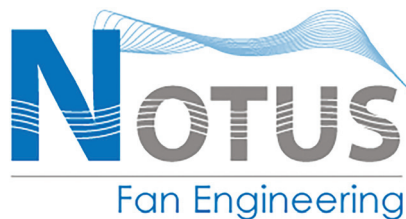


CASE STUDY

REUSABLE SILICONE MEMBRANE FOR VACUUM RESIN INFUSION

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CHRIS MEYER

Completed a PhD under the supervision of Prof Detlev Kröger (University of Stellenbosch, South Africa) investigating the aerodynamic performance of dry-cooled systems.

Currently a professor at the same University, with a research focus on large-scale dry-cooled systems.

Responsible for structural integrity and aerodynamic development.

HANS VAN KAMP

Formal training at Fokker Industries in aerodynamic and structural engineering. 20 years experience working with advanced plastics and manufacturing processes.

Responsible for structural design and manufacturing.

Together they specialize in the design, manufacture, installation and testing of fans.

Notus strives for efficiency.

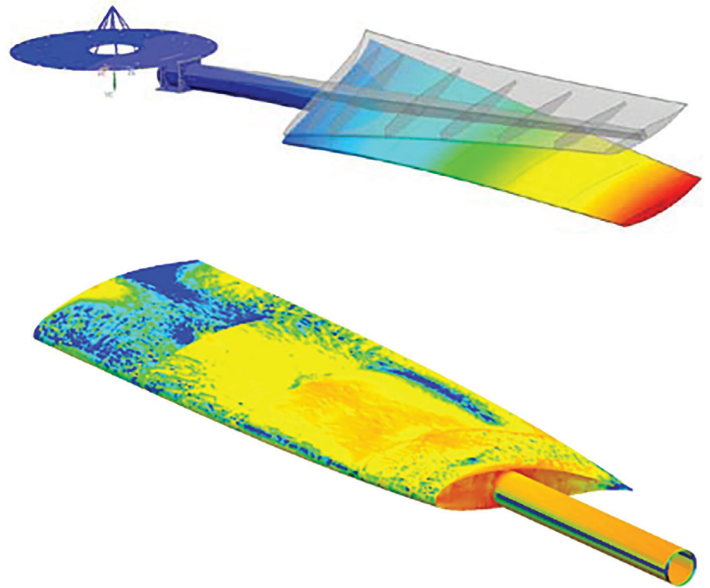
NOTUS FAN ENGINEERING PHILOSOPHY

Duty point specific fan design

- Aerodynamic duty point (CFD – Computational Fluid Dynamics)
- Structural integrity (FEA – Finite Element Analysis)
- Targeted dynamic (vibrational) response (FEA Modal Analysis)
- Fan aerodynamic and structural characteristics verified by independent third party evaluation.

Key features

- No catalogues – each design is unique to specific application.
- High aerodynamic efficiencies combined with maximum protection against the effect of wind.
- Blade configuration based on aviation industry principles
- High structural safety factor to guard against failure and fatigue
- Dynamic tuning to avoid dangerous resonance effects
- Reduction in blade and hub weight to reduce drive train stress
- Unique indexing system for accurate and fast blade angle setting/changes



HOW DID IT ALL START?

We moved away from open moulding and started with resin infusion because of the better control and substantial weight reduction which lead to greater efficiency at lower costs, (50% reduction in overall weight of hand laminating).

With 4 moulds producing 2 sets of parts per day, we were able to run medium volume production. We then started to investigate further options to increase our production output.

WHY THE ALAN HARPER COMPOSITE FIRST SILICONE MEMBRANE?

There were no modifications required to the existing infusion face moulds. We already had the 100mm flange from our standard infusions.

The VMS26, two part addition cure silicone elastomer system comes with morph resin distribution channels & flange vacuum seals that are all built into the silicone membrane.

Not only is the silicone membrane reusable more than 600 times but the brand-new resin distribution system (Morphs) allow full control of the flow of resin when and where it is needed.

Amazingly the morph channel disappears without leaving a trace on the product as soon as the morph vacuum is released.

This technology has simplified the production process and at the same time minimized the risk of failure to nearly zero.

WHY DID YOU CHOOSE SILICONE BAG INFUSION?

The same 4 face moulds with only two reusable silicone membrane would double our production output and at the same time, no further floor space or additional manning would be required.

We also wanted to be more sustainable in our manufacturing methods.

By reducing our consumable usage, we minimize our waste.



WHY AERONTEC?

Besides Aerontec being the Southern African agent for Alan Harper Composites, they were able to design the most efficient resin flow paths and internal vacuum systems as well as build the silicone membrane on site. Within days the new silicone moulds were commissioned and up and running to full capacity. They have also continued to support Notus with technical service during the manufacturing process of the blades.

Added Values

Quicker to apply the bag over the face mould, positioned & vac sealed.

No variation in the flow path layout, no matter who does it.

Vacuum points and flange seals are built into the bag

The resin distribution tape is now the "Morph" resin flow system.

Using their morphing runners, resin flow enhancing technology the reusable vacuum membrane is manufactured with "SMART" pre-designed flow channels within the membrane to provide rapid spread of resin up to 3m in length.

Steel lifting eyes were installed into the silicone membrane for ease of placing & lifting the membrane and at the same time allowing the silicone membrane to breath after each demould. This of course further reduces man hr's and required floor space (stored in the air).

The silicone membrane is also repairable in the unlikely event of damage. Highest quality and strength repair Acetoxy RTV-1 silicone.

Cures rapidly in air (gel time @ 20 minutes).



HOW DID ALL OF THIS IMPROVE THE PRODUCTION PROCESS?

Setting up the infusion bag was reduced from 60 min to 5 min. We no longer need to do a vacuum drop test on every part. Resin flow is far quicker & we never have dry spots. We now have 3 staff members making 8 very large parts a day from just 4 face moulds & the two interchangeable fIRST silicone membranes.

We were able to double our production output overnight. The silicone membrane is cleaner, lower in CO2 emissions and far more ergonomically designed for the operator to work with.

WHAT WAS THE QUALITY OF THE FINISHED PARTS?

The weight consistency that was measured from one part to the next is less than 0.8 %. Bringing precision balance to the 8 blades after full assembly and installation lead to increased efficiency and reduced fatigue.

Blade mass distribution differences is less than 0.6%. This also meant our budgeting & material forecasts are very predictable. 800 panels produced with both membranes & they still look brand new.

FURTHER STATE OF THE ART PRODUCTION

- High quality resins that are not subject to the effects of aging
- CNC cutting of all fibre components
- Specially designed MC³ PVC cores.
- Template jiggling of all sub assemblies

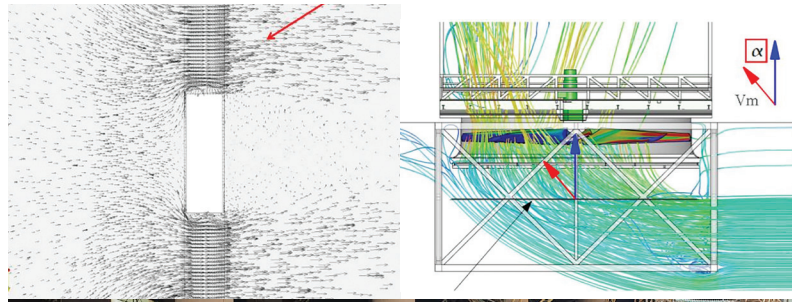
Production control has allowed all our parts to be fully interchangeable.



FAN AERODYNAMICS

The new fan consumes 15-20% less power than current fans for similar flow displacement.

- Alternatively, volume flow rates can be increased by 10-20%
- Greater protection against detrimental effects of wind
- Large-scale system analysis has been done with great success
- Proprietary Computational Fluid Dynamic models
- Effect of wind and structures on ACC performance



PRODUCT STRUCTURAL DESIGN

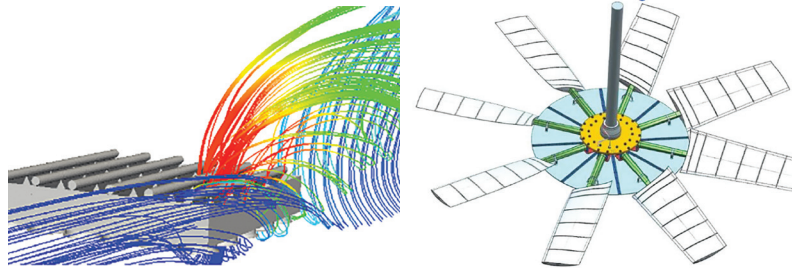
- Load conditions from CFD analysis
- Blades are no longer resonating.
- (vibrational loads on the gearbox have been greatly reduced).
- The blade shape, structure and weight is consistent allowing for interchangeable blades at any time.
- Finite Element Analysis (FEA) was done on all designs.
- Laboratory-verified results by independent third party



MATIMBA POWER STATION – LEPHALALE, SOUTH AFRICA

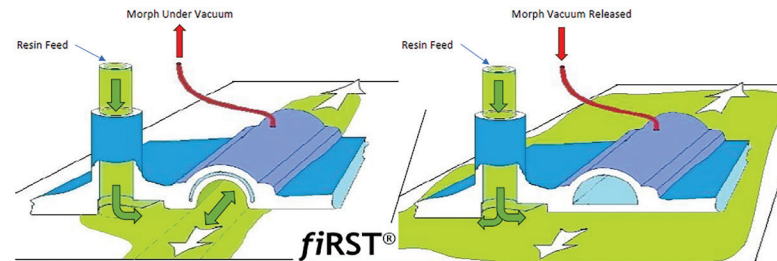
- Owner – Eskom
- 6 x 625 MWe
- 6 x 48 axial flow fans – 288 fans, each 30 ft in diameter

With 8 blades in each fan, every blade has a surface area of more than 2.8m² and an overall diameter of 9.1m.



ADDITIONAL DESIGN CRITERIA FOR THE NEW FANS

- Protection against changing wind effects
- Operate away from harmful excitation frequencies
- Reduced fan blade weight
- Ensure blade weight and mass distributions are continuously accurate.
- Blades must always be completely interchangeable

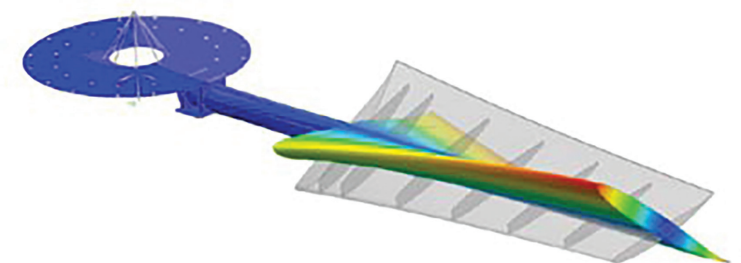


WHAT'S NEXT?

Design and testing has been completed with plugs and moulds already under construction for our next project. Everything has been built around the fiRST Silicone Technology & the Aerontec resin flow path design.

This time we will be using the new Micro Morph resin feed, due to it's greater efficiency based on the scale of the project at hand.

Moving forward, we have been able to predict far greater fan blade production volumes giving NOTUS Fan Engineering and their customers more confidence in the ability to offer continues quality and consistency at unbeatable time & costs.



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