Improving Hand Carving of Tyres

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Public summary

At Apollo Tyres, prototype tyres are carved by hand to prevent wasting an entirely new mould on them. It is an arduous process and especially the longitudinal grooves, which go around the entire circumference of the tyre, are difficult to carve in a straight line. A more accurate prototype pattern carved onto a set of four tyres, that will be tested on a car, would create more reliable test results and these are important when deciding whether to mass-produce such a proposed design. Something had to created which could enable the user to carve grooves more accurately, as this would prevent the company from investing in expensive robotic arms. The goal is to *make a device, tool or machine that stabilizes the existing carving gun and allows the user to make straight grooves on a tyre.*

After inspecting the location and the tools and testing out the hand-carving process personally, a phase of ideation followed in which it could be concluded that there are only so many ways in which rotational and lateral motion can be related to each other in order to carve at various angles with relation to the tyre centerline. Lateral functionality would be disengaged when longitudinal grooves are made. The limited options resulted in the creation of similar concepts for a machine that were mostly different in how the power, either inputted by the user or by an electromotor, would be transmitted from tyre rotation to lateral carving. From these, it was decided that a fully electronic machine would be the best option as no delay from a physical transmission would occur and it would be easier for the user to operate. Lateral carving could be done by a ball screw linear drive.

The decision was made to make the machine 1:1, not simply as a proof of concept and because it is easier to use full-size tyres instead of somehow coming up with tyre replicas, but also in order to know the overall size and to test usability more accurately. At first, an attempt was made to incorporate all the desired functionality into it. The initial design process was very rudimentary and not really evidence-based (though it was also focussed on making a prototype very cheaply), as it simply assumed strengthening a wooden mock-up of the machine well enough would do the job. Such an over-strengthened design made out of weaker materials would not resemble the final device at all, so a metal frame would be preferable and the costs of such a thing were of no issue, to a certain extent of course.

Because the creation of a 1:1 machine, that needed to handle quite a bit of force, was already quite a challenge, this project would only focus on making longitudinal grooves successfully. The functionality of lateral carving was omitted, however the design had to be adaptable to include this in the future, so another person could take over this part of the project.

After designing a metal frame which incorporated some design influences from the earlier design in relation to usability and dimensions, it was still deemed questionable because apart from some simulations there was no concrete evidence to support this design would hold. A third design phase then commenced more traditionally by calculating the counterforces that the machine was required to have, which, along with suggestions from the university tutor, resulted in a new frame that still used a few design features and ideas from before.

The machine was built over the course of two months. After an initial test in which the quality of the carves were successful and the mounting of the tyre went easy, the usability of setting up the carver was still deemed poor. Over the few weeks after, the design was constantly adjusted in order to perform better. The usability continually improved, however when using slightly larger blades it was discovered that the resistance was too much for the current motor and gear reduction to handle.

Eventually the prototype was transported from the university workshop to the Apollo workshop where carving occurred. A few fixes were still made at the university and the parts were later installed at the Apollo workshop. The torque problem could still be fixed later by an Apollo employee as this would simply require a larger gear reduction, and the interior of the machine is easily reachable and adaptable. The machine was now up to a level in which this part of the design, and thus this assignment, could be seen as finished. Due to confidentiality the prototype cannot be shown.

When the prototype is adapted in the future to iron out the flaws that are currently there, with an improved user interface, a fully programmed microcontroller and the addition of lateral carving functionality, it could prove to be an effective new machine. With a bit more work in setting up certain things, an employee would be able to make highly accurate, carved prototype tyres for only a fraction of the price of a robotic arm.

Left: situation before. Right: result after use of prototype.

Image sources (second and third images):

Pirelli tyre cutter [Photograph]. Retrieved from: https://www.revzilla.com/blog_content_image/image/52653/redline_hero/Pirelli_tire_cutter_hero.jpg

R6 Tyre Regroover [Photograph]. Retrieved from: https://www.tyre-equipment.co.uk/media/catalog/product/cache/1/image/800x800/9df78eab33525d08d6e5fb8d27136e95/i/m/image101.jpg