707 Assignment 3 Report

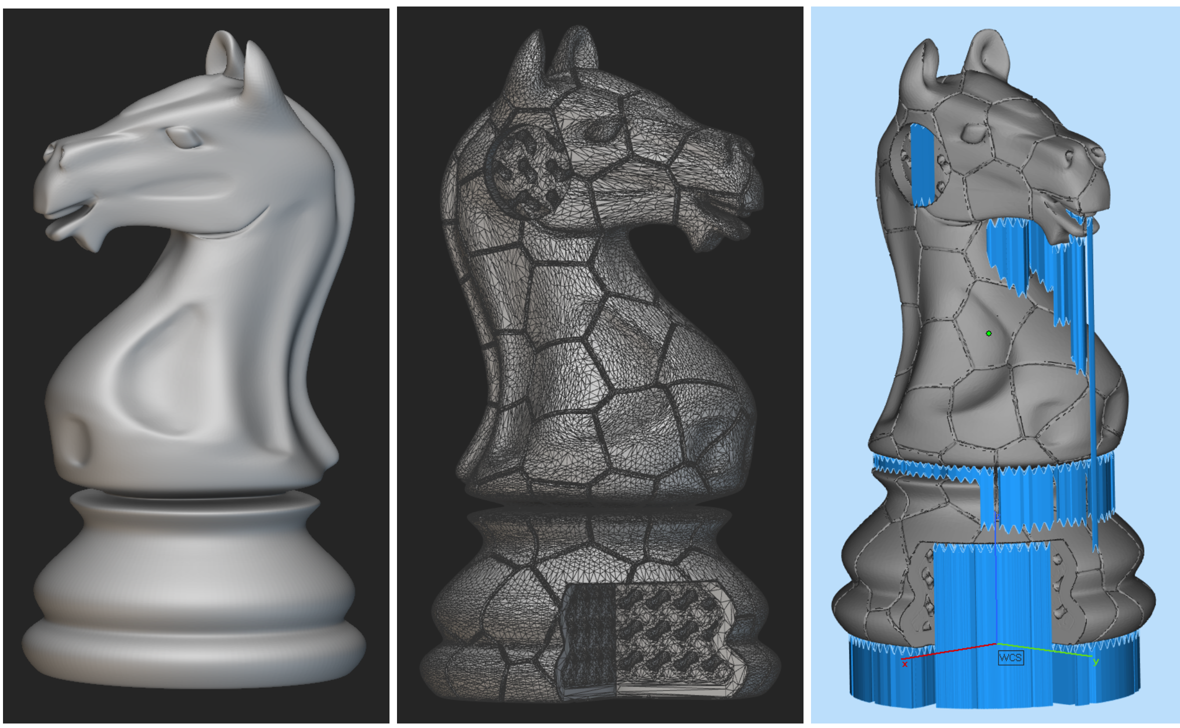
Introduction

This project brief required us to design and construct a heat exchanger from a CAD part, with emphasis placed on the construction of reusable workflows and good practice in Ntopology. This involved designing a part workflow using Ntopology’s block system in a process that is essentially graphical programming.

CAD Process Overview

The original part to be converted into a heat exchanger was modeled as a knight chess piece. This was done not for mechanical efficiency, but largely for novelty as a design. The modeling itself was done in Rhino, utilizing freeform modeling and 3D sculpting tools to produce the initial geometry. This was later imported into Materialize Magics in order to fix the degenerate edges and gaps in the model, as well as making a few other mesh improvements, which notably did not include simplifying the model, as that would be done later in Ntopology during the mesh conversion process. After importing the part into Ntopology and converting it to a heat exchanger, the resulting STL would be imported back into Magics for final print preparation, including support material generation.

The initial modeling was done in Rhino, rather than a parametric CAD package in order to allow for high complexity geometry in less time, as there was less need for exact dimensions and later modification of existing features. Ntopology was used for the heat exchanger conversion in order to produce a reusable workflow, and Magics was used for various mesh fixing functions and print preparation, as it has the best tools for that.



Left to right: Original Model Geometry, Final Heat Exchanger Mesh, Print Preparation

Ntopology Design

The design features in Ntopology are relatively simple; the original part body is shelled out and and a number of boolean features are used to replace the internal volume with a walled gyroid lattice structure, which will form the functional basis of the heat exchanger. In order to create inlets and outlets, primitive solids were used as cutting tools to cut sections from the shell and expose the internal gyroid structure; boolean plug solids were created to ensure that each inlet and outlet prevents mixing of the hot and cold fluid inputs. A simple deboss pattern was also applied to the part, for aesthetic purposes.

Ntopology Workflow

A considerable amount of time was spent to ensure good practice and workflow repeatability and automation in Ntopology. This included simpler practices, such as commenting and organizing blocks, but also using the visual block based programming environment to automate model generation with as little manual input as possible. Ntopolgy's variable system and generative workflow model allows for a process analogous to information hiding in object oriented programming languages, where the user is presented only with the necessary inputs and outputs, and the automated process is hidden; this takes the form of custom blocks and reusable workflows. For this particular workflow, the only required input parameters are the original part geometry and four points in XYZ space which determine the position of subtractive cutting tool shapes, and the output is an STL export file of the finished heat exchanger.

The process of accomplishing this is best shown by viewing the workflow in Ntopology itself (attached) but essentially involved converting every value into a variable which references the input geometry and points; for example, the plug geometries are based entirely on the plug thickness variable and cut shapes, which in turn reference the initial input points, all of which allows the plugs to automatically generate to a desired user specification.

Cost Analysis

Online quote estimators put the price of the part at around 500 Euros to print out of aluminum, which equates to approximately \$850 NZD and probably \$900 NZD by tomorrow. A conservative estimate of 30-40 hours of design time and 3 hours of post processing at \$25 an hour puts the entire part cost at around \$1800.

Post Processing

Post processing for this part should be relatively simple, owing largely to the self-supporting nature of the internal gyroid structure. Breakaway supports were used, rather than building supporting lattices into the part itself, as there is no benefit to increasing part strength, and aesthetics are a key consideration. The idea behind the deboss pattern is that a standard polish of the outer surface of the body will leave rough, unpolished lines between a polished surface, giving the appearance of cracks. There may, however, be some complications arising from the more complex geometry on the knight's head, but the minimal size of those features should reduce time necessary to clean them post print.