MECH 577 Optimum Design

Project # 3: Equality-constrained Optimization: The Optimum Design of the Bracket of a Caster Wheel

Assigned: October 24, 2006 Due: November 30, 2006

Caster wheels, i.e., wheels capable of turning about one vertical and one horizontal axes, with the two axes offset, are common components in a host of mechanical systems, from furniture to sports gear to mobile robots. In this type of wheels, an important element, which determines the load-carrying capacity of the wheel, is the *bracket* coupling the wheel to the platform of the moving element, be this an office chair, a rolling skate or a mobile robot.

Commercially available caster wheels come in many shapes and colours. A sample is available at

`http://www.coolcasters.com/?gclid=CKSU9eG3jIgCFRIIHgodQkBK9Q`

The purpose of this project is to optimally design the bracket of a mobile-robot caster wheel, to provide adequate support to the wheel, for given *design conditions*, while avoiding stress concentrations that would lead to failure under fast manoeuvres.

The design conditions for the bracket at hand, as taken from the above website, are given below, with some modifications, as the wheels featured in the site target the furniture market:

(a) Diameter: 65 mm

(b) Overall height: 83 mm

(c) Mounting method: roller bearings (friction ring in above website)

(d) Wheel material: soft polyurethane

(e) Load rating: approx 500 N (static)

Furthermore, the wheel being intended for a mobile robot, the load is assumed to be applied a horizontal distance of 260 mm from the vertical axis of the wheel, thereby producing a bending moment on the bracket.

Design a bracket whose shape is defined by a midcurve blending a vertical line, the steering axis of the wheel, with a horizontal line, the common normal to the axes of steering and rolling. The material selected for the bracket is structural aluminum, due to its strength, when compared to its weight. It is left up to the designer to choose a suitable aluminum alloy. Moreover, the curve should be synthesized with minimum curvature changes, while imposing that the shape be convex—changes in the curvature sign are to be avoided.

Once the midcurve is properly synthesized, an *embodiment* of the bracket should be produced, by means of a geometric model using commercial CAD software, to allow for a stress analysis. The pertinence of the design is to be tested by means of contours of von Mises stress, as available in commercial CAE software. Finally, all pertinent manufacturing drawings of the final design must be provided. A brief discussion on the meaning of von Mises stresses regarding structural failure is to be included in the report.

The crucial point of this project is the *synthesis* of the midcurve. Here, it is advisable to use cubic splines, for which C code, CURSYN, is available in the course website. Link this code with ODA, another piece of C code for the implementation of the *orthogonal-decomposition algorithm*. Both CURSYN and ODA are available at the course website. A summary of the procedure to be followed in the process of curve synthesis is available in (Teng, Bai and Angeles, 2006).

Reference:

Teng, C.P., Bai, S. and Angeles, J., 2006, "Shape synthesis in mechanical design," to appear in *Acta Polytechnica*.