Reinventing the wheel, the design of a gravel specific wheelset

Jesse Haaksman, Industrial Design Engineering, University of Twente, the Netherlands

The iterative design process of a gravel specific bicycle wheel using CAD-software to evaluate its stiffness, strength and weight properties.

Gravel riding is a new discipline within the sport of cycling. The new discipline is quickly gaining in popularity and opened a market for gravel specific bikes and components. Fast Forward Wheels (FFWD) in Zwolle is a company specializing in bicycle wheels for road cycling, track cycling and mountain biking. They now want to enter the new gravel market and set out the assignment to design a gravel specific wheelset.

The objective of this assignment is to design a wheelset that suits the way gravel bikes are used, the wishes of gravel riders and the brand FFWD. The assignments relevance is for FFWD to stay in touch with today's cycling market and meet the customers wishes for the company.

To reach the objective the design was carried out in multiple phases. In the analysis phase research is performed in two parts. The market-, customer- and brand analysis and the literature analysis.
The first part found that gravel riding is a mixture of mountain biking and road cycling. The people who started the discipline wanted an escape of the high-performance mentality of road cycling and instead focussed on fun and exploration on unpaved roads. The market responded to the hype by releasing wheelsets with wider rim widths to better accommodate the wider tires (30 – 45mm) used in gravel riding [1]. The current market standards are disc-brake bikes and tubeless ready rims.
The second part is the literature analysis which investigated the forces which a bicycle wheel is subjected to. And in which way the dimensions and properties of the rim and spokes influences the stiffness and aerodynamics. The analysis phase concludes with a list of requirements in which the customer's and companies demands and the forces on the wheel are taken into account.

The design process continued with the concept phase. Here the decision was made to design the wheelset to be 1400 gram. Two concepts are compared by means of calculations and measurements in order to determine which would fit the requirements best. The

decision was made to design a 24 spoke wheel with spokes in a 2:1 ratio and a hookless rim design. The hookless rim design is lighter and has a better impact resistance than the hooked rim design. Its downside is a limited selection of tires that can be mounted to the rim.

The chosen concept was modelled in Solidworks and analysed and iterated upon in Ansys during the iteration phase. The iterations are performed with design tables in which the dimensions of the rim can be altered to evaluate the changes in weight and stiffness. After the most optimal configuration was chosen its strength was analysed. Once a concept with sufficient strength, stiffness and weight was found the iteration phase ended.

In the detailing phase the last adjustments were made to the rim such as safety beads to prevent tire displacement. The product name and decals were added to the wheel to finalize the product design.

The final design is a 24 spoke wheelset which weighs 1432 gram and has a rear wheel stiffness of 34.5 N/mm. It is well suited for gravel riding due to the wideness of the rim which works well with wider tires and due to its strength properties. It uses disc-brake hubs and is made to be fitted with tubeless tires.

The models used for iteration were build using partial ellipses to define the curvature of the rim. In further research a model which allowed changes in the curvature would be recommended so that a more detailed iteration can be performed.

[1] T. Maier, B. Müller, R. Allemann, T. Steiner, and J. P. Wehrlin, “Influence of wheel rim width on rolling resistance and off-road speed in cross-country mountain biking,” *J. Sports Sci.*, vol. 37, no. 7, pp. 833–838, Apr. 2019.