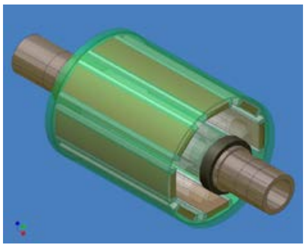
IDAC
Integrated Design & Analysis Consultants

Case Study

Laminated Rotor Design Optimisation

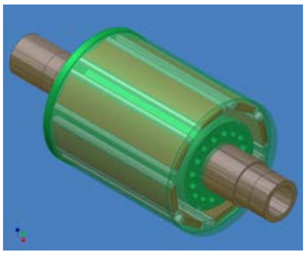
Background



IDAC were required by their client to carry out a prototype design investigation of a laminated rotor to be used in a hydraulic steering system in a car. A series of analyses were carried out on various rotor designs. Two main designs were investigated:

- A hollow laminated core
- A drilled aluminium core

The objective of the investigation for both of the above designs was to evaluate the reduction of weight by hollowing the hub section, whilst maintaining mechanical integrity. Results were required for:



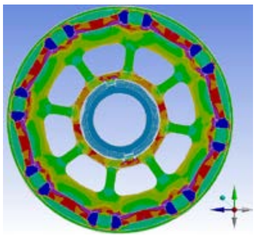
- Stresses due to rotation
- Effects due to heating
- Vibration modes
- Torque applied at one end of the shaft

The rotor was composed of 435 laminations 0.35 mm thick stacked axially onto the shaft. A keyway on the shaft retained the laminations in rotation. Axial location was provided by the rotor endplates clamped by the nut and lock washer. A banding layer was wound onto the outer circumference of the laminations and was included to retain the structure against radial loads.

The laminations include 8 shaped magnet pockets; the cavity around the magnets was filled by a structural epoxy adhesive. The area around the magnets and banding was of particular interest.

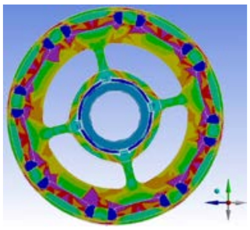
The operating conditions (speed, temperature, fundamental frequency) and material properties of all materials were supplied by the client.

Analysis



Analyses were run for many different design and load configurations of the laminated rotor. The two main design types were as follows:

Hollow Laminated Core
In this design the hub area was filled by extending the laminations down to the shaft. Weight reduction was achieved by hollowing the laminations between the back iron region and the shaft interface.

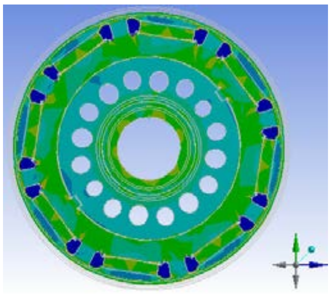


The area underneath each magnet was shaped leaving eight connecting spokes. The amount to which the spoke number or width could be reduced was investigated.

The graphics to the left shows examples of radial cross-sections of hollow lamination rotor hubs.

IDAC, Airport House, Purley Way, Croydon, Surrey, CR0 0XZ, England
Tel: +44 (0)844 212 5900 **Fax:** +44 (0)844 212 5910
Email: info@idac.co.uk **Homepage:** www.idac.co.uk

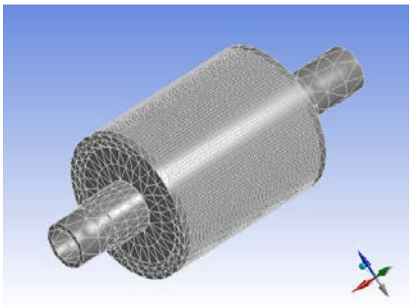
Drilled Aluminium Core



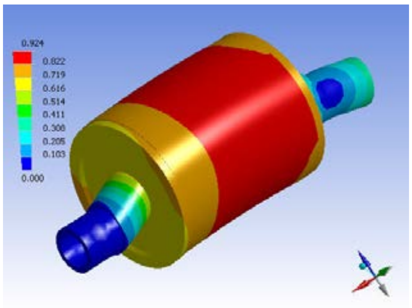
In this design an aluminium hub was included between the shaft and laminations. The rotor hub was retained by an interference fit with the shaft.

The rotor construction was similar to the Hollow Laminated Core design with magnets inserted into axial cavities running the length of the back iron. This back iron was then located onto the hub using two keyways displaced at 180 degrees. The drive end balance plane is integral with the hub. A second balance plane at the non-drive end also provides axial location to the lamination assembly. A radial cross section of the drilled aluminium rotor hub is shown in the graphic to the right.

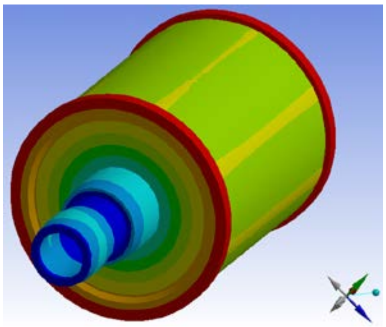
The stress distribution resulting from hollowing the hub was investigated, as were the effects due to the hoop stress near the shaft interface. All analyses were carried out using ANSYS DesignSpace.



The graphic above shows the mesh obtained from DesignSpace



An example of one of the modes shapes from the vibration analysis



Radial deflections of the rotor

Design Benefits

The shape was optimised to minimise mass and maximise the responsiveness of the system once installed in the car. The client was provided with results of analyses carried out on many design and loading combinations, from this the client was then able to make a decision on which design they thought would give them the most material saving without compromising on the performace of the rotor. The design team felt that this analysis technique provided them with a cost effective and time efficient method without having to go to the expense of manufacturing and testing prototypes.

IDAC, Airport House, Purley Way, Croydon, Surrey, CR0 0XZ, England
Tel: +44 (0)844 212 5900 **Fax:** +44 (0)844 212 5910
Email: info@idac.co.uk **Homepage:** www.idac.co.uk