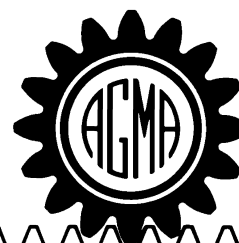


The Ikona Clutch and Differential

by: J. Colbourne, Consultant, V. Scekic and S. Tesic, Ikona Industries Corporation

American Gear Manufacturers Association



TECHNICAL PAPER

The Ikona Clutch and Differential

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

This paper describes two devices, a clutch and a differential, which are based on the Ikona CVT. This CVT is essentially an internal gear pair, in which the pinion is mounted on an eccentric that can drive or be driven by an electric motor/generator, thus providing a variable ratio. Since this arrangement allows for “branching” of energy flow(s), it can be classified as summation-type CVT. The range of ratios depends on the input speed. For example, with an input speed of 600 – 2000 rpm, the ratio can be anything from infinite to about 1:2.

When the CVT is used as a clutch, it would replace the friction-plate clutch in vehicles with standard transmissions, and the fluid torque converter in automatic transmissions. In these existing devices, energy is wasted during modulation from standstill, and at every gear change, while the engine speed is altered to match the speed of the gearbox input shaft. In the case of the fluid torque converter, energy is also lost during acceleration, due to the inefficiency of the device whenever the engine speed differs from the speed of the converter output shaft. The new clutch will be referred to as the electric torque converter. Any excess energy is converted into electrical energy, and either stored in the battery, or reintroduced into the system through the motor/generator. With very efficient energy recovery, modulation of the clutch can be very smooth which is particularly advantageous when the vehicle starts from rest on uphill slopes. Since no friction element is involved, and only a fraction of torque is being manipulated, the modulation can be repeatable regardless of conditions. Finally, in a hybrid-vehicle arrangement, the clutch can be used to maintain the engine at its optimum speed (within limits), regardless of the road speed and the gearbox ratio.

Similar principals apply to the Ikona differential. Unlike today's limited slip differentials, the Ikona differential allows full torque to be transmitted through one drive wheel, even though the other drive wheel may have completely lost traction. Unlike traditional differentials that allow wheels to rotate at different speeds, the Ikona differential forces the wheels to do so. Accordingly when the vehicle is changing direction, the differential can be used to control the speed of each drive wheel, thus providing active torque steering.

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Introduction

The Ikona CVT consists of an internal gear pair, in which the pinion is mounted on an eccentric, as shown in Figure 1. The eccentric is connected to an electric motor/generator, whose speed can be modulated, thus providing the variable ratio. The CVT can be used as a clutch (Figure 2), replacing the plate clutch in a standard transmission, or the fluid torque converter in an automatic transmission. When the CVT is used in this manner, it will be called an electric torque converter. The CVT can also be adapted to form a differential (Figure 3). In this case the internal gear is meshed with two pinions, each mounted on separate eccentrics, so there are two outputs with independently controllable ratios. The electric torque converter and the differential are the subjects of US provisional patent applications 577088002pro and 577088003pro.

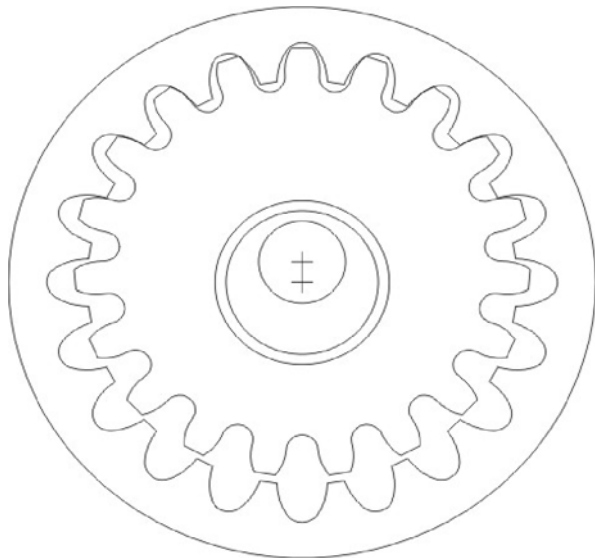


Figure 1. Ikona CVT

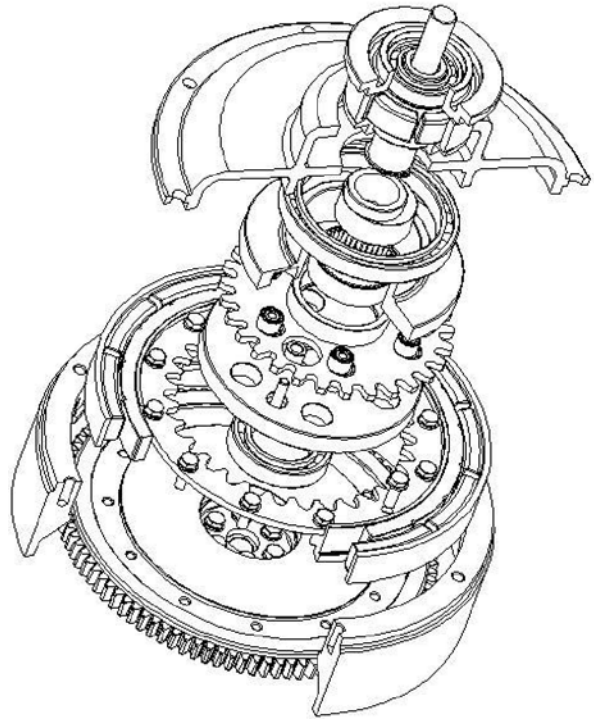


Figure 2. Sectional exploded view of Ikona CVT clutch

Description of the CVT clutch/electric torque converter

The Ikona gear is an internal gear pair, described in patents US5505668 and EP770192B1. Compared with conventional involute gear pairs, it has the following advantages. First, the difference between the tooth numbers can be as low as one. Secondly, the contact ratio is high, meaning that a gear pair can transmit a larger torque than an involute gear pair of similar size. Thirdly, the backlash is minimal. All these properties are important when the gear pair is used to form a CVT.¹

¹ Along similar principals, a solar epicyclical gear system can be used in which case the following has to be satisfied:

$$\left(\frac{N_{\text{ring}}}{N_{\text{sun}}}\right) * \omega_{\text{in}} = \left(1 + \frac{N_{\text{ring}}}{N_{\text{sun}}}\right) * \omega_{\text{out}} - \omega_{\text{sun}} \quad (\text{N1})$$

where N_{ring} and N_{sun} stand for number of teeth on the ring gear and sun-pinion respectively, ω_{in} , ω_{out} and ω_{sun} stand for rotational speeds of flywheel, output shaft and sun-pinion respectively. This embodiment may be referred to as Solar CVT Clutch. More detailed analysis of this type of arrangement may be subject of another paper.