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# TECHNICAL INNOVATIONS FOR DEVELOPING COUNTRIES: THE CASE OF A HUMAN-POWERED FRUIT BLENDER

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## ABSTRACT

*There are several electric blenders available in the market today which uses electric motor to drive a blade in order to blend food items, but product availability and reliability are important factors for sustainability. A human-power blender uses alternative power generation sources to operate the blender. Having highlighted areas of possible applications of human powered machines, the aim of this work is to design a manually operated blender which has an efficient operation. In this design, the electrical components of a typical blender are replaced by a gear train system designed to multiply human efforts for maximum efficiency. The driving mechanisms of this blender are gears and shafts which were cast and machined respectively. When tested, the blades of the blender were able to achieve speeds that were 8 times more than the input speed.*

**Key words:** Blender, human-power, sustainability, gears, design and efficiency.

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## 1. INTRODUCTION

A blender is a machine which uses the rotary motion of its blades to grind and crush items. It is used mainly in kitchens, laboratories and industries to chop, blend, mix, puree and liquefy foodstuff and other items. The use of blenders are especially very useful in the home, to blend items such as fruits, tomatoes and the likes for daily consumption. Today electric blenders are utilized more often than any other type due to the ease of usage and the efficiency and the speed given by the rotor but it cannot be utilized in the absence of electricity for example: during periods of power failure or voltage fluctuations without the benefit of prior warning which can result to damage of equipment and restart costs [1]. In many developing countries such as

Nigeria, especially the rural areas, they do not have steady access to electricity. Due to this, most residents find it difficult to carry out simple operations such as blending, one of the cooking processes that require the use of electricity.

However, there are several electric blenders available in the market today which uses electric motor to drive a blade in order to blend food items, but product availability and reliability are important factors for sustainability. Therefore, the use of human powered blenders becomes handy when availability and reliability of such products comes to mind as a direct consequence of unreliable delivery of electricity during periods of power failure or voltage fluctuations. Unlike electricity and fossil fuel, human power can be a clean source of energy.

The design is a manual or hand operated fruit blender which is a domestic kitchen appliance used to blend and puree fruit. Having highlighted areas of possible application of human power, the aim of this work is to design a manually operated blender which has an efficient operation. Provided in this design is a gear assembly which comprises of a rotary handle connected to a power transmitting shaft which drives a pair of spur gears which in turn drives a pair of bevel gears, each with varying diameters. The bevel gears drive a shaft which controls the rotary motion of a clutch which spins the cutting blades housed in a container known as a blending jar.

## 2. TECHNICAL INNOVATION

Technical innovation implies a process of change. skills to design products have been used to transform the ways in which people relate with systems [2-3]. Several authors have taken steps in making human-powered machines a food for thought, from house-hold items to medical gadgets to agriculture and transport systems [4-9]. [10] defines appropriate technology as any object, process, ideas or practice that enhances human fulfilment through the satisfaction of human needs. The human-power solution in which the interest of people are redirected towards creating a condition for a more satisfying use of resources looks promising as a transition towards sustainability [11-13].

Figure 1 represent a human-powered shredder that was designed to serve farmers in Soweto due to lack of access to electricity and rising cost of fossil fuel. This has led to the use of alternate source of energy known as human-power energy. The human-powered shredder was designed to be incorporated in a bicycle because their use are common so that servicing could be easily carried out by local bicycles mechanics.

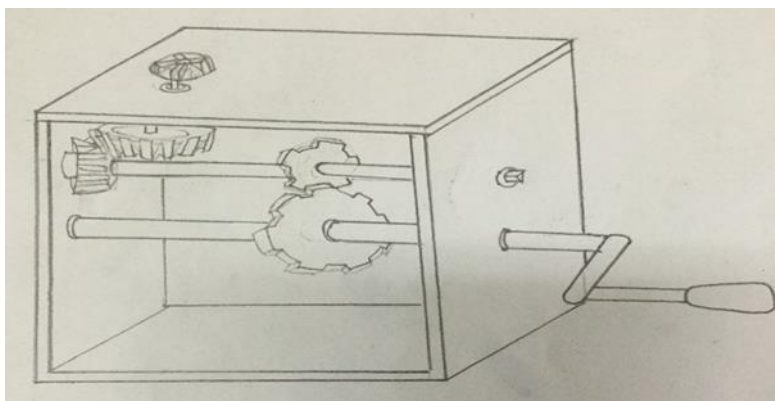


**Figure 1.** Bicycle component of a human-power shredder [10].

### 3. HUMAN-POWERED BLENDER

#### 3.1 Preliminary Design Concepts and Components

The conceptualized design was synthesized to obtain the end product. The materials selected for this design were chosen based on safety, health factors and the required properties. The mechanical blender is made up of various functional elements and components that make up the blender as a whole. These components were assembled in the order shown in figure 2.



**Figure 2.** Conceptual Sketch of the blender

##### 3.1.1. Blending Jar

The blending jar is where the cutting blade is housed. It is the container for the food that is being blended. The lid is used to cover the blending jar to prevent spills. The blending jar can contain up to 1-2 litres (about 4-7 cups) of foodstuff at a time.

##### 3.1.2. Cutter Assembly

This consists of the blender blade, the clutch, shaft, o-rings and rubber seals. One of the main purposes of the cutter assembly is to hold the cutting blade in position. When assembled, the cutter assembly is mounted on the clutch connected to the bevel gears i.e. the drive coupling. Here, the rotational motion from the gear system transferred to the blade which blends the food in the blending jar. The blade of a blender is designed in such a way that once it rotates, a vortex/spiral is formed and this sweeps in any unblended material thereby, making the consistency of the blended mixture smooth and uniform.

##### 3.1.3. Machine Base

This is where the gears, shafts, bearings and all other mechanical components are housed. The housing is the base where the blending jar and cutting assembly are mounted. The machine base is designed so as to give a sturdy and stable base for the other components.

##### 3.1.4. The Rotary Handle

The handle is the element which rotates the shaft, which in turn drives the gears. It is designed keeping in mind the force (turning force) exerted by the average human being.

##### 3.1.5. Set of Bevel Gears

Bevel gears are used to change the direction of the shaft's rotation. As the handle of the blender is turned along the horizontal axis, the bevel gears change the axis of rotation to the vertical

axis. This is where the vertical motion of the blade is gotten from. The bevel gears are assembled at 90 degrees ( $90^{\circ}$ ) to each other in order to change the horizontal motion to vertical.

### 3.1.6. Set of Spur Gears

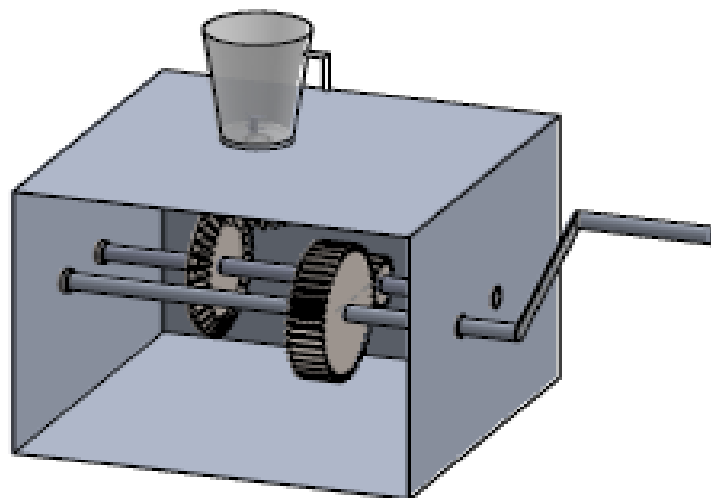
This is the main power transmission component of this machine. It transmits torque from one shaft to another (in this case, from the handle to the other shafts). This is what is used to multiply the effort input by the user and transmit it to the other mechanisms of this machine.

### 3.1.7. Shaft

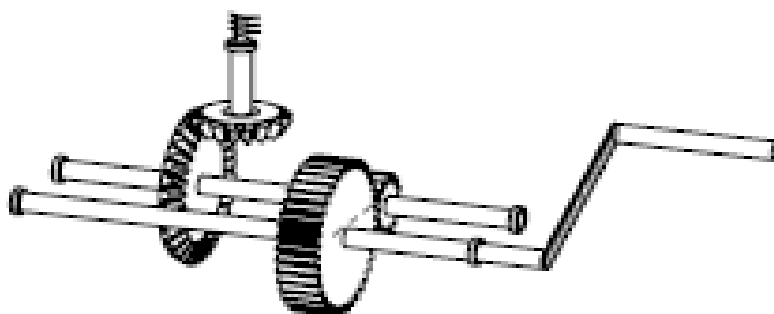
A shaft is a slender rotating member of a circular cross-section used to transmit power or motion. They are at times used to convert reciprocating motion to rotary motion; as most shafts are under fluctuating loads of combined bending and torsion with various degrees of the other stress. For adequate shaft design for strength, the strength (static, fatigue and reliability of the shaft under static, dynamic and impact loading) should be considered. Shafts can be used to provide support and an axis of rotations or oscillation for other mechanical elements. The shaft was considered for material selection and based on the lightness in weight, strength, low rate of corrosion, chemical stability, toughness, non-toxicity. Aluminum and Stainless Steel were chosen for the shaft and blade components.

## 3.2. CAD Modelling

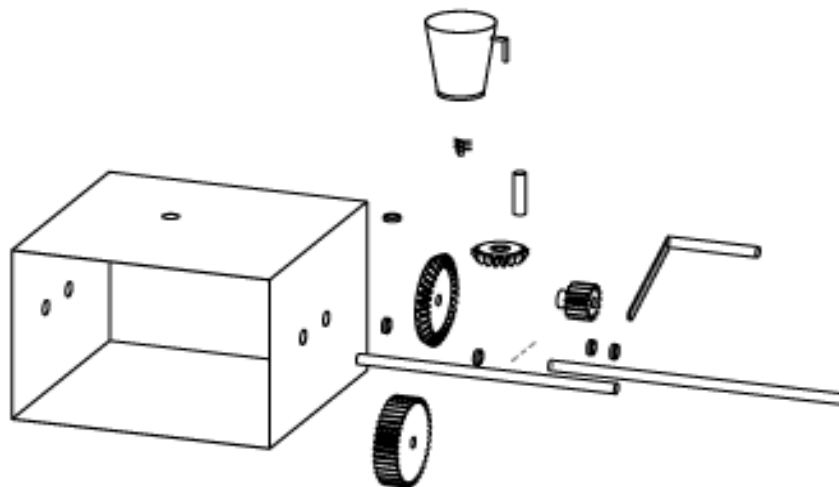
The CAD model of the fruit blender shown in Figure 3 was created to help visualize the design and to show the interaction between the assembled components.



**Figure 3.** Rendered drawing of the Fruit Blender



**Figure 4.** The gear train mechanism of the blender



**Figure 5.** Exploded assembly view of the Blender

#### 4. RESULTS AND DISCUSSIONS

The machine was tested by successfully blending watermelon slices into a fruit smoothie in less than a minute. The velocity ratio given by the gears enabled the blender to crush and blend the fruit pieces into a puree/smoothie form. It was also used to roughly chop peppers however, it was unable to blend the peppers into a fine paste efficiently. The gear train system comprised of a pair of meshing bevel gears, a pair of meshing spur gears, three shafts, bearings and a chuck. When operated, the blades of the blender were able to achieve speeds that were 8 times more than the input speed. The spur gears had a velocity ratio of  $8/3$  which was transferred to the bevel gears, through the shafts, increasing the speed and finally from the bevel gears to the blade which had a velocity ratio of 3. Some friction was experienced while turning the gears but with proper lubrication using bearing grease, this was reduced.

The complete assembly fruit as shown in figure 6 was able to transform the fruit into blended mixtures successfully. However, the handle required a bit of force to overcome inertia. This was as well caused by friction between the meshing parts. It was able to blend fruits smoothly and effortlessly.



**Figure 6.** The complete assembly fruit blender

## 5. CONCLUSION AND RECOMMENDATION

The human-powered blender is quite useful for individual and household use. If the blender was to be mass produced, the aluminum gears would be replaced with reinforced plastic gears to reduce the overall cost of manufacturing and make it more affordable. The low cost of maintenance and the ease of maintenance are highlight of the human-power blender. By utilizing a gear train system, an easy to use and efficient human-powered blender can be made.

The fabrication of the mechanisms especially the gears should be done with precision and accuracy in order to achieve perfect meshing of the gears. A horizontal milling machine should be provided to ensure the gears are cut precisely, this would help to avoid any errors that can cause friction and wearing of meshing parts. Also, the assembly of the machine should be done as carefully as possible to avoid getting backlash, misalignment and noise. Metal Inert Gas and Tungsten Inert Gas welding should be used as opposed to Arc welding in order to obtain a better finish. If necessary, a higher velocity ratio would be required in order to make the blending time even faster. Finally, the housing should be insulated in order to reduce the vibrations and rubber mountings should be put in place to help absorb further vibrations. This would significantly reduce the noise caused by the blender.

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