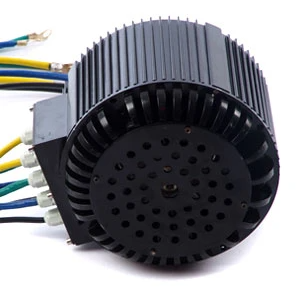
**JIBEBE**

ELECTRICAL SUBSYSTEM

MOTOR SIZING  
Calculations for Shujaa Tractor Motor

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# INTRODUCTION

This document will focus on the sizing of the motor to be used for the Shujaa Tractor. Proper sizing of a motor requires that 3 criteria must be met: torque, load inertia, and speed.

## 

## 

## Considering Tilling only

## Torque

This is defined as rotational force at a distance from the rotational axis. It is measured by units such as lb-in (pounds inch) in imperial or Nm (newton meter) in metric. Torque is just as important, if not more important, than the horsepower of a motor. Horsepower is how fast the work can be done and is calculated with torque multiplied by speed. In other words, torque is the capacity to do the work, and power is the speed at which the work can be done.

## Load Torque

Torque has 2 main components: load torque and acceleration torque. Load torque is the amount of torque constantly required for application and includes friction load and gravitational load. Acceleration torque is the torque required just for the maximum acceleration and deceleration rate for the load. The faster the load needs to accelerate, the higher the acceleration torque is. Sometimes the load torque is higher; sometimes the acceleration torque could be higher.

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## B. Considering Movement only

.For deciding the power rating of a vehicle, the vehicle dynamics like rolling resistance, gradient resistance, aerodynamic drag, etc. have to be considered. For illustration procedure for selecting

motor rating for an electric car of gross weight 450 kg is considered.

The force required for driving a vehicle is calculated below [1]-[4]:

Ftotal=Frolling+Fgradient+Faerodynamic drag (1)

Where, Ftotal =Total force

Frolling= force due to Rolling Resistance

Fgradient resistance= force due to Gradient Resistance

Faerodynamic drag=force due to aerodynamic drag

Ftotal is the total tractive force that the output of motor must overcome, in order to move the vehicle.

### ROLLING RESISTANCE

Rolling resistance is the resistance offered to the vehicle due to the contact of tires with road. The formula for calculating force due to rolling resistance is given by equation (2):

Frolling=Crr\*M\*g (2)

Where, Crr= coefficient of rolling resistance

M= mass in kg

g= acceleration due to gravity= 9.81 m/s2

Reference for Crr

Car tire on concrete: 0.010 to 0.015 , Steel on steel: 0.02 , Steel on wood: 0.22

Car tire on tar or asphalt: 0.030 to 0.035 , Aluminum on steel: 0.10 to 0.15

For the application considered, i.e a farm , choose rolling resistance to be 0.09 .

This [paper](https://www.cambridge.org/core/services/aop-cambridge-core/content/view/ECD7544F00543D596B2D0EB3DD639516/S2633776220000758a.pdf/rolling-resistance-of-atv-tyres-in-agriculture.pdf) has values for rolling resistance in agriculture.

Crr=0.09 M= 450 kg, g = 9.81

Therefore,

Frolling= Crr\*M\*g

Power required to overcome the rolling resistance is:

Prolling= Frolling\*V/3600 (3)

Where, V=velocity in kmph.

### GRADIENT RESISTANCE

Gradient resistance of the vehicle is the resistance offered to the vehicle while climbing a hill or flyover or while travelling in a downward slope.

The angle between the ground and slope of the path is represented as α, which is shown in the Figure below.

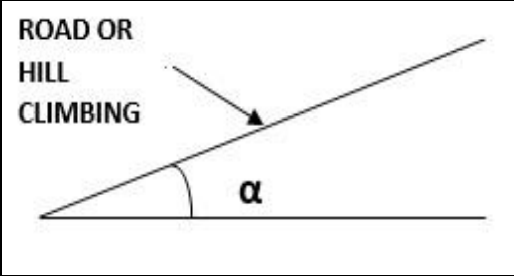


Figure: Angle between the ground and slope of a path

The formula for calculating the gradient resistance is given by equation (4):

Fgradient resistance=+ M\*g\*sin α (4)

In this illustration, let us consider the electric tractor runs on a flat road. Therefore, the angle α =0⁰

### AERODYNAMIC DRAG

Aerodynamic drag is the resistive force offered due to viscous force acting on the vehicle. It is largely determined by the shape of the vehicle.

The formula for ca lculating the aerodynamic drag is given by equation (5):

Faerodynamic drag= 0.5\*CA\*Af\*ρ\*(V+Vo)2 (5)

These are the three main forces which act on the vehicle when it travels at constant speed. While accelerating and decelerating the effect of force due to inertia also acts. In this section, let us consider the power required to overcome Aerodynamic drag and other resistive forces to be around 1.3 kW.

### EFFIENCY

The total Power can then be calculated from the addition of the three powers above.

But electric motor with output power rating above should not be selected. The losses due transmission of power to the wheel must be included.

Therefore, the mechanical power output (Mtractive) required to drive the vehicle is given by equation (6):

Mtractive = Ptotal / η (6)

Where, η= efficiency of the transmission gear system.

Let us consider the efficiency of the transmission system to be 0.85.

Therefore the mechanical power output required can be calculated and appropriate motor can be selected.