Design and Development of Sliding Glass Pedestrian Entrance Control unit

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***Abstract*— Pedestrian entrance control systems (PECS) are coming into picture to control flow of mob in public or private place with moderate or high population. This type of system can also be used for security purpose so as to allow authorized personnel in and out of a place. The traditional PECS come with flap barrier, swing barrier, turnstiles, etc. in which sliding barrier uses linear motors, LVDTs, etc. In the proposed research work, the time of actuation is restricted to 0.5 second, the width of single unit is 300 mm and the height of glass is 1000 mm. This research work also focuses on the design of Sliding glass pedestrian entrance control system which is an inversion of double slider mechanism. In this mechanism, a DC motor is used to convert oscillations of crank into linear motion of sliding glass to achieve the required output. The research work includes design of the pedestrian entrance control unit.The research work also includes the Computer aided design of the unit.**

***Keywords*— Pedestrian Entrance Control System (PECS), Automation**

I. INTRODUCTION

Turnstiles and other Pedestrian Entrance Control (PEC) devices are increasing in modern security system projects, for new construction as well as for upgrades to existing systems. Why the recent increase in demand for Turnstiles and Pedestrian Entrance Control Systems (PEC's)? Here are a few of the reasons we note as driving the trend:

- Many existing installed turnstile systems are over 10 years old are needed to be replaced.
- Clients who are considering replacing or enhancing their access control system want to look at automating their entrance control at the same time.
- Increasing concerns over domestic, workplace violence and terrorism.
- Property managers of down town Class A office buildings require automated entrance control for tenants.

A. History of PECs

Humans have employed pedestrian entrance control for thousands of years. Turnstiles just happen to be our modern answer to the age-old need, any place where we wanted to control who is getting in. We can imagine in the stone-age a cave man would have rolled a large boulder in front of his entrance to block out intruders. In more modern times we have employed door locks and keys for a couple hundred years. Over 100 years ago the first revolving waist high turnstiles came on the scene, to control customer traffic flow in a retail grocery environment. More recently, optical turnstiles using infra-red photo-beams with/without moving barrier arms and wings became very popular over the past 20 years. Now today, we have IP networked, highly efficient security lanes of all types for the most secure and demanding high volume office tower applications.

B. Turnstiles and PECs

Turnstiles control who is getting in. Most of the times the access control integration is via dry contacts but some systems allow for software level integration. The main advantage of turnstiles is that they make your lobby staff and security team more effective and efficient. Typically, we look for any secure building or campus having a minimum of 500 authorized occupants, and where every credential (access card, biometric, or other) is currently checked by an access control reader and/or monitored by an officer or lobby staff person. These conditions make for an excellent prospective application for automated pedestrian entrance control. We use a turnstile/PEC because the secure facility has an interest in controlling access to authorized persons (the security need), and manpower is currently employed to that end (potential for improved efficiency = this is your ROI)

C. Some of the most common types of turnstiles include:

1) Mechanical Turnstile
2) Optical Turnstile
3) Barrier Type Optical Turnstile
4) Security Portals /Revolving Doors

D. Problem Statements

- Smooth control of mob: Quick actuation of glass (0.5 sec) so that t least 60 people should be able to pass through this equipment.
- Avoid vaulting or trespassing: Make the product flexible enough so that company should be able to fit glass up to 1 m Hight. If this full-length glass is used any vaulting can be avoided. Since actuation is very fast if an unauthorized person tries to trespass immediately after a person, sensors will detect and will immediately close the glass barrier.
- Improve aesthetics: Metal panel, bar cage, plastic sheet, etc. are either not very attractive or lose their aesthetic looks eventually over the period of time.

E. Objectives

- Sliding of glass (linear horizontal motion): Most important objective of this project is that linear horizontal motion of glass must be achieved.
- Bidirectional control: People should be able to pass through the equipment in both directions (enter and exit).
- Size of unit: It should not occupy too much floor area. Width of unit should exceed 300 mm. The company has given us freedom to choose length and height of unit.

Actuation time: Minimum 60 people should be able to pass through the PEC; therefore actuation (in and out) of glass should be in 0.5 sec.

II. Literature Review

Anthropometric principles by R. Bridger [1] in workspace and equipment design

- The word 'anthropometry' means measurement of the human body. It is derived from the Greek words 'Anthropos' (man) and 'Merton' (measure).
- Designing for Population of users: Design for range of people as wide as possible (normally 90%). Here, the word population is used in a statistical sense and can refer to a group of people sharing common ancestors, common occupations, common geographical locations or age groups. May contain Different races (different ancestry) or different ethnic groups (different cultures & customs).
- Anthropometry and its uses in ergonomics: "The approach of ergonomics is to consider product dimensions in human terms in view of the constraints placed on their design by body size variability." Body sizes and shapes vary greatly across cultures and regions over the world. This should be kept in mind when designing product on global/international market. It's impractical to design for individuals, therefore most mass-produced products are designed for wide range of users.

Functional Anthropometric data: Functional anthropometric data are collected to describe the movement of a body part with respect to a fixed reference point.

The mechanism used in design is scotch yoke mechanism. Scotch-yoke mechanism is known to generate a pure-harmonic motion. Kinematic ally, it is equivalent to the slider crank mechanism of conventional reciprocating links when the connecting rod is imagined to have an infinite length.

Inverted slider crank, which is the inversion of the slider crank chain, are usually used to create straight line oscillating motion in industrial application.

Inversion of the double slider crank chain and slider crank chain, namely Scotch yoke and inverted slider crank (oscillating mass mechanism) were compared in terms of their performance regarding transmission capability and required control effort for the possible use in control actuation systems.

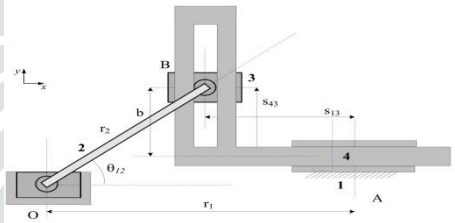

Figure 1 Scotch Yoke Mechanism

There exists a non-zero normal force in sliding parts. Which results in rapid wear of slot in the yoke due to sliding friction. So the inference can be made that:

- Slider crank mechanism is usually used if the precise transfer of the rotation to the translation is required.
- Scotch yoke mechanism with having fewer moving parts has smoother operation than slider crank mechanism. However, it suffers from rapid wear of the slot in the yoke caused by high contact pressure.

The glass used in design is a toughened glass. As demonstrated in the experimental test by QiyuanXie, et al,[2] the critical breakage temperature range is greater for thicker toughened glass i.e. 10 mm thick glass has larger range of than that of 6 mm thick glass. To prevent a large and tall toughened glass to fallout completely during enclosure fires, the glass is suggested to be horizontally partitioned into small panes with frames.

As far as its manufacturing is concerned, toughened glass is itself made from small pieces of glass under high pressure. So when external breaking stroke/force is applied the glass as whole is affected i.e. cracks but doesn't shatters. In addition, the results show that in engineering applications, sprinkling or water mist can be used to protect toughened glass in cases of maximum temperature differences.

According to T. R. K. Mandeville [3] in previous PECS, a ticket reading means is placed adjacent the entrance to the passage. If a person approaches the barrier without having first presented a valid ticket to the reading means, the barrier is controlled to be in a closed condition which prevents access. Further sensors are provided to ensure that the barrier does not close if there is an obstruction at the barrier position, thereby increasing passenger safety. In general, such systems may operate in a normally open state (in which the passage is open until the barrier is placed into its closed condition when an invalid fare and a subject are sensed), or a normally closed state (in which the barrier is only placed into its open condition when a valid fare and a subject are sensed).

A disadvantage with such systems is, however, that the throughput of people in such automatic gates is low.

People tend to wait at the ticket reading station until the barrier has responded. This causes a queue at busy times or requires the owner of the access system to purchase many more gates than would be necessary if the throughput could be increased. These disadvantages tend to reduce throughput of the access system resulting in queues with concomitant safety and ticket security problems.

In the invention the improved apparatus is used.

There are around 10 claims in short - subjects (humans) passing through apparatus will only pass if it has valid ticket, while increasing throughput of apparatus. When one subject is comprised in apparatus and other subject comes with valid ticket, barrier would not close the path, and both will be able to pass through immediately. While if second subject has invalid ticket, barrier would close the path immediately; and only valid subjects will be allowed to pass through the barrier.
PECS were modified by T. Ropelato [4], by integrating a protection system for motorized pedestrian access passageways, such as those used for controlling the passage of people in places Such as Subways, airports, factories, offices, etc.

Carl Julius Jorgensen [5] invented some improvements in passenger-gates. This invention relates to passenger-gates so¨ constructed as to admit of the entrance and passage of but one person at a time.
His improvement consists of various combinations, specifically set forth in the claims at the close of this specification, of certain mechanical devices, of which devices the following are the most essential ones, viz. a pair of barriers which normally extend sufficiently far across the gateway from opposite sides to prevent the passage of a person, but which readily yield laterally by receding under the pressure of a passing person, and an auxiliary pair of barriers, which normally do not obstruct the gateway, but are partially thrown across the same on the recession of the primary pair of barriers, so as to confine the use of gateway to one person at a time.

The previous systems were used to have separate cashier, and systems were not very aesthetic. In rush time cashier is too busy to supervise admission through turnstile. It was found that people were able to pass by climbing over or by ducking under the turnstile. High level cage type (which solved problem of climbing over) was not only unattractive but also had tendency trap some kind of bag or small-scale luggage or even limb of person in it. Installing and maintenance of previous turnstiles needed construction underground. Whenever it needed maintenance they had to tear up the floor to repair it, which took lot of time. These problems have been solved by the system made by H. A. Powers.[6]

Many passageways used turnstiles type devices to allow access to authorized personnel or paying person. The problem of this devices was that the access was allowed for single person at a time. The next person had to wait for his/her turn until the previous person has travelled the passageway. Thus, in places of large mob traffic such devices caused obstruction of mob. This increased the crowd and had its own disadvantage. The time of the people was wasted waiting for their turn. Also, turnstiles operate on force exerted by the passer by i.e. People needed to push this device to pass through it. This created an undesirable psychological effect on customers such as turnstiles consisted of rod barriers, if this device were not under surveillance, the cheaters passed through them by ducking under the barrier. The problem of a powered turnstile was that the customer had to adapt to the speed of the barrier, otherwise the customer was pushed by the barrier causing discomfort. System was developed to overcome these problems by John B. Crews and Edward Dillingham.[7]

The gate assemblies used before were mostly turnstiles and scissor-type. The common limitation of this systems was the floor space required for a single unit. Due to this the lanes/passageways for entry in an enclosed space like sporting events, transportation facilities, recreation areas, etc., decreased. This led to crowding of people near this lane for exit and entry. Also, the size of unit increased for compensation of space for barriers in inoperative conditions or in open state. Also, a single lane required a whole unit and for more units more whole units were required respectively. This took lot of space and caused unnecessary space constraints. In case of turnstiles, only locking and unlocking of the rotating arm was done by the system and actuation of this arm was done by the person passing through. This meant that people had to apply force to pass through this barrier which is quite discomfort. In case of scissor type gate assemblies, the barriers rotated about a vertical axis, thus the width of single barrier would be half the passageway. Due to this size and the scissor action of the gate, only a single gate of each pair could be housed in each console.

Later a system was developed by Gordon H. May et al, [8] which used one or more relatively thin planar gates. These gates were mounted vertically in the console adjacent a passageway. Each gate is selectively extended from or withdrawn into the console to block or open the associated gateway. The actuation of this gates was in the plane normal to adjacent passageway. Due to such arrangement one console could hold more than one barrier. This reduced the floor space required. The length of passageway also significantly reduced. In this case more lanes could be incorporated as single console could hold gates for both of its sides. The system was designed based on the number of lanes required.

According to T. Tomita [9], the conventional gate equipment, the horizontal rotating barriers are closed at right angles. The actuation of this gates is also done at the shaft about which this gate pivot. So, the time and power required for operating these gates will be more. As the gate doors closed at right angles to the direction in which passage, there was danger of passenger subjected to strong impact if they happened to strike against the gates resulting to the feeling of uneasiness and oppression. This impact also had effects on the driving mechanism leading to its disruption. The delay of the closing of gate due to right angled final position lead to passing of certain unauthorized people also. The impacts on mechanisms lead to increase of frequency of maintenance and hence the maintenance cost. The power required was also more due to the moment of inertia of barrier about the pivot which is supplied power.

Pedestrian access control as described by Carl W. Kellem et al [10] , were operated with input of fare payments, tickets, identity cards, etc. Access to those people with valid inputs was allowed. But when person with invalid input is not allowed he had to go back disrupting the flow of traffic of mob. This was discomforting for the unauthorized as well as the people waiting to pass through. Also, problems like tailgating and likes of that were faced. Due to which presence of attendants was required which was unnecessary. An automatic system was needed to regulate the flow of people without obstruction caused by invalid personnel.

III. Design

A. Mechanism Selection

Mechanism selection is one of the very initial and most crucial part of designing PECS. There are some things to be kept in mind while designing are-

- Type of motion required- linear motion
- Does Mechanism fits in available space?
- Does mechanism convert rotary motion into linear motion?

Last point is necessary since it is one of the objectives. There are various mechanisms that can attain linear motion and that from circular motion e.g. rack and pinion, slider crank mechanism, scotch yoke mechanism, etc. Among all these mechanisms scotch yoke mechanism is the one that is most compact and satisfies all the mechanism related objectives.

B. Width of Passage

For determination of gap between two units, necessary ergonomic data is used. Hip width of 5 to 95th percentile is shown in table I-

TABLE I
HIP WIDTH OF 5TH TO 95TH PERCENTILE

Population	Male		Female	
	5th	95th	5th	95th
US	310	410	310	440
Northern European	320	395	320	440
Japanese	280	330	270	340
Brazilian	306	386		
African	280	345		

Selection for use of the data for 95th percentile adult population. Taking average of 95th percentile data of all male and female across 5 countries; average hip breadth is found out to be as-

$$\frac{3086}{8} = 385.75mm$$

Consideration of movement done while walking e.g. movement of hands, holding bag etc. Therefore, giving some clearance to hip breadth and functional ergonomics, consideration of total path width is taken as 500 mm.
Newtonian Anthropometric data: Newtonian anthropometric data are used in mechanical analysis of the loads on the human body. Consideration of this data is not done since this product does not put any load on human body.

C. Computer Aided Design of PECS

Design of PECS starts with deciding width of one unit.

- Since width of passage is 500 mm.
- Which is divided in two parts of 250 mm width of glass
- By adding some clearance for outer covering of unit

The width of unit is considered as 300 mm.System is designed for 10 mm thick toughened glass. Height of glass is 1000 mm to avoid trespassing or vaulting over glass. Leaving 30 mm gap between two glass width of glass is 235 mm. Half of it is 117.5 mm which is centre distance between two holes in crank. Similarly, for all parts dimensions of are decided with their dependency on each other.

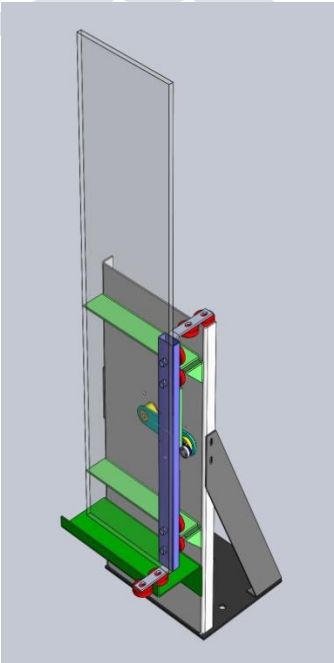

Figure 2 Assembly

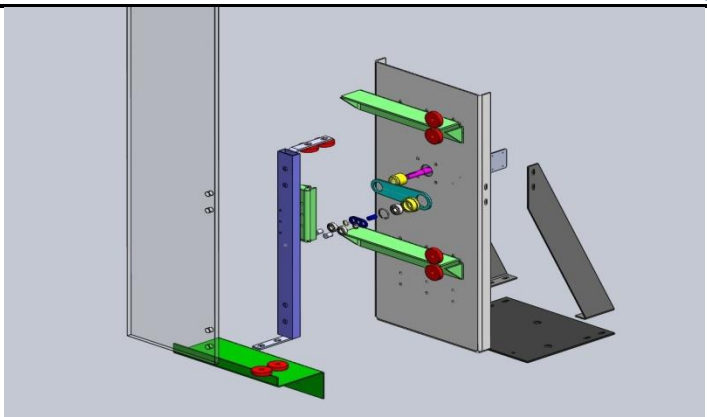

Figure 3 Exploded View

D. Gear Box

One of the crucial things is that input of crank is rotary motion by motor. BLDC (Brush-less DC) motor does not have enough torque to push the weight of glass. Therefore worm-worm wheel gear box is used for transmission. The most important thing is need to be take in mind during the design of gearbox is it must be able to transfer very large force and it also be durable. Speed of base motor I.e. BLDC motor is 1500 rpm rating 40 watt. Gear ratio of gear box is 1:20 and output torque of gearbox is 60 N-m.

Figure 4 Motor with Gear Box

IV. CONCLUSIONS

The pedestrian entrance control system was designed from ground up with need of improved development in PECS. All parts and components are designed to be as robust as possible without increasing cost above existing PECS.

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