# Web Centric Design for Smart Gate Systems

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***Abstract— This project introduces an innovative design approach aimed at streamlining the design process and reducing the time required for multiple iterations. It involves the implementation of a web-based application integrated with smart gate technology to enhance security measures and offer convenient control over gate access. The focal point of the mechanical design is the rack and pinion system, a crucial element in transforming both existing manual rolling gates and new smart gates controlled by an electric motor. The web application processes all relevant data and delivers the necessary power for automation, facilitating a seamless system. In-depth case studies have been conducted to calculate the power requirements for the electric motor, a pivotal component in the conversion of manual gate systems to smart ones. The results obtained are highly satisfactory and align well with the objectives of the project.***

## I. INTRODUCTION

The project at hand aims to modernize the process of converting traditional gates into smart gates by simplifying complex design calculations. Through a web-centric approach, a user-friendly interface is being developed using HTML, Bootstrap, and JavaScript. Users input gate specifications, and the interface swiftly computes design requirements for safety and functionality.

Beyond modification, custom gate systems are designed in CATIA V5 to meet specific needs, with output specifications seamlessly integrated with the interface. Real-world validation involves practical case studies, enhancing efficiency and innovation in gate system engineering.

By combining technological innovation with practical applicability, this project promises to revolutionize gate system design, ensuring enhanced functionality, safety, and customer satisfaction.

## II. LITERATURE SURVEY

Rahul Semil's research paper explores essential coding languages and software methods in web development, emphasizing HTML, CSS, and JS for a self-designed website. The work highlights CSS3's modular layout, enhancing style separation and supporting various browser functionalities.

Nina Setiyawati, Hindriyanto Dwi Purnomo, and Evangs Mailoa present a study on enhancing agricultural productivity through a mobile-based interface, prioritizing User-Centered Design for a positive user experience among horticultural farmers.
Z Sofyan, Zulkifli, and Bustami propose a participatory web-based Geographic Information System, utilizing User-Centered Design methods, to identify crucial features for enhancing usability in spatial-based planning and government agency coordination in Banda Aceh Municipality.

Patwardhan and Nimbalkar present a methodology for customizing solid modeling tasks using CATIA V5 for a two-stage spur gearbox. Utilizing macros and GUI forms, users input basic requirements, and the system calculates parameters, generating the gearbox part model.

Dr. M. Raja Roy and S. Swarna Bala present a project aiming to enhance student attendance and academic performance tracking through a responsive mobile-compatible web app. Automation minimizes errors, and the system manages exam marks, improving overall administration efficiency. This paper gives clear idea about user interface development and enhancing UI with bootstrap.
Shubham Torvi, Vaishnavi Ingale, and Rajkumar E study rack and pinion mechanisms in automobiles and presses, using structural steel and eco-friendly PLA. Employing Solidworks and ANSYS, they validate

findings through 3D-printed PLA prototypes, highlighting additive manufacturing's potential for intricate, cost-efficient, high-strength components.

Gibson and Kramer use the complex number method to analyze a rack-and-gear mechanism, emphasizing its versatility in generating various functions. Utilizing the PDP 11/70 system, their study offers valuable insights into planar mechanisms.

## III. DESIGN PROCEDURE

### *3.1 WEIGHT CALCULATIONS FOR GATE*

METHOD 1:

*Design Specifications:*

- Travel Distance: Defines the overall size of the gate, influencing its structural design.
- Travel time: The duration it takes for the gate to travel its specified distance.
- Volume: Could be relevant for understanding travel distance and potential load variations.
- Density: Influences the weight of the gate structure, impacting its material selection and load-bearing capacity.

$$\rho = \frac{m}{V}$$

*Design outcomes:*

- Velocity: The speed at which the gate moves.

Velocity = travel distance/ travel time

$$v = \frac{L}{t}$$

- Weight: The force exerted by the gate due to gravity.

Weight = mass ×acceleration due to gravity

Weight= $\rho_g V$

METHOD 2:

- This method provides a practical and hands-on approach to understand the force requirements for operating a sliding gate. Keep in mind that the actual force needed during operation might vary based on factors such as gate size, materials, and environmental conditions.
- The obtained weight or force measurement can then be considered in the design and engineering of the sliding gate system. It influences the selection of components such as motors, rack and pinion mechanisms needed to facilitate the smooth operation of the gate.
- Hand weighing machine used for finding force required to move the gate is shown in figure 1.


Figure 1. Hand weighing machine

METHOD 3:

*3D Modelling*: The smart gate design process involves customized 3D modeling, ensuring precise dimensions and aiding material selection. Volume calculation guides material choice for optimal strength and cost-effectiveness. A holistic cost analysis, covering material and motor expenses, ensures a tailored and budget-friendly smart gate solution that aligns with technical requirements.

Figure 2. 3D Gate modelling

A 3D modelling of gate is shown in figure 2.

### *3.2 RACK AND PINION CALCULATIONS*

*Design Specifications*:

- Number of Teeth(T): The count of teeth on the pinion or the rack.
- Module(m): The size of the gear teeth, determining the gear's dimensions.
- Ultimate tensile strength ($S_{ut}$): is a material property that represents the maximum stress a

material can withstand while being stretched or pulled before necking.

- Face Width(b): The width of the gear tooth along its face.
- Factor of Safety: A safety margin applied to the design for unforeseen loads or stress.
- Service Factor($C_s$): A factor accounting for the service conditions and environment.

*Design Procedure:*

- Pitch circle diameter (d): The diameter of the theoretical circle that passes through the center of the gear teeth.

$$d = mT$$

- Pinion speed (N) : The rotational speed of the pinion gear.

$$v = \frac{\pi DN}{60}$$

$$N = \frac{60v}{\pi D}$$

- Lewis Form Factor: A factor considering the shape and strength of the gear tooth.

$$y = 0.154 - \frac{0.918}{T}$$

- Bending stress: ultimate tensile strength /3

$$\sigma_b = \frac{S_{ut}}{3}$$

- Beam Strength: The ability of the gear tooth to withstand bending stresses.

$$S_b = mb\sigma_b y$$

- Velocity Factor: A factor considering the velocity of the gears in motion.

$$C_v = \frac{3}{3 + v}$$

- Tangential Component: The force acting along the tangential direction.

$$S_b = fos \times \frac{C_s}{C_v} \times P_t$$

$$P_t = \frac{C_v \times S_b}{C_s \times fos}$$

- Power: The amount of energy required for the gate system's operation.

$$T = P_t \times \frac{D}{2}$$

$$P = \frac{2\pi NT}{60 \times 10^3}$$

## IV. WEBCENTRIC APPROACH INTERFACE

The web interface for designing smart gate systems is crafted using a combination of HTML, Bootstrap, and JavaScript. Each technology plays a specific role in creating an interactive, user-friendly, and aesthetically pleasing experience for users engaged in the design calculations for smart gate systems.

HTML (Hyper Text Markup Language): HTML forms the backbone of the web interface by providing the structural foundation of the page. It defines the layout, structure, and essential elements such as input fields, buttons, and text areas. In the context of smart gate systems, HTML is likely used to create forms where users can input various design parameters, including gate dimensions, travel distance, volume, density, and rack and pinion data.

Bootstrap: Bootstrap, a popular front-end framework, contributes to the overall design aesthetics and responsiveness of the web interface. It provides a set of pre-designed components and styles, ensuring a consistent look and feel across different devices and screen sizes. The responsive grid system, styling for forms, buttons, and navigation elements from Bootstrap enhance the user interface, making it visually appealing and accessible.

JavaScript: JavaScript is employed to add dynamic behavior to the web interface. It enables real-time interactions and calculations based on user inputs, creating a more engaging and efficient user experience. For the smart gate system, JavaScript likely handles form validation, triggers design calculations, and updates the content on the page dynamically. It may also be responsible for animating elements, handling user events, and facilitating communication with the server for more complex tasks.

User Input and Design Calculations: The web interface allows users to input essential parameters for smart gate system design, such as gate dimensions, travel distance, volume, density, and rack and pinion data. JavaScript takes these inputs, performs design calculations, and provides real-time feedback. This may include calculating velocity, weight, pitch circle diameter, pinion speed, Lewis form factor, beam strength, and other relevant design parameters.

Responsive Design: The use of Bootstrap ensures that the web interface is responsive, adapting seamlessly to different screen sizes and devices. This responsiveness enhances accessibility and usability, allowing users to engage with the design calculations on various platforms.

In summary, the integration of HTML, Bootstrap, and JavaScript results in a powerful web interface for smart gate system design. Users can input parameters, receive immediate feedback, and visualize the impact of their design choices in real-time. This approach combines functionality, aesthetics, and responsiveness to create an effective tool for designing and optimizing smart gate systems.

ALGORITHM:

1. Start
2. Read
d, t, Wg, T, m, $S_{ut}$, b, fos, $C_v$
3. v = d/ t
4. D = m×T
5. N = $\frac{60v}{\pi D}$
6. y = $0.154 - \frac{0.918}{T}$
7. $\sigma_b = \frac{S_{ut}}{3}$
8. $S_b = mb\sigma_b \pi y$
9. $C_v = \frac{3}{3+v}$
10. $P_t = \frac{C_v \times S_b}{C_b \times fos}$
11. P = $\frac{\pi N P_t D}{60\times10^3}$
12. If $P_t$ < Wg, print design is not safe
13. If $P_t$ > Wg, print design is safe, $P_t$ and P
14. Stop

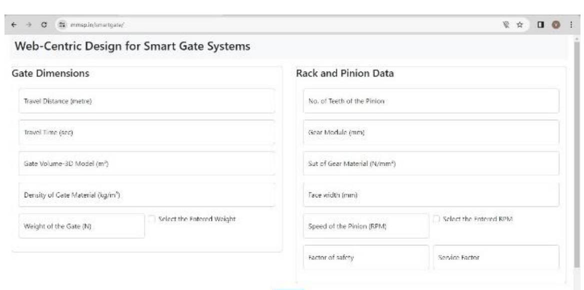
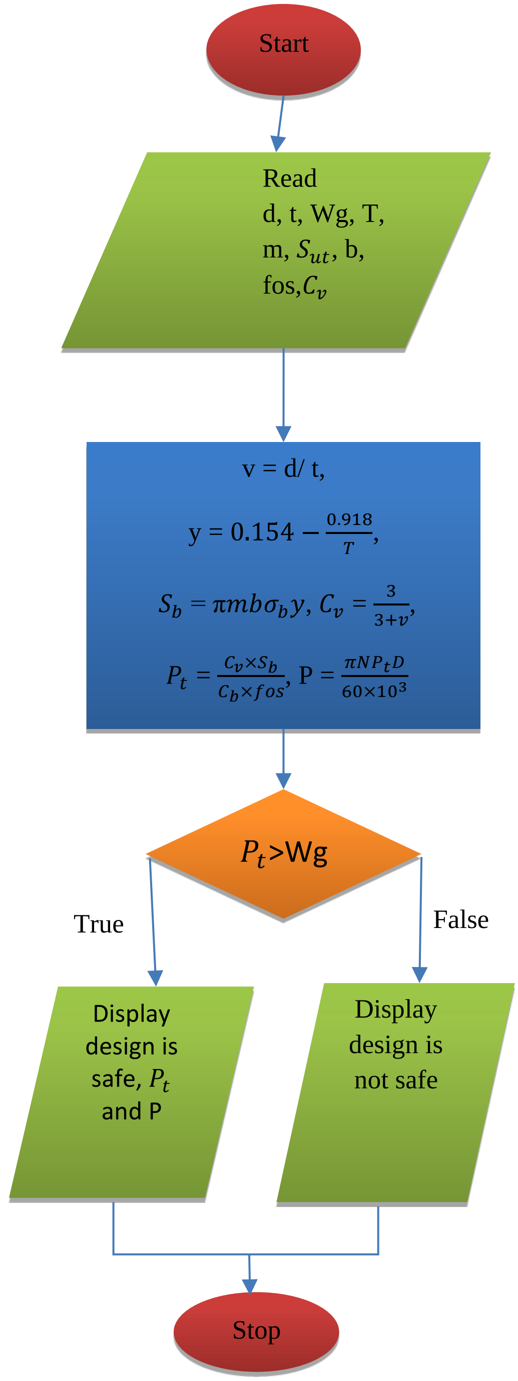



Figure 3. Web interface

Figure 3 shows web interface

FLOWCHART




## V. RESULT AND DISCUSSIONS

Case studies are carried out

CASE STUDY 1:

*Sample calculations:*

RAPID MODE:

*Design specificatios:*

- Travel distance = 4.25 m
- Travel time= 10 seconds
- Weight (or) force required to pull the gate = 120 N
- Number of teeth = 50
- Gear module = 1 mm
- Sut for gear material = 300 $N/mm^2$
- Face width = 15 mm
- Factor of safety = 2
- Service factor = 2

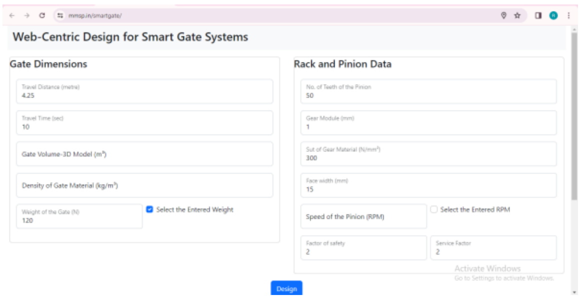



Figure 4. case study 1- Rapid mode

Results:

- Velocity = $\frac{travel\ distance}{travel\ time} = \frac{4.25}{10} = 0.425$ m/s
- Pitch circle diameter of pinion = m × T = 1 × 50 = 50 mm
- Pinion speed(N): $v = \frac{\pi DN}{60}$ $N = \frac{60v}{\pi D} = \frac{60 \times 0.425}{50\pi}$ = 160rpm
- Lewis form factor : $y = 0.154 - \frac{0.918}{T} = 0.154 - \frac{0.918}{50} = 0.14$
- Bending stress : $\sigma_b = \frac{S_{ut}}{3} = \frac{300}{3} = 100\ N/mm^2$
- Beam strength $S_b = mb\sigma_b y = 1 \times 15 \times 100 \times 0.14$ = 659.74 N
- Velocity factor $C_v = \frac{3}{3+v} = \frac{3}{3+0.425} = 0.8772$
- Tangential component $(P_t)$ :

$$S_b = fos \times \frac{C_s}{C_v} \times P_t$$

$$P_t = \frac{C_v \times S_b}{C_s \times fos} = \frac{0.8772 \times 659.74}{2 \times 2} = 144.68\ N$$

- Torque (T) = $P_t \times \frac{D}{2} = 144.68 \times \frac{50}{2} = 3617$ N mm
- Power $P = \frac{2\pi NT}{60 \times 10^3} = \frac{2\pi \times 160 \times 3617}{60 \times 10^3} = 60.6036$ W


Figure 5. Case study 1-Rapid mode

Tangential Component of gear teeth force (Pt = 145N) > Gate weight (Wg=120N). Hence Design is safe and power required at 160RPM to implement smart gating system is 60W.

Web centric approach for case-1 rapid mode is shown in figure 4 and figure 5.

MEDIUM MODE:

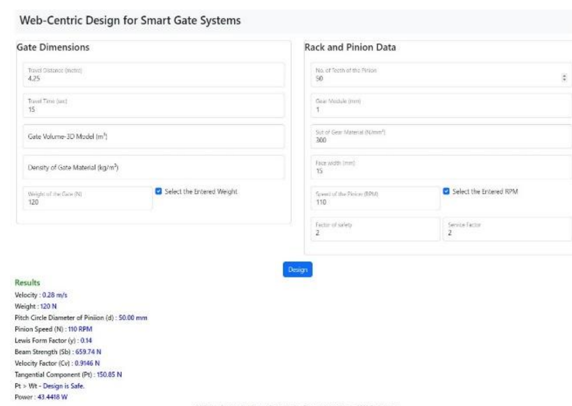



Figure 6. Case study 1- Medium mode

Tangential Component of gear teeth force (Pt = 151N) > Gate weight (Wg=120N). Hence Design is safe and power required at 110RPM to implement smart gating system is 44W.

Web centric approach for case-1 medium mode is shown in figure 6.

ECONOMICAL MODE:

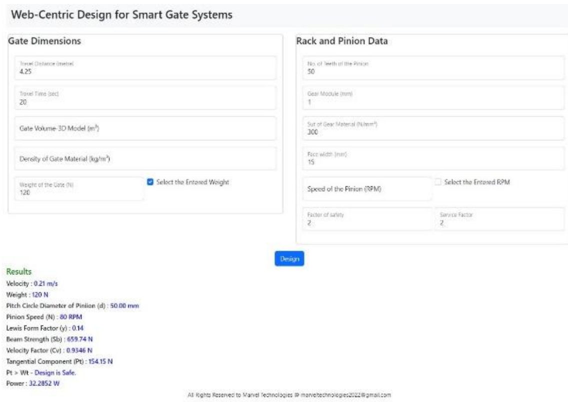



Figure 7. Case study 1- Economical mode

Figure 8. Case study 1

Tangential Component of gear teeth force (Pt = 155N) > Gate weight (Wg=120N). Hence Design is safe and power required at 80RPM to implement smart gating system is 33W.

Web centric approach for case-1 economical mode is shown in figure 7 and figure 8.

Figure9. Case study 2

## CONCLUSION

- Web centric design is successfully developed using html, bootstrap and java script. Web-app is deployed in the web server with the following URL https://mmsp.in/smartgate/
- This system can be implemented for new gating systems by creating the 3D model for weight calculation.
- Four case studies were carried out with the existing gating systems to test the software interface to design rack and pinion mechanism and power requirement of motor. Results obtained are good in agreement with theoretical results.

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