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EXPERIMENTAL STUDY OF REVOLVING DOOR AT AMGOI CAMPUS

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ABSTRACT

The work focuses on an experimental study of revolving door usage on AMGOI campus, personal observations made on campus that has four main entry gates around 2600 students were entering to campus at morning between 9.00am to 10.00am and leaving the campus 4.00pm to 5.00pm using these gates sparked our curiosities about revolving door usage on campus. A human pushing on a door increases the rotational kinetic energy of the door. This energy is a result of the inertia of the door and its angular velocity. The kinetic energy of the rotating door is calculated 130.20 Joules and the mass of the door used in the test were approximately 32 kg and the lateral dimensions Height and weight were 120 cm and 55 cm respectively. During the door opening testing, the average door speed of 4 rpm resulted in the door's kinetic energy. While sizing of the generator found that about 2kg-cm of torque was required to turn the generator, nominal electrical load connected.

Keywords: door, pushing, revolving, sizing, torque etc.

I. INTRODUCTION

1.1 Revolving door

Revolving door was invited to reduce the noise while opening and closing door, entrance of wind, snow, rain, or dust. This revolving door moved only in one direction, streams of people could pass through a building with reduced possibility of collision. An American patent was granted to Theophilus Van Kennel of Philadelphia in 1888 for a three-partition revolving door was design.

Fig: 1.Top view of revolving door

1.2 Door Energy

Measurements of door parameters were made to determine approximate energy levels typically found in human powered door motion. Revolving Door rotation speeds were recorded for users at four gates. A typical door was weighed and measured such that its moment of inertia could be calculated. Today, the revolving door is set on a rotating shaft and revolves in a frame with unlimited rotation. Most revolving doors have four transparent door with push-bars attached to the door Curved walls surround the circumference of the revolving door,A human pushing on a door increases the rotational kinetic energy of the door. This energy is a result of the inertia of the door and its angular velocity. The kinetic energy of the rotating door is calculated as

1.3 The Door kinetic energy

Fig: 2. schematic diagram of revolving door.

Let D is the overall diameter of the door, r the radius of the cylindrical core, and l the width of each radial panel. The total number of radial panels is arbitrary and is given by n.

The rotational kinetic energy of any mass distribution associated with rigid rotation of the mass distribution about a fixed axis is

$$E = \frac{1}{2} I\omega^2 \quad (1)$$

Where

I = is the moment of inertia of the mass distribution about the fixed axis of rotation,

ω= is the angular velocity of the rotation, in rad /sec

The moment of inertia is the second spatial moment of the mass distribution about the axis of rotation.

$$I = \frac{1}{12} ML^2 \quad (2)$$

Where

M = is the mass of the bar, in kg.

L= is its length, in meter.

M is here the mass of an individual radial door panel and L its width. Combining (1) and (2), the rotational kinetic energy of a radial panel of mass M and width L due to its rotation about its own center-of-mass is

$$E^{(\text{center of mass})} = \frac{1}{24} ML^2\omega^2 \quad (3)$$

The kinetic energy due to the rotation of the center-of-mass of the panel about the axis of rotation of the door is

$$E^{(\text{orbit})} = \frac{1}{2} M\rho^2\omega^2 \quad (4)$$

Where

$\rho =$ the radial distance of the center-of-mass of the panel from the axis of rotation of the door.

The total kinetic energy of each radial panel due to its rigid rotation within the structure of the door is the sum of the two components given by (3) and (4)

Namely,

$$E^{(\text{Panel})} = E^{(\text{center of mass})} + E^{(\text{orbit})} \quad (5)$$

From Fig 1,

$$\frac{D}{2} = l + r \quad \text{or}$$

$$r = \frac{D}{2} - l \quad (6)$$

Since the distribution of mass across the width of the radial panels is uniform, the center-of-mass of the radial panels is located at the center (in the horizontal direction) of the panel.

That is, at a distance l/2 from the attachment point of the radial panel to the 2 “Rigid” here means that, due to the fact that the panel is rigidly attached to the structure of the door, it is forced to rotate about its own center-of-mass as well as to rotate as a whole about the axis of rotation of the door. Equation (5) accounts for both of these rotational components that characterize the motion of the panel.

Cylindrical core Given that the radius of the cylindrical core is r, the radial distance of the center-of-mass of a radial panel from the axis of rotation at the center of the core is

$$\rho = r + \frac{l}{2} = \left(\frac{D}{2} - l\right) + \frac{l}{2} = \frac{D-l}{2} \quad (7)$$

Where (6) has been introduced for r.

Let the mass of the cylindrical core be mc and that of a radial panel mp.

From (4) and (7), the kinetic energy associated with the rotation of the center-of-mass of a radial panel about the axis of rotation of the door is

$$E^{(\text{orbit})} = \frac{1}{2} m_p\omega^2\rho^2 = \frac{1}{8} m_p\omega^2(D-l) \quad (8)$$

And, from (3), the kinetic energy associated with the rotation of a radial panel about its own center-of-mass is

$$E^{(\text{center of mass})} = \frac{1}{24} m_p \omega^2 l^2 \quad (9)$$

Therefore, from (5), (8) and (9), and the fact that there are n radial panels in all, the total kinetic energy associated with the revolving radial panels is

$$E^{(\text{panels})} = \frac{n}{24} m_p \omega^2 [3(D-l)^2 + l^2]$$

$$= \frac{n}{24} m_p \omega^2 (3D^2 - 6Dl + 4l^2) \quad (10)$$

Since the cylindrical core is assumed to be hollow, the entire mass mc of the core is concentrated at the radius r. Therefore, the kinetic energy associated with the rotation of the core

$$E^{(\text{core})} = \frac{1}{2} m_c \omega^2 r^2 (\frac{D}{2} - l)^2$$

$$= \frac{1}{8} m_c \omega^2 (D - 2l)^2$$

$$= \frac{1}{8} m_c \omega^2 (D^2 - 4Dl + 4l^2) \quad (11)$$

Where (6) has been used for r. The total rotational kinetic energy of the door is the sum of (10) and (11). Namely,

$$E = E^{(\text{panels})} + E^{(\text{core})}$$

$$= \frac{\omega^2}{24} [n m_p (3D^2 - 6Dl + 4l^2) + 3m_c (D^2 - 4Dl + 4l^2)] \quad (12)$$

Grouping by descending powers of D yields

$$E = \frac{\omega^2}{24} [D^2 (3n m_p + 3m_c) - 6Dl(n m_p + 2m_c) + 4l^2 (n m_p + 3m_c)] \quad (13)$$

And taking out a factor of 12 gives

$$E = \frac{1}{2} \omega^2 \left[\left(\frac{D}{2}\right)^2 (n m_p + m_c) - Dl\left(\frac{n}{2} m_p + m_c\right) + l^2 \left(\frac{n}{3} m_p + m_c\right) \right] \quad (14)$$

II. CONSTRUCTION

Fig: 3. shows the contraction of revolving door, around the central shaft of the revolving door, there are three panels called “wings” or “Leaves” are 120^0 inter leaved each other, and in complete revolution it takes 3600. Bottom of shaft gear system is connected with the gear ratio of 1:20. GM-motor of rating 12v, 10rpm is connected to the gear. Output terminal of GM-motor is connected to storage battery trough the charge controller.

Fig. 3: Typical Revolving Door

Fig 4 - Typical Revolving Door

III. WORKING

Manual revolving doors rotate with push-bars, causing all wings to rotate. Revolving doors typically revolve counter-clockwise (as seen from above), allowing people to enter and exit only on the right side of the door. Direction of rotation is often enforced by the door governor mechanism. The rotational kinetic energy stored in the revolving door is extracted by human pushing on a door increases the rotational kinetic energy of the door. This energy is a result of the inertia of the door and its angular velocity. The kinetic energy of the rotating door is calculated intern is used as a torque input to the GM-Motor. Speed of rotation of door is increased by gear assembly which is connected to bottom of the shaft. GM-motor of having rating of 12V, 10 rpm, 2 kg-cm is used and produce a 12V DC output that is stored in battery of having 12V, 7.2Ah, charge controller will helps in charging the battery. Block diagram is shown in fig.5.

Fig.5: Block Diagram

IV. RESULT

4.1 Technical parameters

Table: 1Specification of Door

Wing/Panel Height	120 cm
Wing/Panel width	55 cm
Wing/Panel Weight	5 kg
Center Shaft Height	128 cm
Center Shaft Width	7 cm
Center Shaft Weight	4 Kg
Gear Weight	12 Kg
Door Weight	0.5 Gg
Base Fittings	0.5 Kg

Table.2: Specification of Gear ratio 1: 20

Diametrical Pitch (P)	drive gear 6.73 cm
	driven Gear 6 cm
Pitch Circle	16 cm
Addendum (A)	drive gear 0.15 cm

	driven gear 0.17 cm
Dedendum (B)	drive gear 0.17 cm
	driven gear 0.19 cm
Outside Diameter (OD)	drive gear = 30 cm
	driven gear = 2 cm
Root Diameter (RD)	drive gear = 29.42 cm
	driven gear = 1.33 cm
Base Circle (BC)	drive gear =27.93 cm
	driven gear = 1.57 cm
Circular Pitch	drive gear = 0.47 cm
	driven gear = 0.52 cm
Circular Thickness (T)	drive gear = 0.23 cm
	driven gear = 0.26 cm
Whole Depth (WD)	Drive gear = 0.32 cm
	Driven gear = 0.36 cm
Pressure Angle (PA)	Preferably choose either
	14.5 degree or 20 degree.
Center Distance	15.7 cm
Velocity	drive gear = 93.37
	driven gear = 5.25

Table.3: Specification of DC-GM Generator

Motor Type	150 RPM, 12Vdc
Shaft Type	DC with Geared box, Metal Gear
Base Motor	DC, Circular 6mm Diameter With internal hole for coupling,

	23 mm Shaft length
Maximum Torque	2 Kg-cm at 12 volt
RPM	150 RPM at 12 volt
Weight	130Gms
Max No Load Current	70 mA at 12 volt

V. CONCLUSION

The purpose of study is to extract "Green energy" from the revolving door. The study is conducted as a case to AMGOI campus were 2600 students entering and leaving the campus at morning and evening by use of gates. When more and more people begin to use the revolving door, energy generation increases. During the door revolving, the average door speed of 4 rpm resulted in the door's kinetic energy equal to approximately 130.20 Joules. Laboratory testing of the generator found that about 2 kg-cm of torque was required to turn the Generator, single generator arrangement generates 3.6W and four generator arrangement is made radial to the gear, power generated 14.4W for one revolution. Total power generation for one day is 54.75W.

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