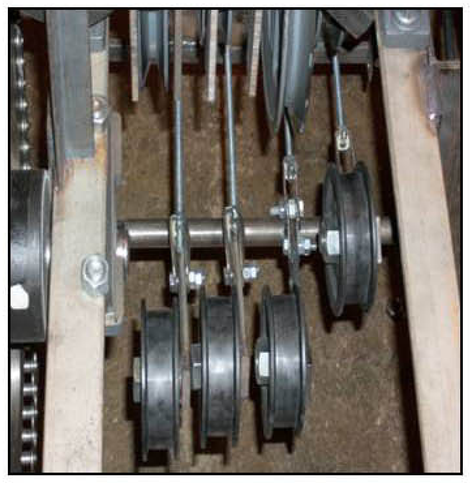
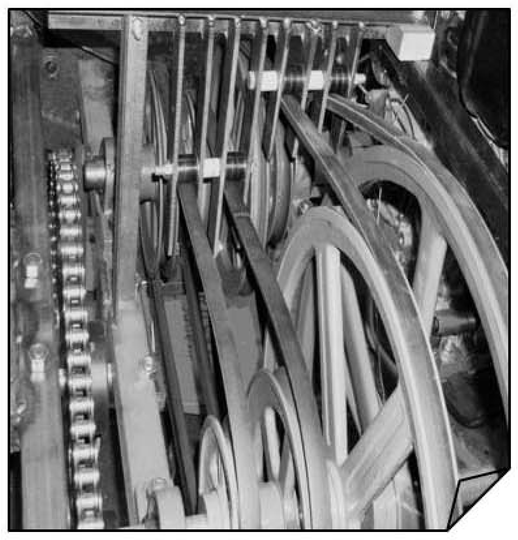
DESIGN:

The driveline needed to be simple, easy to repair, and work effectively. The final goal for this driveline is to be simple enough to be produced in the villages of Africa. As a result, it also needed to be able to handle the added stress of heavy loads and operate in mud, water, and other elements.

	Criteria
1	Simple system; belt and pulley
2	Haul 1200+ lbs
3	Cost must be less than $700
4	Operate in all conditions
5	Easy to work on and repair
6	20 mph top speed



Tensioning pulleys

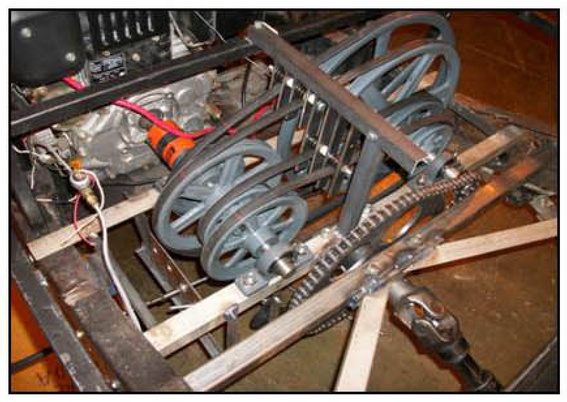


Top view from right side of BUV

FABRICATION:

Restrained by a limiting budget and trying to use only tools available in Cameroon, much of the driveline was fabricated. Besides the pulleys, sprockets, belts, and shafts, everything else was fabricated. A customized tensioning system was made to apply just enough pressure to the belts to lift them off the pulleys when not engaged. Additionally, the tensioning actuators and driveshaft both were also fabricated. Mounting brackets, braces, and frame supports were tailored to the BUV for an accurate fit and other parts were modified to fit.

Pulley arm connectors

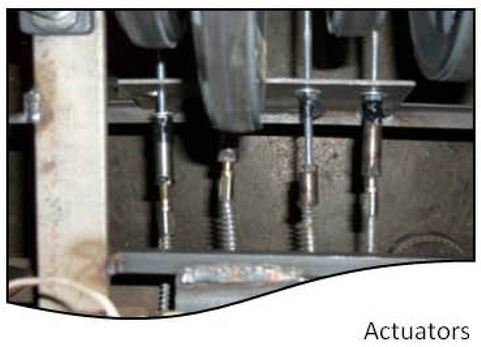


Above view from left rear

Heath operating drill press

Preparing pieces for welding

BUV driveshaft



Actuators

Driveline connection and bracing

TOOLS AND SUPPLIES:

Most of the tools used in this build exist in some form in Cameroon. The initial list of tools available in Cameroon that was given to us included: common hand tools, home-made welder, drill press, and maybe a band saw. There are no CNC machines or mills or other high precision machines in Cameroon. Consequently, we limited the amount of use of such tools.

	Shop Supplies
1	Emery Cloth
2	Drill bits
3	Grinding wheels
4	Electrical tape
5	Welding rods
6	Hex-head nuts
7	Bolts
8	Washers
9	Lock washers

	Tools
1	Vertical band saw
2	Horizontal band saw
3	Upright sander
4	Stationary grinder
5	Drill press
6	Vice
7	Welder
8	Pliers
9	Screw drivers
10	Wrenches
11	Hammers
12	Drill
13	Handheld grinder
14	Oxyacetylene torch
15	Ratchet and sockets

PURDUE UNIVERSITY

BUV Driveline, Charles Young, Heath Hook, Edmund Hyde, ASM, April 22, 2010

Basic Utility Vehicle (BUV)
Driveline

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Department of Agricultural and Biological Engineering

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April 22, 2010

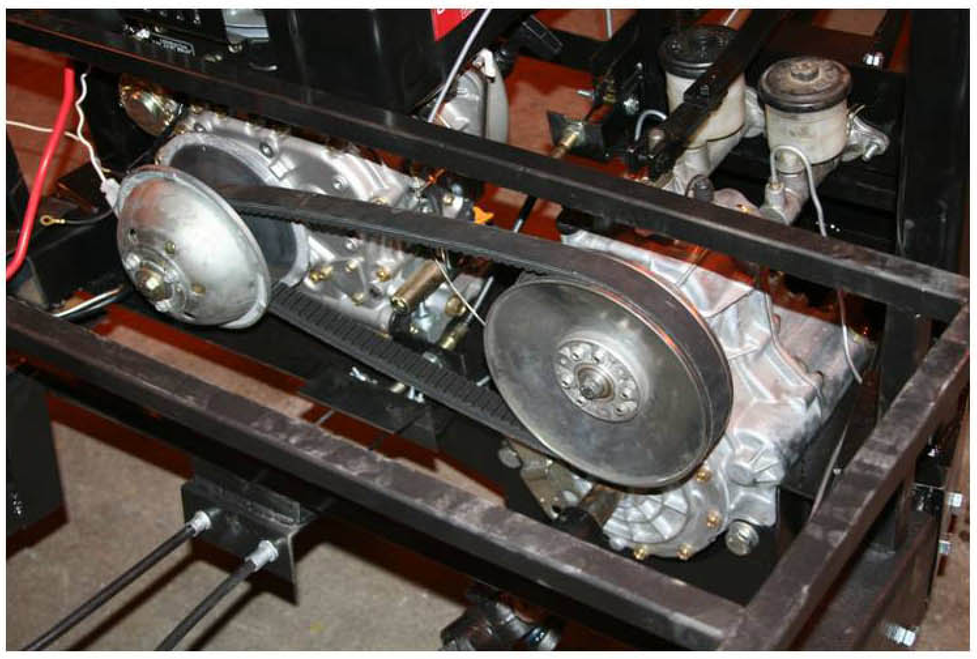
Objective

Design and fabricate an alternate driveline for a 10 hp basic utility vehicle (BUV). The new driveline design takes into account the specific resources available to the people of Cameroon and western Africa in general.

Introduction

The first prototypes of the BUV built by Purdue students contained a CVT transmission. The CVT transmission works well on the BUV; it handles the loads demanded of it; it provides a wide range of speed ratios needed; but the drive belt is a weak point which is a very expensive and time consuming piece to replace and it is hard to acquire in the remote parts of Africa . It also requires some amount of engineering knowledge and training to do any kind of moderate repair work on the CVT, which knowledge and training most West Africans do not have. The idea for the belt and pulley driveline stems from the desire to make the driveline simpler to maintain, parts easier to obtain, and ultimately cheaper to manufacture. Simple belts, pulleys, and shafts are much easier and cheaper to maintain, replace, manufacture, and are abundantly more available than is a CVT transmission for the people of Cameroon and western Africa.

Original BUV we started with



What we started with! (Left) Yanmar diesel engine,
(Right) CVT Transmission coupled by belt

Testing Procedures

Throughout the whole fabrication process we would conduct small scale tests on each piece that we fabricated just to make sure the part would fit and work the way we intended it to work. These tests consist of installing the part and manually actuating to check for proper fit. Also, four separate times during the fabrication process and installation of the shafts, pulleys, belts, tension pulleys, guides and actuators, we started the engine to see how all these parts performed and if they all worked together as we had intended.

Finally we conducted a battery of tests to see if the BUV driveline would meet the design criteria that we had designed the driveline to meet. These criteria are; carry a net payload of 1,200 lbs and reach a max speed of 20 mph.

Test 1: BUV was operated on a flat paved surface in each gear to check how well each gear performed and checked the max speed reached for each gear.
Results: Each gear mechanically performed as designed and we reached the 20 mph goal.

Test 2: BUV was hooked to a 7,500 lb diesel truck on a flat paved surface to see how the driveline would perform under a towing load.
Results: The BUV took off with the load in tow and as the tow vehicle brakes were applied the BUV wheels spun then we popped the master link off the reduction sprocket chain.

Test 3: BUV was loaded with approximately 1,200 lbs to see if the BUV would be able to pull that load from a standstill in first gear.
Results: Loaded the BUV gradually increasing weight until we reached approximately 1,200 lbs and drove on a flat paved surface. The belts did not slip or break.

Heath pulling truck during testing

Drive line Calculations

Engine (Yanmar L100V, 4-stroke, 10 hp Diesel Engine)

No. of Cylinders	1			
Bore x Stroke	3.39	x 2.95	in^3	
Displacement	26.5	in^3		
rpm	3600	3200	2500	
hp SAE	9.1	8.7	7.4	
Torque (ft-lb, theoretical)	13.3	14.3	15.5	

Gear Reduction

Rear Axle	3.1 : 1
Final Drive	6 : 1

Wheel Dimensions

Outside Diameter	28	in
Width	6	in
Suggested Tire Pressure	30	psi
Rpm at 20 MPH	258.56	rpm

Pulley Sizing

Reduction at 20 MPH	13.92327	: 1
Smallest pulley*	5.4	in

Target ratio	Pulley 1	Pulley 2	Actual ratio	Gear Reduction	Total Reduction
3.3	5.4	18.4	3.41	18.6	63.38
2	9.4	15.4	1.64	18.6	30.47
1.15	5.4	7.4	1.37	18.6	25.49
0.68	7.4	5.4	0.73	18.6	13.57

*Gates belt selection from tables 11 and 20 of HD v-belt design manual; B Hi-Power II with 5.4"Od is needed to transfer 9.87 hp, with 180 degree contact.

Calculated Outputs

Engine Speed	3600	rpm
Total Drivetrain Reductio	13.57	:1
Max Wheel Speed	265.3	rpm
Est. Max Ground Speed	20.51	mph
Max wheel output	982.39	ft-lbs

Max Speed Per Gear (MPH)

	1	2	3	4
Actual	4.39	9.13	10.92	20.51
Target	4.53	7.48	13.02	22.00

Notice: Our actual speeds for 2nd and 3rd gear are different than our calculated target speeds. The actual design utilized equal belt lengths to produce a more serviceable transmission with common wear parts. This design keeps it simple but the trade-off for this is that 2nd gear is a higher, and 3rd is a lower speed. This creates a wide gap between 3rd and 4th gears.

Cost Analysis

ITEM	PRICE
B-Belt Pulleys	$ 177.00
Belts	$ 29.00
Pillow block bearings	$ 53.70
1" keyed shaft	$ 33.95
Coupler	$ 42.00
Gear reduction unit (sprocket s and chain)	$ 82.90
U-joints	$ 30.00
Steel for fabrication	$ 50.00
TOTAL	$ 498.55

Project Timeline