Continuously Variable Transmission

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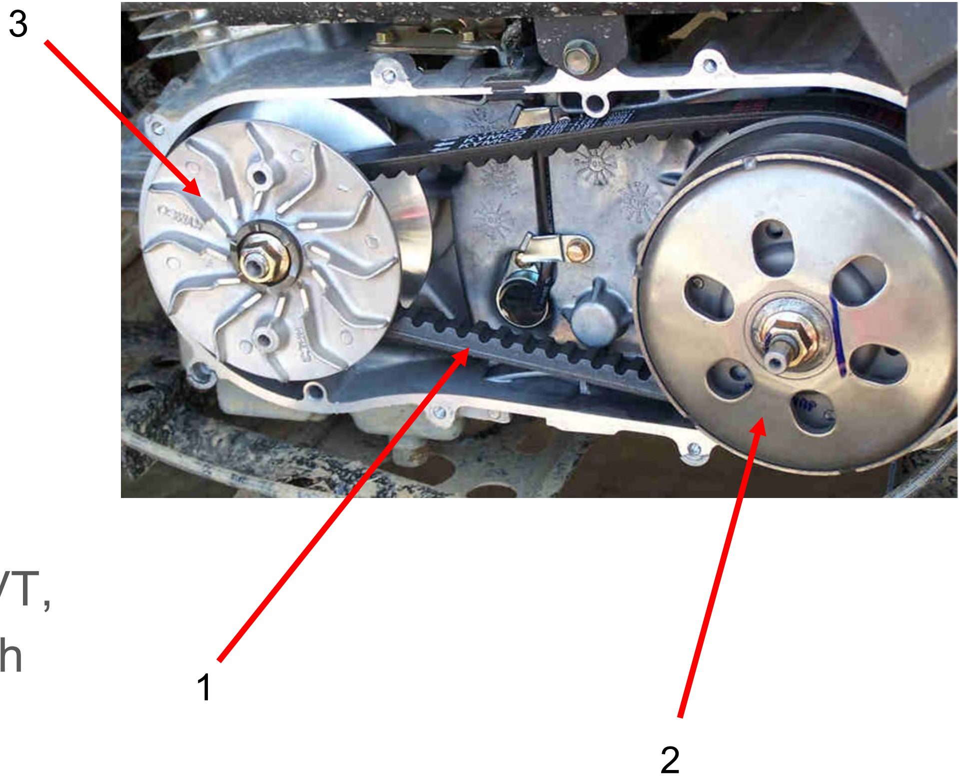
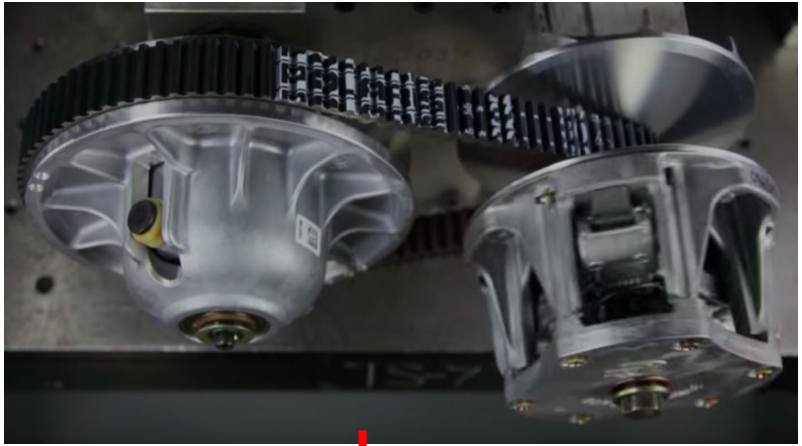
How it works

Consists of 3 major components:

1. Belt
2. Primary (Driving) Clutch
3. Secondary (Driven) Clutch



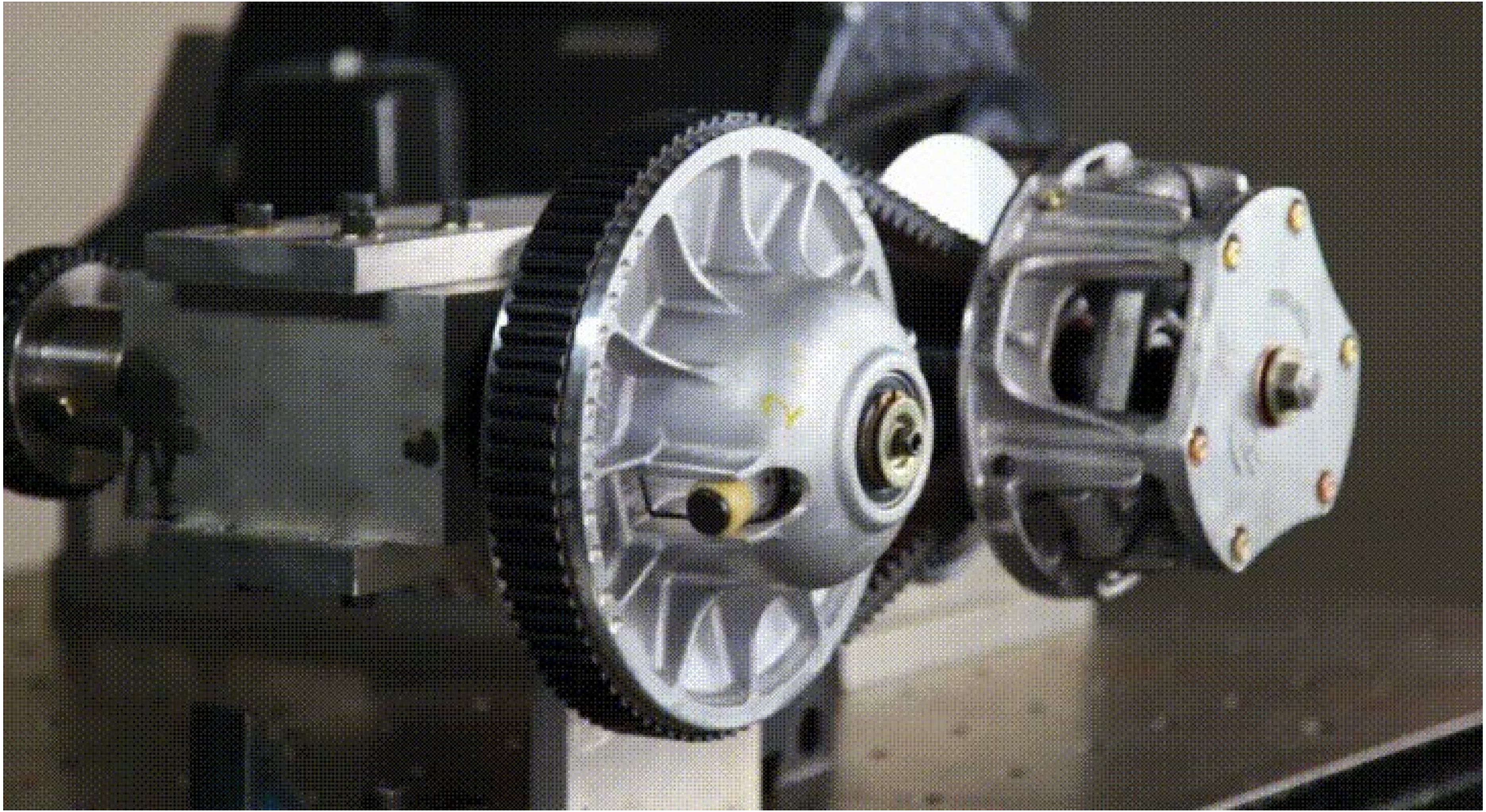
Primary pinches belt and engages CVT, transmitting power to secondary clutch



1. Primary clutch spins, flyweights move sheave toward belt pinching it, engaging secondary clutch
2. Helix cam senses deceleration, then shifts back into low ratio

1.

2.



Purpose/ Goal of Tuning

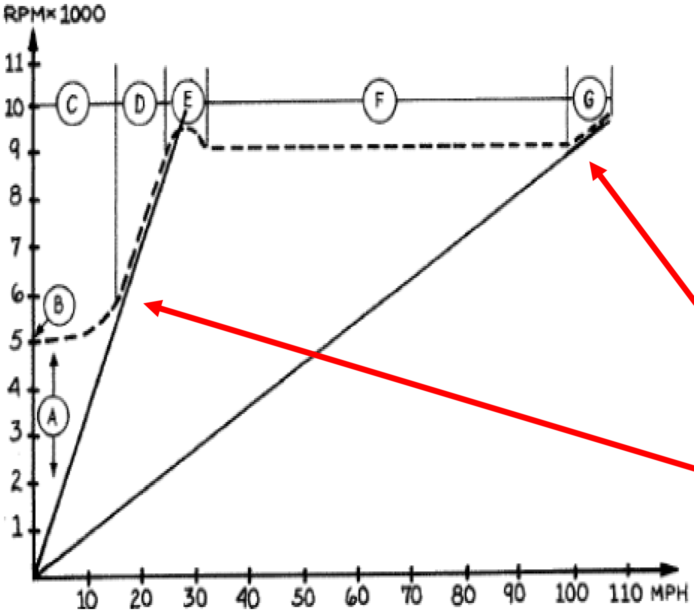


Figure 10: CVT speed diagram. The area represented by A: idle range of the transmission. B: engine engagement speed. C: the belt is gripped. D: low ratio. F: straight shift acceleration. G: High ratio shift out.

To allow the the engine to operate at optimal power for varying vehicle driving conditions

Our goal of tuning: to increase shift speed

Ratio of primary to secondary radii

Low Ratio (primary<secondary)

High Ratio(primary>secondary)

Tuning Variables

4 tuning components that affect calibration of transmission:

1. Primary Spring
2. Flyweights
3. Helix Cam
4. Secondary Spring

Spring Properties

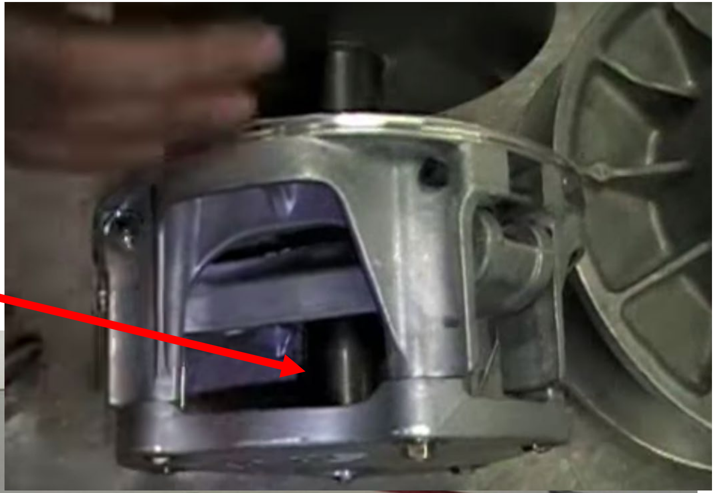
Engagement load - The load the flyweight must overcome to engage the belt.

Full shift load - The load the flyweight must overcome at the end of the shift when top speed is achieved.

Rate - Controls the shift RPM during shift.

Pretension - Controlled by the compression of the spring. So greater the compression, greater the pretension.

Primary Spring (Primary Clutch)

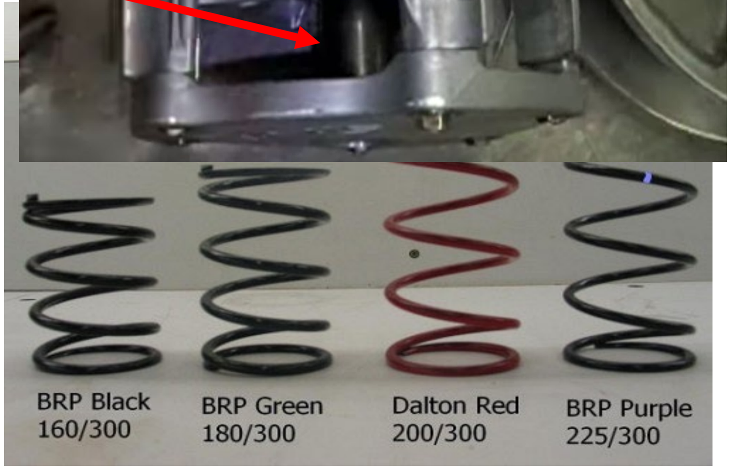


Function:

Maintains pressure between bearing and weight and allows bearing to move

Effect on tuning:

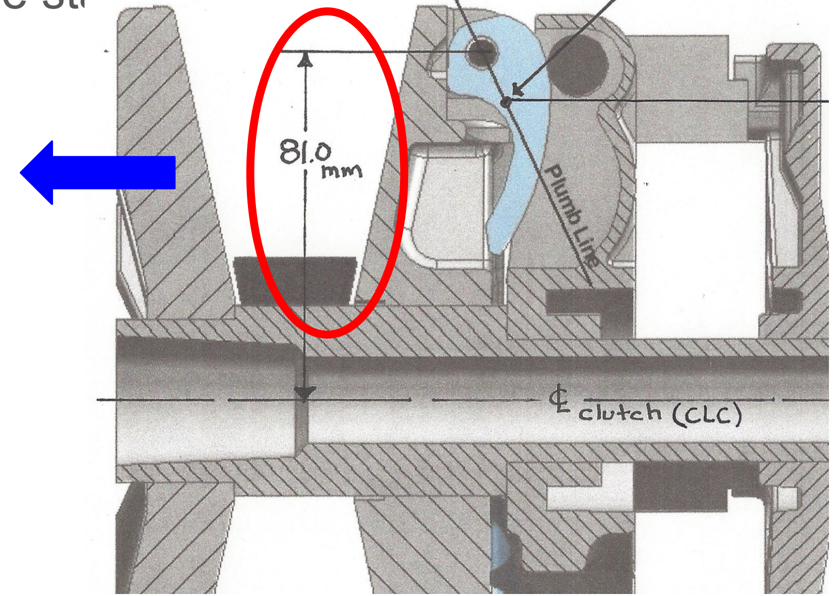
Higher the engagement load and full shift load, Higher the shift speed.



Flyweights (Primary Clutch)

Function:

Allow movable sheave to move toward the stationary sheave through centripetal force provided by the flyweights.



Effect on tuning:

The lighter the flyweight,

the higher the shift speed.

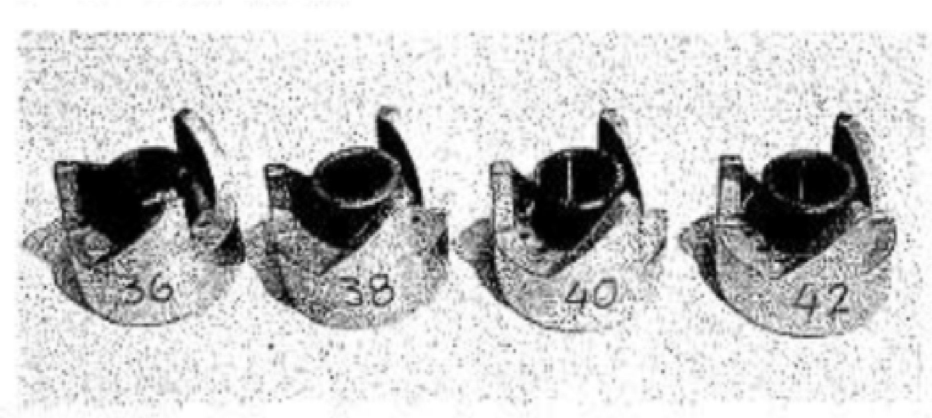
Helix Cam (Secondary Clutch)

Function:

Senses torque provided by primary and prevents high ratio upon acceleration and allows high ratio upon deceleration.

Effect on tuning:

The smaller the helix angle, the greater the shift speed



Secondary Spring (Secondary Clutch)

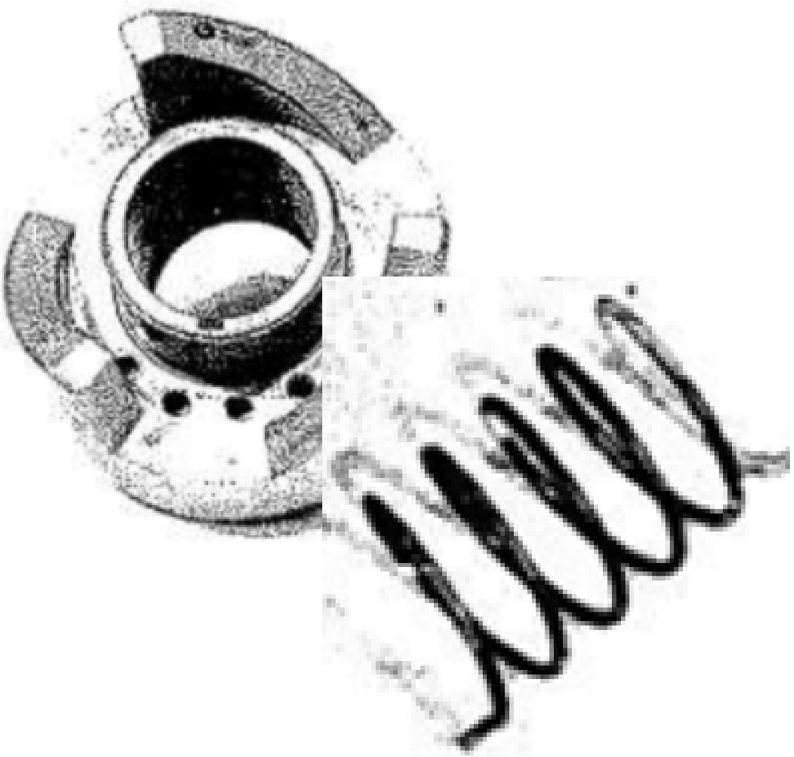
<u>Function</u>:

Forces the sheaves

<u>Effect on tuning</u>:

More the pretensio

shift speed



Summary (Conceptual approach to tuning)

CLUTCH COMPONENT INFLUENCE ON TUNING OBJECTIVE
CHANGE ONE COMPONENT AT A TIME

TUNING OBJECTIVE	PRIMARY CLUTCH		SECONDARY CLUTCH	
	PRESSURE SPRING	FLYWEIGHT	TORSION SPRING	HELIX CAM
Increase Shift Speed	Same Rate Higher Engagement Load Higher Full Shift Load	Lighter Flyweights	Same Rate More Pretension	Less Cam Angle
Decrease Shift Speed	Same Rate Less Engagement Load Less Full Shift Load	Heavier Flyweights	Same Rate Less Pretension	Larger Cam Angle
More RPM on Top End	More Rate Same Engagement Load	Less Aggressive Curvature	More Rate Same Pretension	Less Angle at End of Shift
Less RPM on Top End	Less Rate Same Engagement Load	More Aggressive Curvature	Less Rate Same Pretension	More Angle at End of Shift
More Aggressive Acceleration Less RPM at Beginning of Shift	More Rate Less Engagement Load Same Full Shift Load	More Aggressive Curvature	More Rate Less Pretension	More Angle at Start of Shift
Less Aggressive Acceleration. More RPM at Beginning of Shift	Less Rate More Engagement Load Same Full Shift Load.	Less Aggressive Curvature Grind Flat and Extend it Into Shift Curve	Same Rate Higher Pretension	Less Angle at Start of Shift
Increase Engagement Speed	Less Rate, Add Shim More Engagement Load Same Full Shift Load	Grind Flat or Notch	No Change	No Change

Mathematical Approach

3 important rpms:

1) Rpm at engagement
2) Rpm when 1:1 ratio is reached
3) Rpm at shift out phase

$$m_{fw}g = \frac{2*453*F_{PS}}{3*(\frac{2\pi r_{fw}*\omega_{eng}}{720}\frac{ft}{s})^2}$$

$F_{flyweight} \geq F_{primary\ spring}$ in order to engage the CVT

$F_{primary\ spring} = kx$ $F_{flyweight} = m \times a = \frac{1}{2} mv^2$

$F_{Tension\ Spring} = F_{flyweight} - F_{primary\ spring}$

$$\omega_{outeng}\frac{rev}{min} = \frac{\omega_{eng}\frac{rev}{min}}{G_{Fl}}$$

$V_f = r_{out} \times \omega_{out}$ calculates the final maximum speed we can get when running at a particular gear ratio

Goal: To try and find the flywheel weight and pressure spring constant that will lead to fast shift speeds and decent acceleration

Could possibly look into making a system that takes in current rpm values to find what changes would be best for the environment

References

- Aaen, Olav. *Olav Aaen's Clutch Tuning Handbook: for Serious Racers and Anyone Who Wants More Performance from Their Variable Ratio Belt-Transmission*. Aaen Performance, 2015.
- https://www.google.com/search?biw=1440&bih=900&tbm=isch&sa=1&ei=kfghWrmYDuaf0gKk2KKgDQ&q=cvt+baja&oq=cvt+baja&gs_l=psy-ab.3..0i30k1j0i8i30k1j0i24k1.6551.7004.0.7219.4.4.0.0.0.0.95.308.4.4.0....0...1c.1.64.psy-ab..0.4.307...0j0i67k1.0.RAHJw8MTx2Q#imgrc=ik
- https://bajatutor.net/cvt-baja-car/
- https://www.youtube.com/watch?v=uCEvBGT8twM
- https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwjYt92jxerXAhVG6oMKHRG2At0QjRwIBw&url=https%3A%2F%2Fieeenitk.org%2Fblog%2Fcvt%2F&psig=AOvVaw2Kr3bMbyK6Z7n3oXQkke7u&ust=1512277053144884
- https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwiKrr2ezerXAhVr3IMKHSs1Cm4QjRwIBw&url=https%3A%2F%2Fieeenitk.org%2Fblog%2Fcvt%2F&psig=AOvVaw1WFpCRLKrM23ykrDP9cbRr&ust=1512279215450854
- https://www.youtube.com/watch?v=LMnnTaAYREo
- https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwi2meq23urXAhUM5oMKHZJpClIQjRwIBw&url=https%3A%2F%2Fwww.ibackshift.com%2Farticle%2Fcalibrating-112.asp&psig=AOvVaw01xE4__dQ7R1oTh2AUH16W&ust=1512283815446407
- https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwiLwL2A9urXAhUE34MKHffiBSQQjRwIBw&url=http%3A%2F%2Fwww.rzrforums.net%2Fgeneral-rzr-discussion%2F172685-cvt-clutch-design-101-a-3.html&psig=AOvVaw3DljbtIVlzxKnC3iNC1j6H&ust=1512290008048632