Analyzing Acting Resistances in Electric Wheelchair at Different Speeds

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Abstract: On the journey to mobility and freedom, motorized wheelchairs and E-locomotive are the tool to finish that journey. The addition of some devices enables persons with physical disabilities a comfortable travel beyond their own world. Mobility helps disabled person to move from one place to another place and it mostly useful for covering short distance thereby reducing their reliability on others. Basically wheelchair are either manually driven with human force or driven by motors. Wheelchairs driven by motors, located on the rear wheel are called by electric powered wheelchair.

Key Words: Aerodynamic Resistance, Rolling Resistance, Gradient Resistance, Torque, Power, Electric Powered Wheelchair.

I. INTRODUCTION

In current world a large number of people suffering from some severe physical disability. Hence in today's era they required large number of E-locomotive to go from one place to another place without any physical effort. For the physical disabled persons wheelchair is most appropriate locomotive to travel form one place to another. To neglect the physical effort wheelchairs are customized in electric powered wheelchair. Electric powered wheelchair propelled by an electrically based power source, typically motors and batteries. There are two type of mechanisms are used in electric powered wheelchair:-

1). Indirect Drive: Indirect drive systems (pulleys and drive belts) are used on the conventional type wheelchairs.

2): Direct Drive: Direct drive systems (gear boxes) are used on the power based wheelchairs.

1.1 TYPES OF WHEELCHAIR

There are three type of wheelchair in the market of locomotives:

A). Simple Wheelchair Operated by others: These types of wheelchairs are used in the case of transport wheelchair that can be pushed by someone walking behind the wheelchair.

B). Manually Operated or Self Operated Wheelchairs: Manually operated are just that, wheelchair which are propelled by good old muscle power of rider.

Manually Operated or Self Operated wheelchair further divided in to two parts-

a). Crank Operated: In crank operated wheelchair a hand crank is attached on side of both hand rest and crank is directly connected to main wheel with the help of chain and spocket mechanism. When we rotate both crank with the help of attached paddle by hand the our wheelchair move forward and when we rotate only one crank with the help of paddle then it moves on the opposite side.

b). Lever Operated: In lever operated wheelchair geared lever is provided to propel the wheelchair to move forward and backward. Wheelchair moves with the help of attached gear mechanism.

C).Self Propelled (Either Electricity or any Other Sources) Wheelchair: In modern word, to reduce the manual load we modify the simple wheelchair in motorized wheelchair. Motorized wheelchairs are also called by electric powered wheelchair.

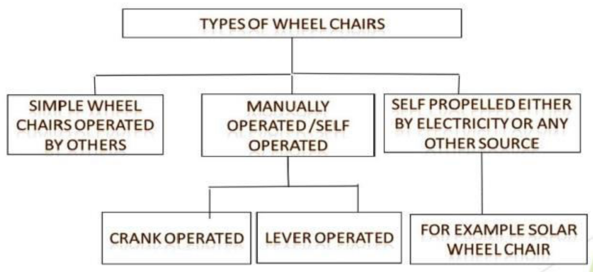

Fig.1 Type of Wheelchairs

1.2 RESISTANCES ACTED IN WHEELCHAIR

There are many different type of resistance acted in wheelchair but here we describe mainly three type of acting resistance:-

A). Aerodynamic Resistance: The component of acting force exerted by the air on the solid object, that force is acting in parallel and opposite direction to the motion of object is called by the aerodynamic drag or aerodynamic resistance, Mathematically, it is represented by Ra.

$$Ra=1/2*\rho*C_d*A*V^2$$

ρ = Air Density,
C_d = Coefficient of Drag,
A = Projected Area,
V – Relative Velocity,

B). Rolling Resistance: Rolling resistance is the force the force which resists the motion of the body when it rolls on the surface. The resistance helps to roll the body without slipping. Rolling resistance is the combination of hysteresis loss and friction loss. Mathematically, it represented by R_R .

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R_R = HYSTERESIS LOSS + FRICTION LOSS
$R_R = C_H W + C_F W$,

$$R_R = C_{RR}\ W$$

C_{RR} = Coefficient of rolling resistance,
W = Total kerb weight.

C). Gradient Resistance: It is the resistance, due to road gradient. It depends on the steepness of the gradient and weight of the body. Mathematically, it represented by R_g.

$$R_g = Mg*\sin\alpha$$

Mg = W = Total kerb weight,
α = Road gradient

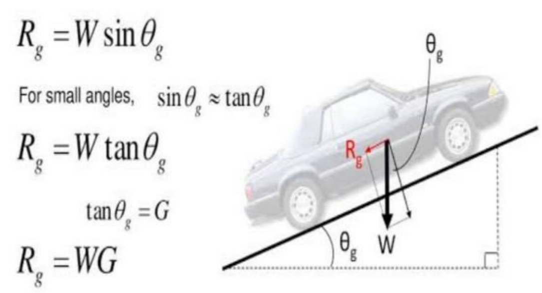

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Fig2. Gradient Resistance (R_g)

II. CALCULATION

Calculation of acted resistance in wheelchair at different speeds.
Data we have for calculation:
Radius of wheel= 30cm (general data for wheelchair)
Weight of the wheel chair: 50 kg (any general wheelchair)
Total kerb weight = 130 kg (including rider weight)
Coefficient of rolling resistance = 0.01(for cycle tyre)
Coefficient of drag = 0.88 (form wheelchair standard)
Projected area of wheelchair = 0.914*0.63 m

At speed of 2 Km/hr.
Speed= 0.556 m/s
Rolling Resistance = CRR X Mg
= 0.01 X 130 X 9.81 = 12.8 N
Gradient Resistance = Mg*Sinα
= 130 X 9.81 X Sin3
= 66.74 N
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(0.556 *0.556)
= 0.09594 N
Total Resistance = 79.6359 N
From this calculation we get that rolling resistance and gradient resistance are not depend on the speed of wheelchair so for every speed these resistance are same.

At speed of 3 Km/hr.
Speed= 0.833 m/s.
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(0.833 *0.833)
= 0.2153 N
Total resistance = 79.7553 N

At the speed of 4 Km/hr.
Speed= 1.11 m/s.
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(1.11*1.11)
=0.4183 N
Total resistance =79.9583 N

At the speed of 5 Km/hr.
Speed=1.39 m/s.
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(1.39 *1.39)
= 0.6560 N
Total resistance = 80.196 N

At the speed of 6 Km/hr.
Speed= 1.67 m/s
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(1.67 *1.67)
= 0.9470
Total resistance = 80.487 N

At the speed of 7 Km/hr.
Speed= 1.94 m/s.
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(1.94 *1.94)
=1.2780 N
Total resistance = 80.818 N

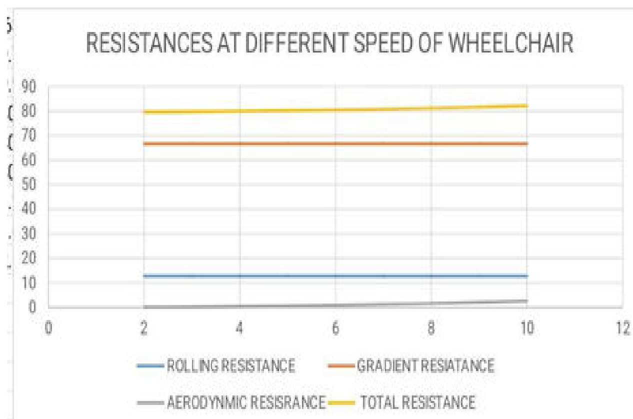
At the speed of 8 Km/hr.
Speed= 2.22 m/s.
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(2.22 *2.22)
= 1.6735 N
Total resistance = 81.2135 N

At the speed of 9 Km/hr.
Speed= 2.5 m/s
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(2.5 *2.5)
=2.1223 N
Total resistance = 81.6623 N

At the speed of 10 Km/hr.
Speed= 2.78 m/s.
Aerodynamic Resistance = (½) ρ Cd AV2
= (½)*1.225 *0.88 *0.914*0.63*(2.78*2.78)
= 2.6243 N
Total resistance = 82.1643 N

SPEED (km/hr.)	R_a (N)	R_R (N)	R_g (N)	Total resistance(N)
2	0.09594	12.8	66.74	79.6359
3	0.2153	12.8	66.74	79.7553
4	0.4183	12.8	66.74	79.9583
5	0.6560	12.8	66.74	80.196
6	0.9470	12.8	66.74	80.487
7	1.2780	12.8	66.74	80.818
8	1.6735	12.8	66.74	81.2135
9	2.1223	12.8	66.74	81.6623
10	2.6243	12.8	66.74	82.1643

Table 1. Resistances at Different speeds of Wheelchair



Graph 1. Resistances at different speed

This graph tells us that rolling resistance and gradient resistance are independent from the speed of wheelchair And aerodynamic resistance depends on the speed of the wheelchair.

III. CONCLUSION

From above calculation we can see that if we increase speed of the wheelchair it only effects on the aerodynamic resistance and aerodynamic resistance depends on the shape of the moving body so if we want to reduce the aerodynamic resistance it need to modify deign of the moving body or wheelchair.

If we want to improve the rolling resistance so it depends on the coefficient of the rolling resistance of the tyre of the wheelchair.

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