KINNEY®

CASE STUDY

ROBUST VACUUM SOLUTIONS FOR AIRCRAFT BRAKE PAD MANUFACTURING

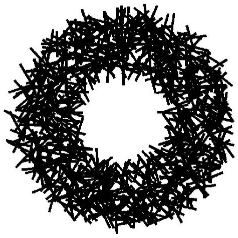
OVERVIEW

Kinney® in Springfield, MO designs and manufactures vacuum systems to be used in the production of aircraft carbon brake pads used on commercial and military aircraft where the brakes need to be able to sustain the conversion of the plane's kinetic energy into heat which creates very high temperatures. The advantages of carbon versus steel aircraft brakes are many.

- Much lighter weight saves on fuel
- Longer life with up to twice the number of landings between overhaul compared to steel brakes
- Greater energy absorption because the carbon has high temperature stability, high thermal conductivity, and specific heat
- At very high temperature operation, carbon is stronger than steel

The disadvantage is the higher cost due to the long processing time.

THE PRODUCTION PROCESS



Ring Shaped Carbon Preform

Aircraft carbon brake pad production typically begins with carbon fiber that is produced either from PAN (Polyacrylonitrile) or petroleum pitch based fibers that go through an oxidation process at lower temperatures and then a carbonization process at high temperatures in an inert gas atmosphere such as Argon to drive off the non-carbon material such as Hydrogen and Nitrogen. The carbon fibers are normally formed into a woven fabric or chopped material and a mold used to produce the preform in the shape of the brake disc desired. The preforms are then placed in a vacuum furnace using CVD (Chemical Vapor Deposition) and CVI (Chemical Vapor Infiltration). The CVD process is normally used for carbon deposition on surfaces while the CVI is used for carbon deposition within the carbon matrix to fill up the voids and add density to the product. In some cases a phenolic resin compound is used to infiltrate the carbon preform and then heated to form a C/C composite. Methane (CH_4) and some other hydrocarbon gases (Propane, etc) are metered through the vacuum furnace at low pressures (5-20 torr) and elevated temperatures (1000-1500°C). The gas penetrates through the preforms and deposits carbon within the voids to build up the density within the brake pads. From the reaction of the Methane rich gas CH_4 C + H_2 + HC (Various Hydrocarbons) the effluent products exiting the furnace include a Hydrogen rich gas containing various hydrocarbon compounds that are formed during the reaction including carbon dust and tarry residues.

Carbon Preform After CVD

KNOCKOUT/FILTRATION SYSTEM DESIGN

The vacuum system must be of a robust design and include the accessories necessary to handle the various hydrocarbons, carbon dusts and tar carryover. Kinney manufactures vacuum systems that have been used in the manufacturing of carbon brake pads since the carbon deposition process originated and has worked with all of the major producers.

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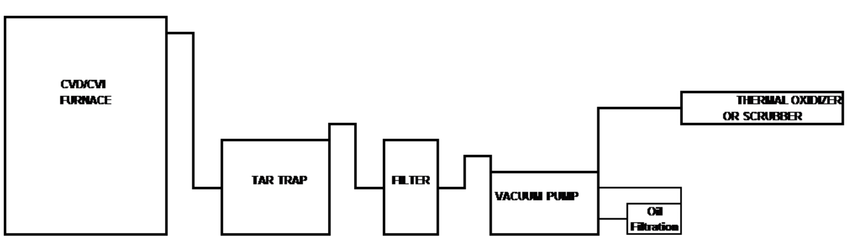
In many such applications a knockout trap designed to capture the tarry residues is used that may utilize both thermal and mechanical capture techniques and in most instances is of a proprietary design formulated by Kinney engineers and the end user. The knockout system is then plumbed in series with an inline particle filter to capture the carbon dusts and any remaining tars not captured by the knockout trap.

Carbon Brakes and Carbon Brake Rotor

OIL-SEALED VS DRY VACUUM PUMPS

The vacuum systems used are normally Rotary Lobe Vacuum Boosters backed by either oil sealed Rotary Piston Pumps or oil sealed Liquid Ring Pumps although in some cases customer's have preferred to go with only multiple large oil sealed Rotary Piston Pumps that will provide a constant pumping capacity from atmosphere down to the processing pressure. The use of an oil sealed pump is an advantage in handling process deposits that may get by the inlet Knockout Trap/ Filter since it helps to keep the deposits from setting up on pump surfaces and collects and transports them to an area where they can be filtered out.

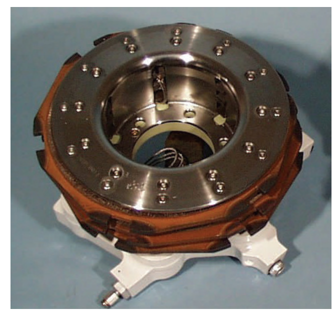
The oil sealed pumps are also an advantage in pumping the hydrogen rich gas which may have a lower average molecular weight and would slip more easily through clearances in dry vacuum pumps resulting in a loss of volumetric efficiency. However, not all oil sealed pumps are suited for this type of process since oil sealed vane pumps are not robust enough to stand up to degradation of the oil from process deposits and can fail due to broken vanes or blocked oil passages.



Typical System Layout

Dry pumps have advantages in many applications, however, their tighter construction clearances and dry surfaces are more prone to failure due to process material buildup on the rotors in this application. The upstream process knockout equipment would need to be even more efficient to reduce process carryover and the dry pumps would need to use intermittent solvent purges to clean up residual deposits. Also most dry pumps are more difficult to repair in plant and require they be returned to the manufacturer whereas the Kinney Rotary Piston Pumps can be easily disassembled and reassembled on site with minimal training.

Booster/Piston Pump Vacuum System



Carbon Assembly and Steel Brake Assembly

SUMMARY

The vacuum boosters and oil sealed rotary piston vacuum pumps used in aircraft brake pad production are all manufactured by Kinney in Springfield, MO, and the vacuum systems are fully assembled and tested by Kinney at the same location. The vacuum systems consist of a Rotary Lobe Vacuum Booster, equipped with oil injection for superior sealing, cooling, and washing of the rotary internals, with a motor that can be driven by a VFD for capacity variation and pressure control in series with an Oil Sealed Rotary Piston Vacuum Pump. Pressure and temperature transmitters can be supplied, to allow monitoring of operational data. Kinney also supplies the upstream protective knockout and filter equipment. Kinney has provided hundreds of these type systems which have an exceptional track record in dealing with the aircraft carbon disc braking process.