Analysing the efficient use of solar energy in an automatic vertical rotary car parking system

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Abstract. The objectives of the experimental investigation, to survey existing parking system and select suitable lift mechanism when design components of lift. In the present research, the main concern is to study the efficient use of solar energy in vertical rotary car parking system and choose the optimal car parking with minimal available area. Present design depends on chain and sprocket mechanism for leading the parking prototype and motor for powering the system working with solar photovoltaic (PV). In this work, the prototype is tested and done analysing to promote the parking land at tricky places and convoluted trade places. The possibility of implementing the project inside Iraq is possible, relying on young Iraqi cadres. The model was programmed on a miniature rotary vertical position. The cost of implementing this project in Iraq is the most appropriate cost compared to neighbouring countries. This is in order to ensure the success of the project as a modern style of new technology to serve the citizens and add a civilized touch to the cities.

Keyword: vertical rotary car parking, solar photovoltaic (PV)

Nomenclature

| Letter | Description                        | Unit |
|--------|------------------------------------|------|
| D      | Diameter of sprocket               | m    |
| K      | Number of chain links              |      |
| KS     | Service factor = K1.K2.K3          |      |
| L      | Length of chain                    | m    |
| N      | Speed of rotation of sprocket      | r.p.m|
| n      | Factor of safety                   |      |
| P      | Pitch of the chain                 | m    |
| ri     | Roller seating radius             | m    |
| T      | Number of teeth on sprocket        |      |
The behavior itself. The public come to the market and simply park.

Different types of parking lot. This can get a considerable impact, especially to commercial property. Parking rises with no initiatives, many problems increase particularly to the confined number of parking lot. This can get a considerable impact, especially to commercial property. Parking issues come from the public behavior itself. The public come to the market and simply park their vehicle anywhere and everywhere they like.

Rahul J.Kolekar, S.S.Gawade (2014) [1] analyzed experimentally the critical components and found that automatic car parking system safe for heavy load. Also found that the mechanism of push pull was able to push and pull the heavy weight, rotating mechanism was able to be rotating the heavy car weight and push unit were able to lift vehicle with required velocity and acceleration. The study was investigated a smart parking mechanism, with attainable car- park costs then choose the most favorable car park for the motorist. This work proposed the assortment network to be brought true advantage to drivers and car park operators. The proposed a smart park mechanisms have ability inclusive designing, moving freely and easily, fulfillment control and assortment. Chandni Patelet et al. (2015) [2] developed a minimize working model of an automatic vertical car parking system for 6 – 24 cars within a park area of 32.17 m². A smart park was an integration of conventional parking mechanisms with less area holding by simpler design and multiple smart park mechanisms that is vertical rotary parking. Sawankumar G. Narone et al. (2015) [3] manufactured a model of rotary vertical car - park mechanisms. This mechanisms have been performed to minimize the spared used of land area. Vehicle - park were investigation in this work with different types such as namely multi-stage automating car parking, smart parking mechanism and finally rotating parking system. The present work was aimed to improve a large parking area. Design was used chain and sprocket wheel mechanism for powering parking platform. This prototype was derived by a D.C motor. Manddeep Kaur, et al. (2016) [4] designed and manufactured an experimental vertical car parking prototype. The experimental prototype has been integrated to minimize the space of land which is very important in cities. All manufactured parts in prototype were assembled and tested successfully. Model has been done with the scaling of 1:9 for real size model. The structure can be sheltered 6 cars in the space of two and can even be to concluded a greater number depending upon the requirements of the user.

Pushpender Raman, et al. (2016) [5] develop a minimized of a smart vehicle - park mechanism for parking 6 - 15 vehicles with a park space of 32m². A smart park is a combination of the traditional park mechanism with adding characteristics of minimized area by developed a sampler smart park mechanism with rotating vertically motion in parking space.
The aim of present work is evolve an automatic car parking model for 12 cars within area of 32 m² for vertical car parking. The new develop work is a combination of developed parking systems with new features that reducing the parking space by modest smart rotary vertical parking mechanism.

In the present project, the main concern is to study an automatic car parking system by using PV solar arrangement with selects the optimal car park for suitable costs. The present work is manufacture a prototype modelling of a vertical rotary car - park mechanism with parking 12 cars for a parking area of 32 m². It is developed vertical smart rotary parking systems with feature of minimize parking space by a simpler design. Automatic vertical rotary car parking system is a modern and required in particular in our country. Since the application of this research practically requires a small area of land to park a large number of cars, and using solar energy to operate the system means no pollution.

2. Experimental component required

The smart vertical rotary parking consists of following components which are designed and manufactured with standard form. Pallet, Pallet guide, Main Frame, Main Chain, Elevator rails, Geared machine motor, Entrance Board, Control system, Guide Frame, solar photovoltaic (PV) and Motor. The automatic rotary parking is design and manufactured according to the area available and customer request. The geometry and coordinate system is shown in Figure (1).

![Figure 1. Rotary smart parking [10]](image)

The rotating smart park mechanism consists of two major consists that can be shown in Figure (2).

![Figure 2. Rotating smart car parking system](image)
2.1 Prototype Formation
The real specification which holds from DYPC Company catalogue [10] and represent in Figure (3).

![Figure 3](image)

**Figure 3.** The real specification which holds from DYPC Company catalogue [10]

2.2 Mechanical Sample
2.2.1 Main Frame
This mechanism is used to support the mechanism of pallet and cars with sprocket and chain. Main frame is shown in figure (4) with schematic drawing with all dimensions.

![Figure 4](image)

**Figure 4.** The Schematic of main frame
2.2.2 Pallet
The smart car parking is easily restored by active the button that pertinent number of vehicle that stopping on. This can be caused the desired vehicle to run down to ground and to be prepared for the driver to get the car out of the system. Vertical rotary car - park mechanism is progressing to appoint maximal vertical area in the least floor area. The pallet is shown in figure (5) with all dimensions.

![Figure 5. The Schematic of pallet](image)

2.2.3 Sprockets
Sprocket wheel is a toothed wheel, cogs. Also sprocket wheel can be merging with a chain, path or other toothed substance. The name (sprocket) refers to toothed wheel which radially chained threading over it. It is different from a gear in that sprockets are never merged jointly directly and also varied from a roller in that sprockets have teeth and pulleys are convenient that is presented in fig. (6).

![Figure 6. The Schematic of sprockets (dimension in mm)](image)

2.2.4 Gear wheels
The gear's definition is a toothed wheel which rotator machined parti to change speed or direction. Gears are merging with another toothed machine to transmitted motion. Gears are devices used to move rotational motion, change the speed or direction and torque. Gear is manufactured by using the standard American gear manufacturers association as shown in figure (7).

![Figure 7. Schematic of triangle (dimension in mm)](image)
2.2.5 Ball Bearings
The ball bearing's definition of is a teeny mineral globular which is used for minimizing drags between rotating shafts. There are utilized for reducing the deformation can cause on a moving mechanism and minimizing drags in pivotal assemblies. Manufactured are according to criterions.

2.2.6 Chained drives
Chained is a way of convey mechanical energy from one place to other. As shown in figure (8) with all dimensions it is often used to transmit the power to the wheels in a vehicle and motorcycles. It is also used in many applications of mechanism.

![Figure 8. Schematic of Chained (Dimension in mm)](image)

2.2.7 Roller chain
Roller chain is the simple method for transmission of mechanical energy in many mechanical and chemical applications. This is consisted of a concatenation of cylindrical pulleys connected by linking which is represented in figure (9). It is move by rotating sprocket which is connecting to motor that moves chain.

![Figure 9. Roller of chain](image)
2.2.8 Solar Power System
Photovoltaic cells are used to convert the solar energy (sunlight) into electricity. Solar Power System (SPS) have many advantages such as public, frugal and ecological advantages over pollution and help to reduce carbon emissions that generated. Solar Photovoltaic (PV) systems are presented in figures (10 and 11).
Solar PV system consists of different components. The major ingredients for solar PV system are; solar controller, grid connect inverter, battery banked, auxiliary power sources and safely loading (appliances).

![Figure 10. Solar photovoltaic (PV)](image)

![Figure 11. Solar- photovoltaic (PV) system](image)

3. Experimental Design
3.1 Chain Design
Steel chain is a transmission element that made of as a number of pin links in order to provide flexible and prevent slipping which driven wheel. When power is transport between rotate shafts, the chain
works matting toothed wheels, called sprockets as shown in Figure (12). These jagged trundles are known as wheels. The sprockets and the chained are affected to move together without sliding and ensures perfect rapidity ratio. The chained are mostly used to transfer motion and energy from one shaft to another. The chained are used for speeds up to 25 m / s and powered up to 110 kW. In some situation, higher capacity transition is possible.

![Figure 12. Sprockets and chain](image)

**Terms Used in Chain Drive**

There are many expressions are utilized in chain drive design as following.

1. **Pitch of chain:**
   The term pitched of chained is referred to the distance between the middle position of hinge of a link and the corresponding hinge middle position linked which is presented in Figure (13). It is normally symbolized by \( i_p \).

![Figure 13. Expressions utilized in chained drive](image)

2. **Pitch circle diameter of chained sprocket:**
   It can be definition as the circle diameter, when the chain is wrapped swirl tooth as presented in Figure (13). The pointes \( A, B, C, \) and \( D \) are the middle of hinges of the chain and the circle pictorial
through these centres are named “pitched circle” and it’s diameter \( D \) is called pitched circle diameter.
The height of the available car is 95 mm. The clearance between two available car is 22 mm.
So, the distance between two pallet = 95 + 22 = 117 mm

Pitch of the chain = 58.5 mm

\[
\frac{117}{58.5} = 2
\]

The distance between two pallets will contain two links

The number of links of the chain will be 12 (number of pallet) *2 = 24 links \[9\]

\[
L = K \times P
\]

\[1\]

Where:

\( L \) : longitude of series
\( K \) : Number of chain links = 24
\( P \) : Pitch of the chain = 58.5 m

\( L = 24 \times 58.5 = 1404\text{mm} \)

3. Centre distance of chain

An open chain drive system connecting the two sprockets is shown in Figure (14).

![Figure 14. Chain drive system connecting the two sprockets](image)

The amount of \((Ki)\) as gained from the above term must to be approximated to the close to number becomes even.
The centre mileage is presented as \[9\]:

\[
X_i = \frac{P}{4} \left[ k - \frac{T_i + T_2}{2} + \sqrt{\left( k - \frac{T_i + T_2}{2} \right)^2 - 8 \left( \frac{T_2 - T_1}{2\pi} \right)^2} \right] \quad \text{........ 2}
\]

\( T_1 \) = Teeth number on the smaller sprocket,
\( T_2 \) = Teeth number on the larger sprocket,
\( p \) = Pitch of the chain, and
\( x \) = centre distance.
\( K \) = Chain number of links
\[ X = \frac{58.5}{4} \left[ 24 - \frac{6 + 6}{2} + \sqrt{\left(24 - \frac{6 + 6}{2}\right)^2 - 8\left(\frac{6 - 6}{2}\right)^2} \right] \]  

\[ X = 526.5\text{mm} \]

**4. Power transmitted by chain:**

The power transfer by the series on the bases of breaking cargo is presented as equation [9]:

\[ P = \frac{W_b \times v}{n \times K_s} \quad \text{(in watts)} \quad \text{[9]} \]

Where:  
- \( W_b \) = Breaking load in newton,
- \( v \) = Serving speed in m/s
- \( n \) = Safety factor
- \( K_s \) = Serving factor = \( K_1 \times K_2 \times K_3 \)

From table 1 at pitch = 58.5 mm  
\[ W_b = 451.31 \text{ KN (Duplex chain)} \]

\[ V = \frac{TPN}{60} \quad \text{[9]} \]

Where:  
- \( T \) = No. of teeth on wheel
- \( P \) = Pitched chain in meter
- \( N \) = Rotation speed wheel in r.p.m

\[ V = \frac{6 \times 58.5 \times 10^{-3} \times 0.6}{60} = 3.51 \times 10^{-3} \text{ m/s} \]

Safety factor (\( n \)) = 1

The values of factors are taken as follows below [9]:

1. Loaded factor (\( K_1 \)) = 1.0  
   - for constant load  
   - = 1.25 for variable load with mild shook  
   - = 1.5 for heavy loads

2. Lubrications factored (\( K_2 \)) = 0.8  
   - for continues lubrication  
   - = 1.0 for droplet lubrication  
   - = 1.5 for periodic lubrication

3. Rating factored (\( K_3 \)) = 1.0  
   - for 8 hours’ day  
   - = 1.25 for 16 hours’ day  
   - = 1.5 for continues eservice

\[ K_s = 1 \times 1.5 \times 1 = 1.5 \]

\[ \therefore Power = \frac{451.31 \times 10^3 \times 3.51 \times 10^{-3}}{1 \times 1.5} = 1056.06 \text{ Watt} \]

3.2 **sprockets Design**

The criterion profiles for wheel teeth are shown in Figure (15). The criterion profiles are according to Indian criterion (IS: 2403 – 1991). The criterion dimensions of the tooth profile are as follows:
3.2.1. Pitch Circle of diameter (D)

\[ D = \frac{P}{\sin\left(\frac{180}{T}\right)} \] \hspace{1cm} \text{[9]} \hspace{1cm} \text{.......................... 5} \\

Where \ P = \text{Pitch of the chain} = 58.5 \text{ mm} \\
D = \text{Diameter of sprocket} \\
T = \text{Number of sprocket teeth} = 6 \text{ (Standard)}

\[ 58.5 = D \times \sin\left(\frac{180}{6}\right) \Rightarrow D = 117 \text{ mm} \]

3.2.2. Top diameter (Da)

\[ D_a = D + 1.25P - d_1 \] \hspace{1cm} \text{.......................... 6} \\

\[ D_a = 117 + 1.25 \times 58.5 - 10 \]

\[ D_a = 180.125 \text{ mm} \]

For Minimum [9]

\[ D_a = D + P\left(1 - \frac{1.6}{T}\right) - d_1 \] \hspace{1cm} \text{.......................... 7} \\

\[ D_a = 117 + 58.5\left(1 - \frac{1.6}{6}\right) - 10 \]

\[ D_a = 149.9 \text{ mm} \]

Take average \ Da= 150 \text{ mm}

3.2.3. Root diameter (Df)

\[ D_f = D - 2r_i \] \hspace{1cm} \text{[9]} \hspace{1cm} \text{.......................... 8} \\

Where \ D = \text{Pitch circle diameter} \\
r_i = \text{Roller seating radius}
For Maximum [9]
\[ r_i = 0.505 d_i \] ………………………. 9
\[ r_i = 0.505 \times 10 \]
\[ r_i = 5.05\text{mm} \]

For Minimum [9]
\[ r_i = 0.505 d_i + 0.069\sqrt[3]{d_i} \] ………………………. 10
\[ r_i = 0.505 \times 10 + 0.069\sqrt[3]{10} \]
\[ r_i = 5.198\text{mm} \]

Take average \( ri = 5.1\text{mm} \)
\[ \therefore D_f = D - 2r_i \]
\[ \therefore D_f = 117 - 2 \times 5.1 \]
\[ \therefore D_f = 106.8\text{mm} \]

4. Results and discussion
As market requirement, the car park has been designed with utilizing solar energy. In this work the vertical rotary car park by utilizing solar energy is designed and all parts it have been manufactured with available in Iraqi market and assembled. Then mechanical prototype analysis has been done for prototype with scale size for actual model. Finally the control software has been performed successfully. Figure (16) demonstrates the finally planned smart vertical parking system. According to the capability of organization and the area available for parking, so the size and number of pan technicians can be determined.
4.1 Results of system description and operation
A dissimilar - frequency is a apparatus that exercised in a mechanical system. This device consisted of three sub- regulation; AC motored, variable controller and operator, as presented in figure (17).

4.2 Implementation of the project inside Iraq
Intelligent parking is one of the most successful service and civilization projects in the world. It is an effective experience in many countries such as America, Russia, Japan, China, Greece, Britain, Iran, Jordan, Qatar, Gulf States and Iraq.
This project was implemented in Iraq in 2016 with a capacity of 12 sedans, providing programming to control the intelligent situation relying on young Iraqi cadres. The programmed model was tested on a miniature rotary vertical position as presented in figure (18).

Figure 18. handles the human–machine interaction

5. Conclusion
Several conclusions can be drawn from this study:

1. Automatic Parking quickly and recuperation of vehicles.
2. Vehicles Up to seven can be facilely and significantly parked.
3. Minimum space area required.
4. For staff or consecrated user parking.
5. Low noise and vibration.
6. The conservation is low cost that required by the system.
7. Readily structured in a small area, just demanding simple concrete base and triple phase electricity.

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