77% less than drilled holes

Technology	Floating height [µm]	Required flowrate [SL/min]	Supply pressure [kPa]	Power consumption [kW]
Porous material	300	~7,000	600~1,000 (by high pressure CDA)	60
Drilled holes	1,000	~30,000	2~5 (by blower)	33
SmartNozzle™	300	~7,000	15~20 (by blower)	7.7

Conclusion

CoreFlow, with its SmartNozzle™ technology, has achieved a cost-effective balance between a working pressure which is: (a) large enough to guarantee non-contact performance even if the air gap reduces drastically, and (b) low enough to be supplied by an economical air pump.

About CoreFlow

CoreFlow develops, manufactures and markets advanced handling and conveying solutions for semiconductor and Flat Panel Display (FPD) equipment manufacturers.
With more than 800 systems installed worldwide, CoreFlow's solutions can be found on the production floors of many top manufacturing and fab plants.

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