Design and manufacture of a turbine for low enthalpy geotermal energy exploitation

Victor Emmanuel Zenón Arroyo

vzenona@ii.unam.mx

INSTITUTO DE INGENIERÍA UNAM

DEA
DESALACIÓN Y ENERGÍAS ALTERNAS
INSTITUTO DE INGENIERÍA-UNAM

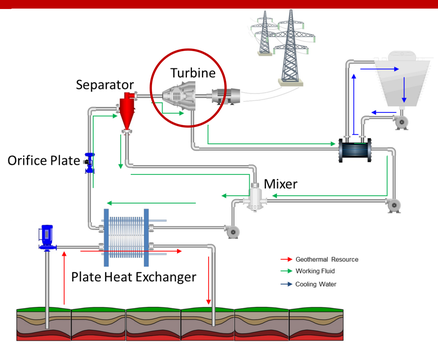
Abstract:

The commercial exploitation of low enthalpy geothermal resources is rising, that is the motivation that thrusts the group named IIDEA, part of the Engineering Institute, the group is developing a modified Organic Rankine Cycle (ORC). One of the major elements of this cycle is the turbine. The aim of this work includes the 3D printing technology in Research & Development stage of the turbine design. The benefits of the inclusion of this technology on conventional manufacturing processes results in a low cost technology, easy maintenance of the entire cycle and easy access to replacement parts or geometrical modifications.

Furthermore, the inherent material properties of the polymers makes its use more reliable in a chemically aggressive and corrosive environments.

This project contains the stress-strain analysis of engineering polymer used in the turbine rotor and housing, taking into account the mechanical and thermal solicitation values based on the theoretical results calculated for the modified cycle.

Modified ORC:



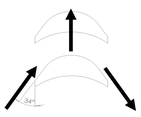
Analysis:

Type: Axial flow action turbine

Flow rate: 0.0037 (kg/s)

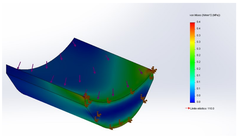
Rotational speed: 36,000 rpm

Turbine Blade:



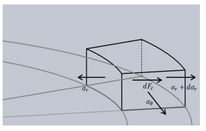
$$F = 2\mathrm{Cos}\beta_2 v_2$$

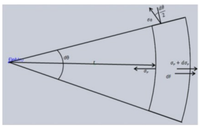
F = 5N



Maximum stress: 0.4MPa

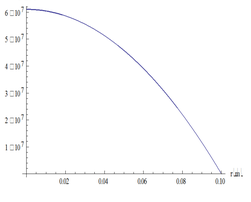
Rotor:

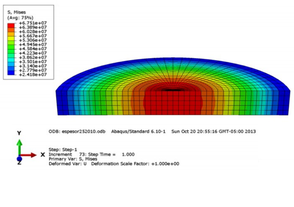




$$\sigma_{r\max} = \rho\omega^2 \frac{(3+\nu)}{8}(R^2)$$

$$\sigma_{\theta\max} = \rho\omega^2 \frac{(3+\nu)}{8}(R^2)$$

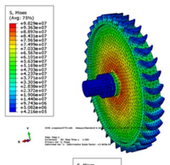




Maximum stress: 61.08MPa

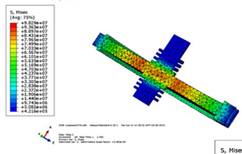
Maximum stress: 67.5MPa

Variance: 9.5%



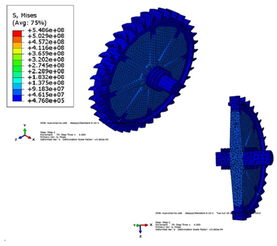
Maximum stress: 98 MPa

$$F_s = \frac{\sigma_s}{\sigma_{max}} = \frac{110MPa}{98MPa} = 1.122$$

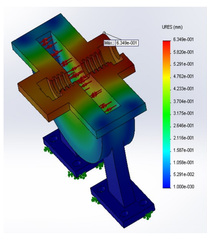


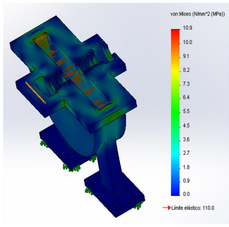
Maximum stress: 55 MPa

$$F_s = \frac{\sigma_s}{\sigma_{max}} = \frac{110MPa}{55MPa} = 2$$

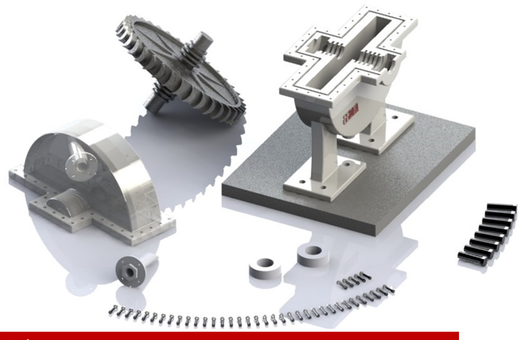


Case:

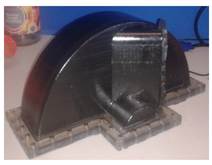


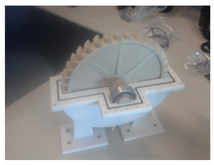


Maximum strain: 0.6 mm



Materials:





Thermoplastics (FDM):

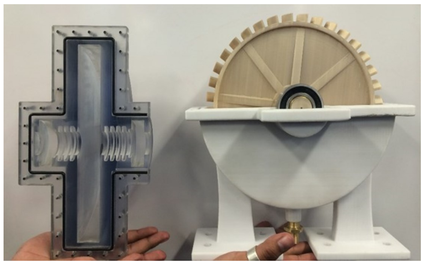
Rotor: PPSU

Bottom Case : PC

Photopolymers (PolyJet):

Nozzle: VeroClear

Top Case : VeroClear



Density	P=1280 $\frac{Kg}{m^3}$
Flexural Strength	110MPa
Flexural Modulus	2200Mpa

Conclusions:

A prototype turbine can be made with a non-conventional manufacturing method, this entails several advantages: less manufacturing time, reduces costs of the materials, the wide catalog of the materials, etc.

The material selection is reduced despite the many material available, but as we saw in the mathematic model, an important factor of the stress state, is the density of the material, so the polymers are useful for the application.

We selected a “top engineer material” for the part that have the highest stress state (the rotor) and the analysis shows the feasibility of use.