Literature Study and Simulation of Screw-type Elevators

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Abstract—Innovating and discovering new ideas and implementing new methodology has led engineering to develop new products for convenient and comfortable living. These innovative ideas and methods led to development in mechanical system by replacing the existing mechanism with newly found ideas. Among those developments, a new elevation mechanism created a platform for screw type elevators. This paper gives the working of the screw type elevators along with structural design of the mechanism and superstructure, the designs were simulated using SolidWorks. The simulated structural modules and the operation of screw type elevators along with its advantages over the existing pulley mechanism are detailed in this paper. Thus the objective of the paper is in two folds, (i) Proves that the screw type elevator is best suited for domestic purpose, (ii) Proposed new drive mechanism performs comparatively better than the existing screw type belt coupled elevators.

Keywords—Elevators, Screw type elevators, SolidWorks.

1. Introduction

Elevation, the basic need for elevation started off with a need for ease of living. Started from the Egyptian era developing across the period of Greeks, Romans and Medieval ages and till now leading to the development of new methodologies [1].

The concept of elevators were used everywhere in water wells, where a pulley mechanism is used to carry water from underground to ground level, this concept was modernized enough to carry people instead of water, by adding additional pulleys, which led to the concept of load distribution in pulley arrangements [2]. To reach heights instead of using ladder, stairways or slopes, elevators were preferred from then, till now [3]. As a result of this, need for elevation of people and things raised since ancient civilization [4].

In Egypt the need for elevation began for lifting the weights and constructional materials, this elevation later used the basic idea of pulley mechanism [5]. People were used to pull the load with the help of pulley arrangements, later on Romans and Greeks discovered new ways for pulling the load using water current from rivers and streams [6].

After the medieval age the idea of counterweights was introduced for means of balancing the load, which eased up the force required to pull the weights. The counterweights were often made of rock fillings and were filled accordingly to the subjected weight [7].

From Iron Age to industrialization in European nations, resulted in developments of rotor mechanisms. These rotational motors were an ideal substitute for pulling the load of elevators [8]. The impact of Iron Age resulted in introducing the metal parts to elevator structures instead of using wooden parts. This replacement of wooden parts gave better results as wooden structures are more vulnerable to moisture and humid conditions, the metal parts also have high tensile strength and high resistance to breakage when compared with wood [9].

During industrialization Elisha.G.Otis invented the safety device that prevents the elevators from falling when the hoist cable fails [10]. This was the first safety measure introduced for the elevation system and after that many safety measures were also implemented in the working of the elevator system. After the industrialization period electricity was introduced [11].
The concept of electrical motors gave a new opening in the operation of elevator system. This newly found electric motors replaced existing drive mechanism in the lifts [12]. Later on many ideas aroused and many efficient way of operation of elevator systems were found which evidently led to the reduction in power, space, mechanical components needed with the improvement of safety features in the elevators [13].

2. ELEVATOR METHODOLOGIES

A. Conventional Operation

The operation of the elevators were primarily based on pulley mechanisms with the counterweight part [14]. This mechanism existed for a while and later on reducing the component size, mainly focused for the improvement of overall efficiency. Later on, this mechanism was treated with additional improvements such as introduction of magnetic slides and frictionless sliding mechanism to the guide rails [15]. These slides proven the frictionless operation and advancements in traction control during elevator operation [16].

As days passed, engineers started building skyscrapers where elevators were the ideal means of transport and again development in the operation of elevators become significant [17]. This necessity led to the development of VFD drives, which is a control mechanism for speed and torque in the elevators and advanced control system was introduced along with improvement in the elevator operating algorithm [18].

Passenger elevators were accustomed for vertical transportation means, however nowadays the elevator structure adds aesthetic look to the infrastructure. When talking about the aesthetic features of elevators, marble flooring surrounded by tempered glass panels along with soothing light conditions with a mild music at the background made it as an ideal transportation [19].

B. Proposed Method

Passenger elevators were a mean of transportation in tall buildings, and nowadays home elevators are also becoming factor for aesthetic and personal convenience. Home elevators require less room and structural components for the elevator structures, with speed in limit unlike lifts used in skyscrapers.

Satisfying all those factors, screw type elevators began to make entrance in home elevation, and made a desirable impact in terms of compactness and affordability.

The proposed screw type elevators eliminates the space needed for the pulley arrangement and also minimizes the space required for the elevator room instalment.

This operation performs slow momentum which would be suitable for the aged and preferred for home elevation.

While motor is in OFF condition the screw and nut mechanism provides breaking naturally by the acme thread arrangement. Also an additional breaking clamp is provided for floor locking as an added safety feature.

Car frame is directly attached with the moving nut, eliminating the oscillation that appears in conventional types. Absence of oscillations provides stability in the system by annihilating noises, which is the main peculiarity in this proposed method. As it is noiseless and provides stable operation assisting the elderly and physically challenged people.

The noises reduction can reduce external disturbances in a favourable way, the stability improvement in the system appears due to the gradual momentum developed by the screw mechanism, and linear increase in the motion ensures the stable elevation with a single speed rotation of the worm drive.

The elevation platform for the cabin is a whole unit of the worm drive unit connected with the car frame. The cabin is placed above the car frame taking up a static load nearly about 1 ton with a
dynamic mismatch load around 1.5 ton. Using the guide rails as the pathway for the elevator superstructure, the cabin is guided into the vertical elevation along the elevator superstructure.

An AC induction motor of required horse power is attached behind the cabin and the motor moves vertical along with cabin and car frame during operation. The AC motor is coupled with worm drive for movement along the screw rod which performs in the rated speed and torque.

3. **SOLIDWORKS**

The structural design for the elevator prototype is simulated using SolidWorks 2016, each part has been simulated as a separate unit and then assembled in assembly section.

Each part has a vital operation in the overall mechanism, the function and description for each part has been briefly explained in each section along with simulated figures.

The cabin dimensions were given by technicians from Selens Elevators Pvt. Ltd., and the car frame and screw rod dimensions were assumed for the prototype development.

In Fig. 1 Main drive and screw rod are shown, these are the main structural part which acts as the backbone for the Screw type elevator. This arrangement works based on the principle of the basic travelling of the nut along the screw rod.
Fig. 2 is the moving part of the elevator. In this part the main drive nut is attached with the car frame and the cabin sits on the car frame where the frame holds the cabin structure.

Fig. 3 depicts the guide rail structure which runs along the whole travel length of the elevator system guiding the elevator along its whole path and also thus keeping the cabin within the track. This avoids the vibrations and deviation from the travel path.
Fig.4 shows the front view of the elevator superstructure which has the advantage of the self-locking mechanism during the times of power shortage which acts as a safety feature. The Car frame attached to the Main nut move along the screw rod structure during operation, which is the uniqueness when compared to other conventional elevators. The above shown diagram is the proposed drive system which is the second objective our paper.

4. RESULT
The proposed screw type elevator uses drive nut mechanism eliminating the belt driven mechanism, thereby escaping the belt frictional losses and wear and tear. The dimensions used in the simulation are given below.

| S.NO | ELEVATOR COMPONENTS | SIZINGS OF THE PROPOSED ELEVATOR |
|------|---------------------|----------------------------------|
| 1.   | L-Frame             | B= 2500 * 1400 * 300, ext=1400 * 1400 * 1200, rev cut: dia-600 * 100, dia-550 * 1100 |
| 2.   | Cabin               | LBH=1200 * 1500 * 1500           |
| S.NO | **ELEVATOR COMPONENTS** | **SIZINGS OF THE PROPOSED ELEVATOR** |
|------|--------------------------|-------------------------------------|
|      |                          | B=1000 * 1000,                      |
|      |                          | ext=350 * 600                       |
| 3.   | Screw rod               | W=1520,                             |
|      |                          | P=100,                              |
|      |                          | DISTANCE= 600,                      |
|      |                          | START ANGLE=270                     |
| 4.   | Thread sizing(Screw rod)| D1=350,                             |
|      |                          | D2=550,                             |
|      |                          | D3=650,                             |
|      |                          | H=900                               |
| 5.   | Nut                      | W=1520,                             |
|      |                          | P=100,                              |
|      |                          | DISTANCE= 600,                      |
|      |                          | START ANGLE=270                     |
| 6.   | Thread sizing(Nut)      | W=1520,                             |
|      |                          | P=100,                              |
|      |                          | DISTANCE= 600,                      |
|      |                          | START ANGLE=270                     |

*The dimensions are given in mm.

Where, B-Base, ext-extruded part,
LBH- length*Breadth* Height
W-Width,
P-Pitch,
H-Height,
D1, D2, D3- Diameters

The simulated results clearly show the design geometry explaining the working and necessity of each part used for the design parameters. From this design, real time structural parts of screw type elevators can be designed accordingly to need of the individual conditions.

The geometry used for simulation were designed considering the domestic usage in houses, the design used in this simulation is made with respect to a travel of elevator up to 1 floor.
5. CONCLUSION

Therefore the paper have analyzed the conventional elevator system and mentions the need of screw type elevator system for domestic purpose which is one of the objective of the paper and the other objective is also addressed by presenting the solid works results and fig.1 -4 proves that the proposed system replaces the belt arrangement and thus stands as an unique feature of the proposed system.

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