October 2018

Test Results IMPACT Drive Train

Huron Cycling LLC

Summary

In this white paper test results are reported on the Huron Cycling IMPACT drivetrain, which includes a novel type of carbon crank set with improved cycling efficiency. As compared to a conventional crank set, we measure an increase of more than 4 % in the speed/power ratio around 200 W power levels on a 3% slope with the IMPACT drive train. Improvement in cycling efficiency on an earlier metal prototype was scientifically validated by an academic team at Eastern Michigan University.

IMPACT Drive Train

The Huron Cycling IMPACT drivetrain (figure 1) consists of two parts:

- A proprietary crank set with increased speed/power ratio for performance oriented cyclists
- An optional, affordable integrated power meter which is currently under development

Figure 1. Huron Cycling IMPACT drivetrain

The crank set stores energy temporarily during the down stroke and releases this energy in the dead spot of the pedal revolution. Both left and right crank contain limited spring action to achieve this goal. Under the load from the cyclist's efforts the internal springs allow each of the crank arms to rotate by a few degrees relative to the spindle. Deflection at the pedals is up to 20 mm and proportional to instantaneous torque. The energy stored in the springs is returned to contribute to torque at the dead spot of the pedal stroke. The overall result is smoothing of the torque profile and less fluctuating transfer of power to the back wheel. In this white paper the test methods and results are described. Limited spring action in crank arms to improve cycling efficiency is novel to our knowledge.

Spring action in spiders of bicycle drivetrains has been reported earlier and is in the early stages of commercialization [1]. Among the benefits, higher speed and delayed muscle fatigue are claimed. In this case, the spider is widened and consists of two parts which, under load, can elastically rotate by several degrees with respect to each other [1]. The different solution we propose has similar benefits and, in addition, it allows independent action of left and right crank arm and improves shock absorption. We believe the IMPACT crank set is simpler to manufacture at lower cost and more compatible with existing other components of the drivetrain, such as spiders and chain rings.

TEST METHODS AND RESULTS

In figure 2 the test setup is shown. The bicycle is mounted on a Tacx Neo smart bike trainer which measures speed and cadence and has a power meter as well.

Figure 2.Test setup

Power is measured at the rear axle of the Tacx Neo and representative of the power transferred from the wheels to the road. All information is displayed and stored on the Tacx app on a smart phone via Bluetooth wireless protocol.

The power is also measured at the pedals, both left and right, with a Powertap P1 pedal-based power meter. This power is representative of the power transferred from the left and right legs to the pedals. The information is displayed and stored on a Garmin Edge 810 head unit via ANT+ wireless protocol.

Table I shows the input conditions for the test. Tests were performed at these conditions, unless mentioned otherwise.

Table I. Experimental setup and conditions

Test equipment	Tacx Neo smart bike trainer
Slope setting	3 %
Average speed target	19.3 km/h
Duration of tests	30 minutes
Gear ratio	36/17
Power meter	Powertap P1 left and right pedal power meter
Reference control conventional crank set	FSA Gossamer BB30 – 175 mm crank length
Prototype IMPACT crank set	BB30 - 175 mm crank length 12 mm deflection of pedal @ 100 lbs (see text)

First, reference control tests were performed with a conventional FSA Gossamer BB30 crank set. After the control testing, the conventional crank set was replaced with the Huron Cycling IMPACT crank set. The chain was freshly lubricated for each set of tests. The deflection of the IMPACT at horizontal orientation under 100 lbs. load at the pedals was measured to be 12 mm at the pedals. Each 30 minute test was done four times to verify repeatability of the results. The slope on the Tacx Neo was set at 3 % to prevent any freewheeling and/or coasting during the tests. In each test the speed was ramped up in less than one minute and then kept constant to end up with 19.3 km/h average over 30 minutes.

Test results are shown in Table II. Repeatability of results was within +/- 1 % and the table shows the average of four tests for each crank set.

Table II. Test results on Tacx Neo at 3 % slope for 30 minutes

	Conventional crank set (average of 4 tests)	IMPACT crank set (average of 4 tests)
Average Speed Tacx (km/h)	19.3	19.3
Average Cadence Tacx (rpm)	71	71
Distance Tacx (km)	9.66	9.66
Average Power Powertap P1 (Watts)	197.2	187.8
Work Powertap P1 (kJoule)	355	337.75

As seen in Table II, for the IMPACT crank set we measure in excess of 4 % lower power (187.8 W vs. 197.2 W) applied to the pedals, while measured speed, distance and power on the Tacx Neo are the same for both crank sets. The work in kJoule on the Tacx Neo power meter was also the same for both sets of tests. It implies that the speed/power ratio is more than 4 % higher for the novel crank set, everything else being equal. The cyclist can maintain the same speed while exerting less energy or go faster using the same energy. This is confirmed by the work (equal to energy spent in kJoule) comparison. It takes less energy to complete the same distance at the same speed for the IMPACT drivetrain (337.75 vs 355 kJoule).

The lower human power needed to maintain the same speed with the IMPACT crank set can be explained by the reduced force on the pedals during the down stroke and the smoothed torque profile and possibly by reduced flexing of the frame and other components. It leads to an improvement of cycling efficiency, a more efficient transfer of power from the legs to the bike. It is likely to reduce muscle fatigue as well [1].

Tests were also performed at the same average speed of 19.3 km/h for different cadence levels by changing the gear ratio to 36/19 and 36/15. In the range of 64 to 80 rpm the improvement with the IMPACT drivetrain remains 4 % ± 0.5 %. For constant cadence of about 72 rpm but lower speeds of 17.6 km/h (gear ratio 36/19) we still see more than 4 % improvement. When the speed is further lowered to 16.2 km/h (gear ratio 36/21) at 72 rpm, the improvement is reduced to about 2.5 %. This is to be expected as a result of the reduced force on the pedals and reduced torque on the crank and therefore reduced deflection at the pedals.

The test results do not depend on the type of pedal-based power meter: For earlier testing on a metal prototype a Garmin Vector power meter for left and right pedals was used with results in the same range as the Powertap P1.

Outdoor tests were performed as well with the Powertap P1, comparing speed/power ratio for the two crank sets. They are less meaningful, since wind conditions, rider weight, traffic delays (if any) and other factors may change from one test to the next and therefore test conditions are not well-controlled. On a stationary bike, on the other hand, the effects of wind and rider weight variations are eliminated, resulting in more accurate test data. Hence, our focus on stationary testing.

DISCUSSION

The deflection of the IMPACT at 100 lbs load is about 5 times the deflection measured with a typical conventional crank set [2]. In a conventional crankset the load is partially absorbed by strain from twist of the crank arm. This stored energy in the crank arm is not elastically returned in the direction of rotation when reaching the dead spot. In the IMPACT crank set, on the other hand, most of the stored energy in the springs is returned in the direction of rotation and contributes to effective torque. For riders of different ability and power different springs with optimized spring constants may be installed. Stronger springs are needed for cyclists that can maintain 300 to 400 W power levels for an extended period of time.

The improvement in cycling efficiency depends to some degree on the pedaling technique of the rider. For a rider who can maintain exactly the same torque during the entire pedal revolution, there will be no benefit from the IMPACT drivetrain. To our knowledge such riders do not exist, since every human applies more torque during the down stroke (and, with cleats, during the upstroke) than in the dead zones (around 12 o'clock and 6 o'clock) of the crank revolution.

CONCLUSION

The Huron Cycling IMPACT drivetrain improves cycling efficiency by more than 4 % for a range of power and cadence levels. The test results confirm earlier scientific measurements at Eastern Michigan University of improved cycling efficiency [3]. The IMPACT drivetrain is therefore attractive for performance cyclists seeking a competitive advantage, especially in time trials, going uphill and in triathlons. The IMPACT drivetrain has an optional, affordable left-right power meter based on sensing the small rotations of each crank arm relative to the spindle.

References:

[1] www.free-power.jp

[2] http://blog.fairwheelbikes.com/reviews-and-testing/road-bike-crank-testing/

[3] EMU results to be published