James Dyson Foundation Undergraduate Bursary 2016/17

Part IIB Project Report: Design of the Front Axle of a Recumbent Tricycle

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Practical engineering design is an important skill for engineers from all disciplines to develop. This can only be done by facing real design challenges and being required to work within constraints to produce a final product. One facet of design that is often omitted is manufacturing; it is crucial that design engineers have a good perception of relevant manufacturing processes and what is likely to be successful. So the aim of the this Part IIB project is to develop a Part IIA project that gives students the opportunity to take on a design task and see it develop from concept sketches and ideas to a final manufactured product. This will require students to consider the impact of manufacturing throughout the process and teach them key lessons from making their designs.

The focus of the project is the front wheel axle of a recumbent tricycle, which strikes the balance between interesting design challenges, relative simplicity and commercially available standard parts. This will mean that the project will be achievable within the 4 week time frame and manufacturable in the pre-existing facilities in the Dyson Centre in the University of Cambridge, Department of Engineering. This also enables final manufactured designs to be tested in an accessible way by giving students the chance to install their parts onto a tricycle and ride it.

The design process was undertaken in order to pilot the design task that the Part IIA students would be expected to complete. This provided guidance on the approach that should be taken by Part IIA students and helped highlight some of the key problems that they will face. Where possible different design options were considered in order to give bounds for the design freedoms that the students should be allowed.

The first stage was preliminary design; developing a complete set of requirements for the project and the final product. This also included the use of functional analysis to help ensure every part of the tricycle was considered. This meant that the aims and constraints of the project were laid out clearly at the beginning to inform all the design decisions throughout the process.

In the conceptual stage different solution principles were explored for different parts of the tricycle and carefully analysed to choose the best options. This was done for the whole tricycle to inform the context in which the students would be designing their parts and then also for the front wheel axle to develop what would eventually become the final designed article.

Embodiment design brought extensive work on finalising chosen solution principles and establishing the mechanical strength of the designed part to avoid failure under expected worst load cases. The final design used waterjet cut aluminium parts which had angled flanges to accommodate a suitable kingpin axis. Igus polymer plain bearings were used in conjunction with a thrust bearing to support all the loads and create a low friction interface around the kingpin axis pin. A reversible brake calliper mounting plate suitable for both left and right sides of the tricycle was designed to connect to the steering system to minimise overall part count.

To finish, the detailed design work was done in CAD by transferring all the dimensions from force calculations. This meant that spatial fit could be tested and final details added. This also made it easy to use 3D printers in the Dyson Centre to rapid prototype the final design. The final prototype was assembled with standard parts to show the efficacy of the design.

The project was successful in meeting the aims and showing one way of the solving the problem within the constraints provided, which demonstrates its feasibility as the basis for a Part IIA project. There is plenty more work that could be done to develop the project further, both to bring it to a stage where it can be implemented and to extend it to include other parts of the tricycle. This project has the potential to leave students excited about engineering design and seeking to pursue it beyond their time at university.

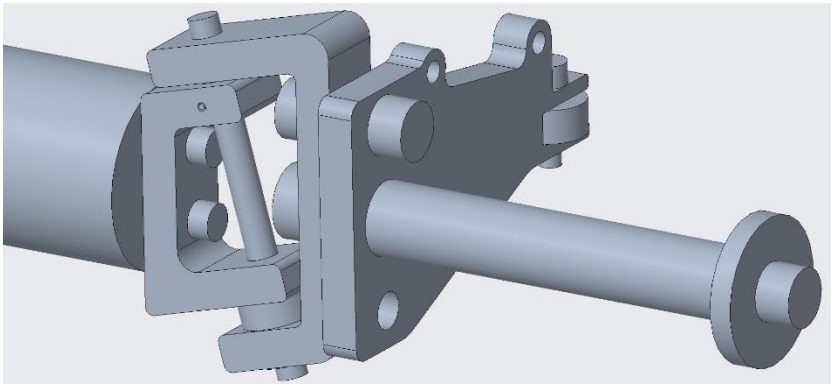

Figure 1 - Final CAD of design

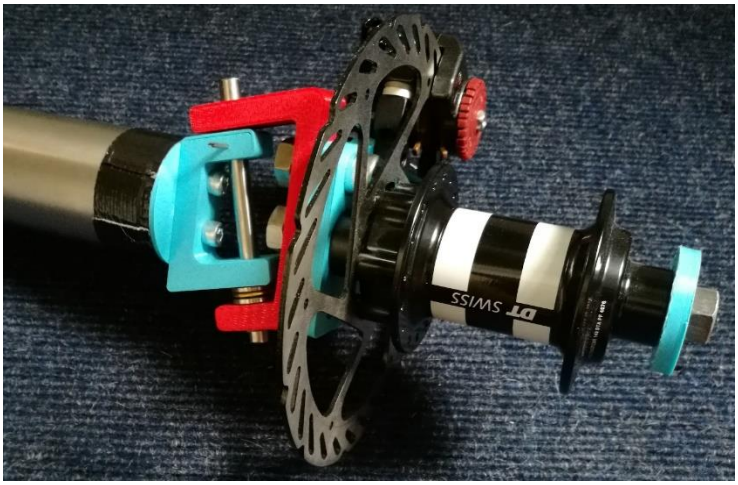

Figure 2 - Photo of 3D printed and assembled final product