

# DEVELOPMENT OF A NOVEL BOWLING MACHINE FOR IMPROVED TRAINING PERFORMANCE

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**Abstract-** This study revolves around designing, simulating, and creating an inventive cricket bowling machine to enrich training sessions by mimicking various bowling styles. The machine introduces a unique ball-propelling mechanism capable of handling six balls simultaneously, delivering them accurately with a time delay of 10 seconds. A sophisticated mechanical gear system is devised and integrated into the machine, ensuring smooth operation. The base of the machine is supported by a portable fan stand, facilitating the prototype's development. The innovative ball-propelling mechanism enhances stability in pitch positioning, ball rotation axis, and speed control, providing batsmen with a controlled practice environment. Extensive test trials have been conducted to validate the machine's ability to replicate different ball deliveries, including spin and fast deliveries, showcasing its practical application for training purposes.

**Keywords:** Cricket bowling machine, Ball-propelling mechanism, Prototype development.

## 1. INTRODUCTION

Cricket holds an unparalleled status in India, transcending beyond just a sport to become a cultural phenomenon. Its popularity is deeply ingrained in the fabric of Indian society, influencing lifestyles, conversations, and aspirations. Several factors contribute to cricket's immense following in India:

India's history with cricket dates to the colonial era, and the sport has since evolved into a national obsession. Iconic moments, such as India's 1983 World Cup victory and various achievements in international cricket, have cemented the game's place in the hearts of millions. Indian cricketers are treated as demigods, with a fan following that rivals that of Bollywood stars. Players like Sachin Tendulkar, Virat Kohli, and MS Dhoni are not just athletes but also cultural icons who inspire millions. The media plays a significant role in promoting cricket, with extensive coverage in newspapers, television, and digital platforms. Cricket matches, especially those involving the Indian cricket team, are major entertainment events that draw massive viewership. Cricket is seen as a unifying force in India, transcending regional, linguistic, and cultural barriers. The sport has the power to bring together people from diverse backgrounds to rally behind the national team. The Indian Premier League (IPL), launched in 2008, revolutionized cricket by blending sports with entertainment. The league's success has not only popularized the sport but also led to significant investments in cricket infrastructure and grassroots development. Cricket is more than just a game in India; it evokes deep emotions and passions. Victories are celebrated as national triumphs, while defeats are mourned collectively.

Cricket features various types of bowling techniques that challenge batsmen. These bowling styles include fast bowling, spin bowling, and variations like swing and seam bowling. Each technique requires specific skills and strategies, making them crucial aspects of the game.

Fast bowling in cricket demands a bowler to sprint and deliver the ball at high speeds. Research [1] on ball release speed and technique impact has been inconclusive, leading to the use of computer simulations for clarity. This study evaluates a 16-segment whole-body torque-driven simulation model of fast bowling's front foot contact phase. Personalized for an elite bowler, adjustments to inertia and torque parameters resulted in a 4.0% RMS difference between actual and simulated performances. Further optimization enhanced ball release speed by 3.5 m/s, achieved through adjustments in joint angles, trunk flexion, and arm movement timing. This suggests the model's realistic representation can aid in performance enhancement through biomechanical adjustments. The role of the bowling arm in cricket fast bowling technique is crucial, and it is widely recognized that higher ball release speeds are associated with a delayed arm circumduction. This means that the timing and movement of the bowling arm play a significant role in the speed at which the ball is delivered. Bowlers often focus on optimizing their arm movements to achieve maximum speed and accuracy. Research [2] and coaching techniques emphasize the importance of a smooth and controlled bowling arm action, as it not only affects the speed of the ball but also its trajectory and potential for swing or spin. Understanding and mastering the mechanics of the bowling arm are key components of a fast bowler's skill set, and continuous practice and refinement are essential for improving performance. This study [3] aimed to pinpoint the key technical elements distinguishing the fastest bowlers. Kinematic data from 20 elite male fast bowlers were analysed, focusing on 11 parameters associated with ball release speed. Four technique variables emerged as the strongest predictors of ball release speed, explaining 74% of the speed variation. Faster bowlers exhibited a quicker run-up, maintained a straighter knee during front foot contact, displayed greater upper trunk flexion, and delayed arm circumduction. These findings offer insights into the technical nuances that differentiate fast bowlers and are valuable for coaching and talent identification in cricket. Fast bowling in cricket aims for high ball release speeds, giving batsmen less time to react. This study analysed the delivery stride of 17 elite bowlers (8

international) filmed at 200 frames per second during country championship competition. Seven bowlers were classified as fast (ball release over 36 m/s), the rest as fast-medium. The research found a weak correlation between run-up speed and ball release speed. The kinematic pattern of joint centre speeds was consistent, increasing sequentially from proximal to distal joints nearing ball release. Strong correlations were observed [4] between adjacent joint centre speeds, except for the shoulder and elbow/wrist, suggesting the bowling arm's relative independence in the kinetic chain. Bowlers who flexed their knee after front foot contact released the ball significantly faster than those who did not. Research in fast bowling has often focused on individuals capable of high delivery speeds. Elite bowlers classified as "fast" can deliver the ball over 40.5 m/s (>145.8 km/h). However, finding and accessing such performers is challenging. Limited access to skilled participants meeting these speed criteria restricts the data quality and wider applicability of results. Only three studies have included first-class/professional cricketers, reporting speeds of 34.2–35.3 m/s (123–127 km/h). Other studies often use lower-standard or less-skilled cricketers, resulting in lower delivery speeds (104.8–115.6 km/h) and non-first-class physiological performance data. Participant numbers in these studies are typically low ( $n < 10$ ), except for one study [5] ( $n = 15$ ). These challenges extend beyond cricket, potentially limiting the usefulness of research for conditioning specialists at the elite level. The aerodynamics of a cricket ball have fascinated players and spectators for years. Understanding the curved flight path, known as swing, has been a key focus. While the basic principles behind this phenomenon have been known for some time, empirical investigations over the past 25 years have shed light on the factors influencing swing, including late swing and the impact of humidity. The concept of reverse swing, its practical achievement, and its connection to ball tampering are also discussed [6]. Some bowlers can manipulate an old ball to swing conventionally, in reverse, and in a contrasting mode. The discussion also touches on the white cricket ball used in the 1999 and 2003 World Cup tournaments, which reportedly behaves differently from the conventional red ball. This overview aims to provide scientific insights into the aerodynamics of cricket ball swing. Aerodynamics significantly influences the flight of a cricket ball when bowled. The ball's ability to curve unpredictably, known as "swing," is of particular interest. The principles governing this nonlinear flight have been studied for years, leading to numerous publications. Recent experimental investigations [7] have focused on swing, revealing its magnitude, and influencing factors. These studies highlight late swing and the impact of weather conditions. The concept of "reverse" swing, achieved through ball tampering, is also discussed. Furthermore, the unique characteristics of the white cricket ball, used in the recent World Cup and reputedly differing in swing properties from the traditional red ball, are examined. Aerodynamics thus plays a crucial role in cricket, affecting the ball's trajectory and challenging the bowler's control. A smart cricket ball, equipped with three high-speed MEMS gyroscopes, measured key parameters in off-spin bowling. Bowlers achieved an average spin rate of 22.7 rps and generated 0.28 N·m of finger torque. The spin-axis vector diagram clearly showed the arm motion and closely followed the bowler's forearm orientation. The finger force's centre of pressure (COP) was found between the ring and middle fingers. This study [8] identified crucial performance parameters for off-spin bowling, including spin rate, spin axis position relative to the seam plane, applied torque, arm velocity, finger COP, and impact point on the ball. These parameters offer a quantitative assessment of off-spin bowling performance. Spin bowling coaching traditionally follows a standard framework without comparative biomechanical analysis between leg-spin and off-spin techniques. This study [9] used a Cortex motion analysis system to analyze 3D kinematics of 23 off-spin and 20 leg-spin bowlers, revealing differences in their techniques. A multivariate ANOVA confirmed some coaching literature differences: off-spinners had shorter stride lengths ( $p = 0.006$ ), lower spin rates ( $p = 0.001$ ), but higher release heights ( $p = 0.007$ ) than leg-spinners. Unique kinematic differences included greater rear knee flexion ( $p = 0.007$ ), faster approach speeds ( $p < 0.001$ ), and flexing elbow actions during arm acceleration, contrasting with leg-spinners. These findings suggest distinct coaching models are needed for off-spin and leg-spin techniques. Bowling delivery is crucial in cricket, with batsmen deciphering bowler actions to predict deliveries and avoid misjudgements. While studies explore biomechanics and kinematics of deliveries, little is known about the constituent factors, bowling mechanisms, and subtle release variations' impacts. This research [10] delves into how bowlers' control and vary deliveries, analysing performance data from the 2005 England-Australia Ashes second test. Two bowlers' six-over spells were scrutinized for variability within each over, aiming to quantify delivery mechanics. This study sheds light on the intricacies of bowling, enhancing our understanding of bowlers' delivery control and variation.

Developing cricket bowling machines has become essential for several reasons. Firstly, it allows batsmen to practice against different bowling styles and speeds, enhancing their ability to face diverse bowlers. Secondly, it provides consistent and accurate deliveries, enabling players to refine their batting skills effectively. Additionally, bowling machines reduce the reliance on human bowlers, allowing for more structured and focused training sessions. The use of bowling machines for cricket training, whether indoors or outdoors, has significantly increased. These machines allow batsmen to practice for extended periods without tiring bowlers. Typically derived from machines used in other sports like tennis, cricket bowling machines have often lacked crucial visual information, such as a simulated arm and hand. A novel cricket bowling machine [11] with an arm and hand was developed and tested for usability, functionality, repeatability, and accuracy. The machine, originally designed by Dr. Kelvin Loutan Jr at The University of Trinidad and Tobago in 2016, was further refined and validated using Pitch Vision hardware and software. The machine demonstrated the ability to

consistently bowl at medium-fast speeds between 120 km/h (75 mph) and 130 km/h (81 mph) with various lengths and speeds, providing valuable training for batsmen. This paper [12] outlines a methodology used in the design of anthropomorphic hands with multiple fingers, focusing on analyzing the biomechanical characteristics of the human hand. Ergonomic and anthropometric principles were employed as fundamental references for developing grasping mechanisms. A kinematic analysis was proposed to define the requirements for designing these functions, along with a discussion on the selection of materials and actuators. The methodology draws from previous experiences with prototypes developed at the Laboratory of Robotics and Mechatronics (LARM) of the University of Cassino. An application of this methodology is demonstrated through the design of initial prototype of the LARM Hand.

Innovative design and development of cricket bowling machines are crucial to enhance the training experience for players and to keep up with the evolving demands of the sport. The paper discusses the innovative design and development of a cricket bowling machine. The machine is designed to simulate real bowling actions, offering customization options for speed, trajectory and spin.

## 2. AUTOMATIC BOWLING MACHINE TECHNOLOGY

Automatic bowling machines come in various types, each offering unique features and functionalities to enhance cricket practice sessions. One popular type is the programmable bowling machine, which allows users to set specific bowling parameters such as speed, line, length, and swing. These machines are ideal for practicing against a variety of deliveries and can simulate game-like scenarios. Another type is the remote-controlled bowling machine, which enables the coach or user to control the machine's operation from a distance. This type of machine is useful for adjusting settings on the fly and providing a more interactive training experience. Some automatic bowling machines are designed to be portable and lightweight, making them easy to transport and set up. These machines are suitable for use in indoor facilities or smaller outdoor spaces.

### 2.1 BOLA Cricket Bowling Machine

Equipped with a state-of-the-art brushless motor, the Machine delivers greater efficiency, reliability, and a longer working life compared to its predecessors. This motor also contributes to its lighter weight, better build quality, and improved control response. The machine features concave profile molded urethane ball delivery wheels, enabling adjustable speeds in 1 mph increments between 15 and 95 mph (24 and 152 kph). It also offers 19 settings for spin and swing, allowing for a variety of bowling styles. Additionally, the machine includes an electronic random variation facility with solid-state electronic wheel braking, ensuring precision in line and length. It can be operated using a 12-volt battery or with an optional BOLA Power Supply from 230v mains (or 110v if specified). The 2023 Professional Bowling Machine is designed to elevate your cricket practice sessions to a new level of performance and convenience.

### 2.2 JUGS Cricket Bowling Machine

The set includes three robust 41" steel hollow inner legs, which can be used independently to deliver balls at a standard JUGS Curveball height for baseball. Additionally, it contains three sturdy 47" steel hollow outer legs, six 3/8" lock washers, three 3/8" x 2 1/4" hex bolts, three 3/8"-16 hex nuts, three 3/8"-16 x 3/4" hex flange bolts, and three crutch tips for indoor use. Key features of the set include three height adjustments for different levels of play, a retractable design for easy transportation, and dual bolts for a safe and sturdy leg base. This set is designed to provide durability and versatility, making it ideal for baseball training sessions.

### 2.3 Heater Sports Cricket Bowling Machine

The Straight, In-Swing & Out-Swing Lite-Ball Cricket Bowling Machine offers versatility with a simple twist of a knob, allowing the slider to bowl straight, in-swing, and out-swing deliveries. Additionally, the machine features adjustable tripod legs, enabling anglings for fielding training. It is compatible with Slider & PowerAlley Lite balls, with a speed knob that adjusts pitches from 10-80 MPH, depending on the ball used. The machine's durable plastic housing covers its rotating wheel, ensuring safety for users of all ages. For convenience, the machine includes an automatic 12-ball feeder, powered by A/C, which drops a ball into the machine every 8 seconds, eliminating the need for manual feeding. Moreover, the Slider can connect to Heater Sports batting cages, allowing for a complete home bowling system in your yard. Look for any Heater Sports batting cage for easy connection to the Slider's Easy Connect Housing.

## 3. FABRICATION OF AUTOMATIC BOWLING MACHINE

The assembly of an automatic bowling machine is a meticulous process that requires attention to detail and adherence to specific steps. The process begins with the assembly of the base frame, which provides stability and support for the machine. The frame components are connected using bolts, nuts, and tools. It is crucial to ensure that the frame is level and securely fastened to prevent wobbling during operation. Next, the delivery mechanism, responsible for propelling cricket balls, is installed. The ball hopper stores multiple cricket balls and supplies them to the feeder system, ensuring a continuous supply of balls during practice sessions. Bowling machines need a power source to function, which can be electricity, battery power, or a combination of both, depending on the design and portability requirements. This involves attaching the motor or power source to the

frame, ensuring proper alignment and secures mounting. The delivery mechanism components are connected and tested to ensure smooth operation and any necessary adjustments are made. Adjustable settings and controls, such as speed, spin, trajectory, and line adjustment mechanisms, are installed. Control panels, switches and displays are mounted in convenient locations on the machine for easy access by users. Wiring and cables are connected to integrate the controls with the delivery mechanism and power source. Safety features are integrated into the assembly, including guards, sensors, emergency stop buttons, and warning indicators. These safety mechanisms are essential to minimize the risk of injury to users during operation. If the machine has a remote-control functionality, the remote is programmed and synced with the machine accordingly. The remote control is tested to verify that it can operate the machine effectively from a distance. The pitch or trajectory of the deliveries can often be adjusted to simulate different bowling styles and lengths, allowing players to practice against a wide range of deliveries. Before finalizing the assembly, thorough testing and calibration of the machine are conducted to ensure proper functionality and performance. Various settings and adjustments are tested to verify that the machine can deliver cricket balls accurately and consistently. Any necessary adjustments or fine-tuning are made to optimize performance based on test results. A final inspection of the assembled machine is conducted to check for any defects, loose connections, or missing components.

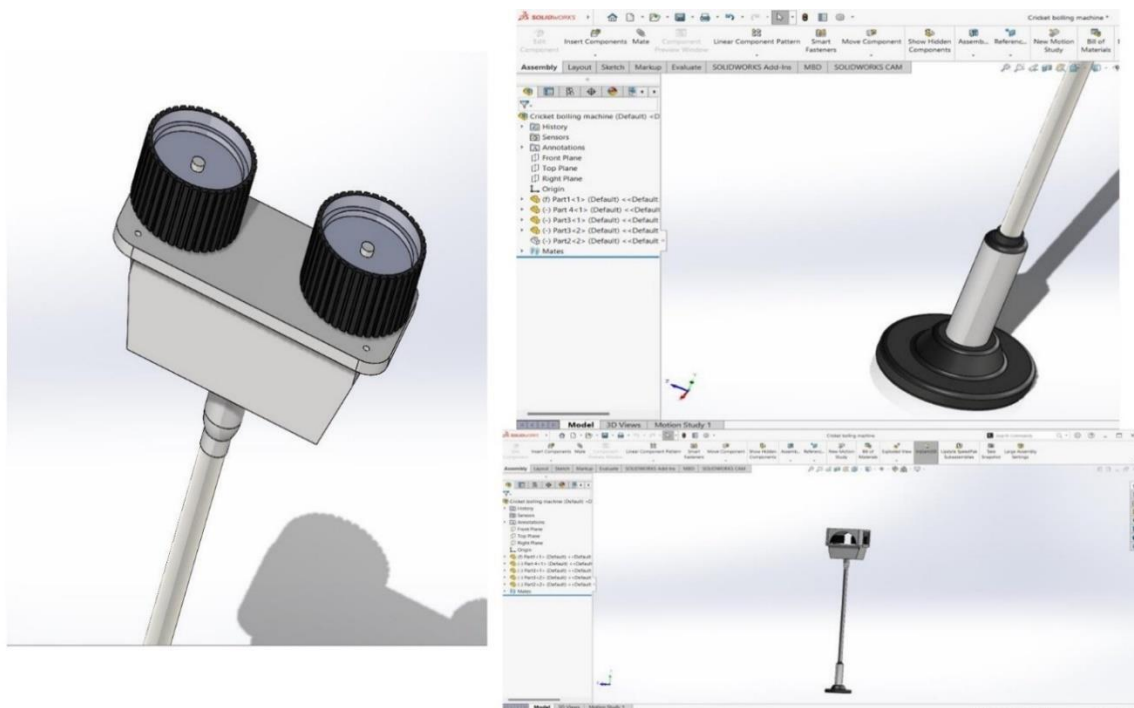
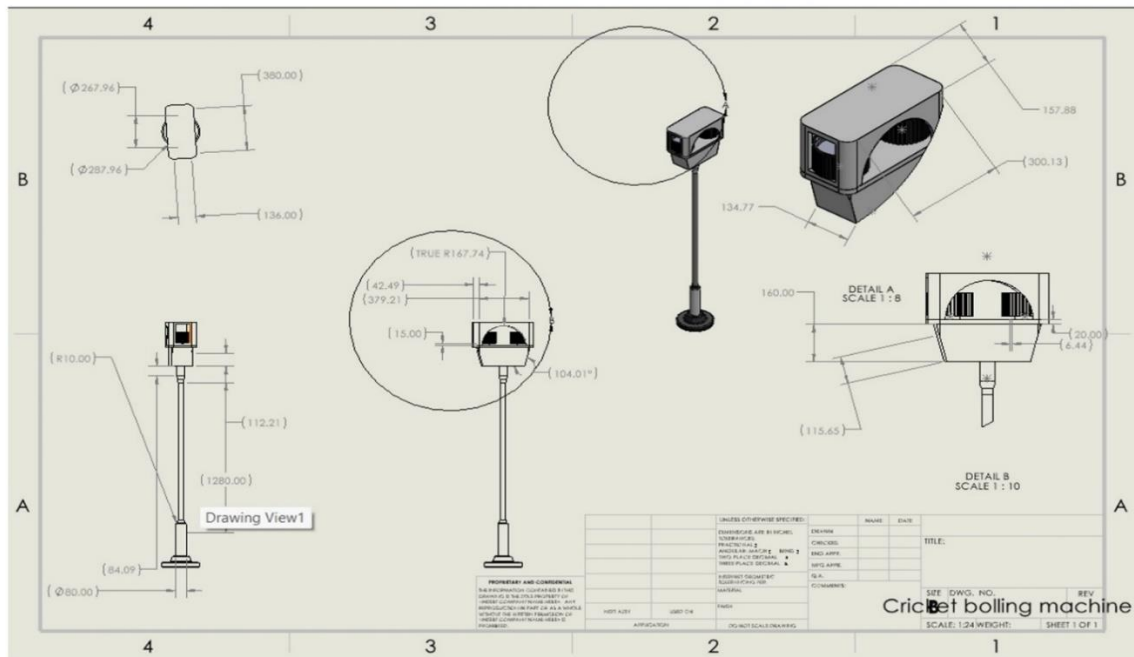


Fig. 3.1 CAD drawing of Cricket Bowling Machine and its Components



All parts are ensured to be securely fastened and properly aligned, and safety features are checked to ensure they are functioning as intended. Quality assurance checks are performed to confirm that the machine meets the manufacturer's specifications and standards. By following these assembly steps carefully and thoroughly, manufacturers can ensure that automatic bowling machines are assembled correctly and function reliably for users in cricket training and practice sessions.

#### 4. CIRCUIT CONNECTION

The circuit connections in an automatic bowling machine are diverse, influenced by the machine's design and features. A typical setup includes various components such as the power supply, which connects to the machine to provide electrical energy, ranging from direct AC power to battery sources. The control system manages crucial functions like speed and spin control, utilizing microcontrollers, sensors, and interface components, often linked to a control panel for user adjustments. The motor control circuit governs the motor's speed and direction, ensuring accurate ball propulsion through motor drivers, speed controllers, and feedback mechanisms. If equipped with an automatic ball feeder, the machine contains circuitry to control this mechanism, potentially involving motors or solenoids for ball release.

Speed sensors are employed for precise delivery speed control, detecting motor or ball speed, and providing feedback for adjustments. Safety features like emergency stop buttons, obstacle sensors, and protective cages are connected to the control system to ensure user safety. The user interface, comprising buttons, switches, and a display screen, enables user interaction for adjusting settings and initiating practice sessions. Power distribution wiring ensures each component receives the necessary voltage and current. Some machines may feature external connections for remote control, data logging, or integration with other devices. Additionally, diagnostic ports allow technicians to connect tools or software for maintenance and troubleshooting. These components collectively form the circuitry of an automatic bowling machine, tailored to its specific design and functionalities.

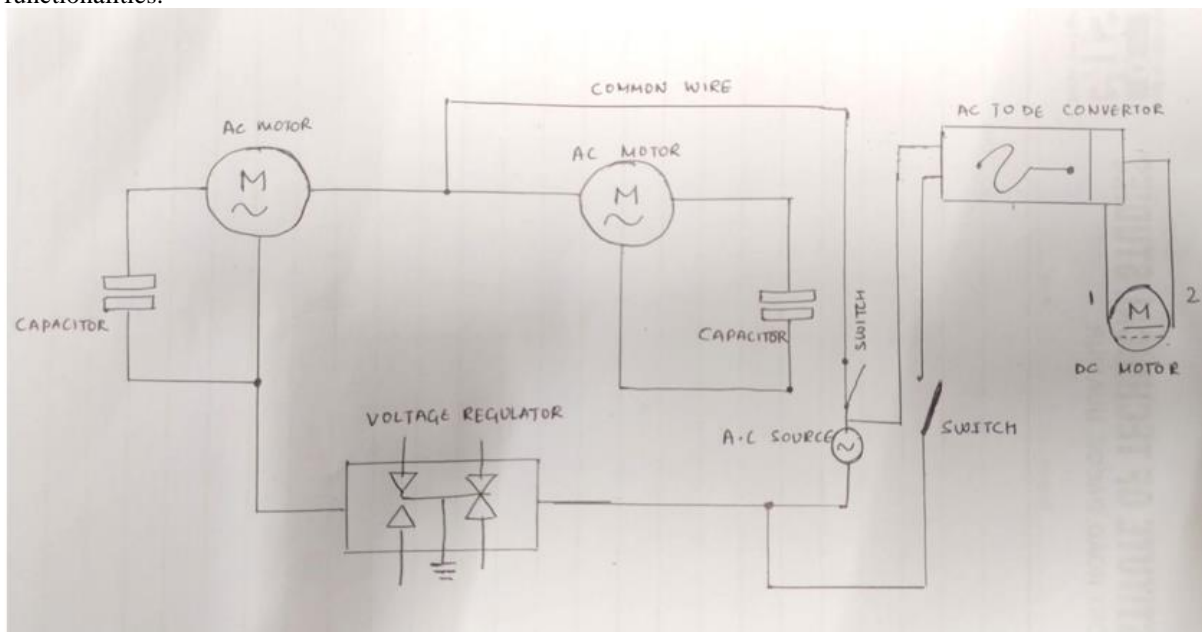


Fig. 4.1 Circuit Diagram

#### 5. APPLICATION OF AUTOMATIC BOWLING MACHINES

Automatic bowling machines play a crucial role in cricket training across various aspects of the game. In batting practice, players can customize the machine's settings for speed, line, length, and swing, enabling them to hone their skills and address specific training needs. Similarly, bowlers can use the machine to replicate different delivery types, improving their accuracy, variations, and consistency. Fielders also benefit by practicing catching, reflexes, and ground fielding, with the machine simulating diverse fielding scenarios. These machines contribute significantly to skill development, enhancing players' consistency, refining techniques, and improving footwork and timing through controlled repetitions. Moreover, they aid in decision-making skills by presenting varying deliveries for players to adapt to. Coaches and analysts utilize the machines to collect performance data for analysis, helping identify strengths, weaknesses, and areas for improvement. Additionally, researchers leverage the machines to study cricket physics, including ball trajectory, spin, and impact dynamics. Beyond training and research, automatic bowling machines offer entertainment and recreational opportunities. They find applications in cricket-themed amusement parks and friendly matches where participants of different skill levels can enjoy playing without the need for skilled bowlers. Moreover, advanced machines can be programmed with adaptive training routines, adjusting difficulty based on player performance for continuous challenge and improvement.

**Table-5.1 Different types of Bowling deliveries for a Cricket Bowling Machine**

S.No.	RPM of Wheels	Bowling Speed (km/h)	Projection Angle of Ball	Bowling Outcome
1	2000	40	Angle 1	Slow
2	2200	60	Angle 2	Medium
3	2400	80	Angle 1	Medium Fast
4	2600	100	Angle 1	Fast
5	2800	120	Angle 1	Fast

This table provides data for various types of bowling deliveries, including fast, medium-fast, medium and spin. It includes the rotation per minute (RPM) of the wheels, bowling speed in kilometres per hour, projection angle of the ball, and the nature of bowling for each scenario.

The data table illustrates the varying characteristics of different types of bowling deliveries produced by a cricket bowling machine. The RPM of the wheel's correlates positively with bowling speed, as expected, with faster deliveries requiring higher RPMs. For instance, fast deliveries with speeds ranging from 100 to 140 km/h are achieved with RPMs from 2000 to 2800. Similarly, medium-fast deliveries range from 90 to 110 km/h with RPMs from 1800 to 2200, while medium deliveries range from 80 to 100 km/h with RPMs from 1600 to 2000. The projection angle of the ball also increases with the speed of the delivery, likely to simulate the natural trajectory of the ball. Fast deliveries have higher projection angles (10 to 20 degrees) compared to medium-fast and medium deliveries (5 to 12 degrees). Additionally, spin deliveries, with speeds of 70 to 90 km/h and RPMs from 1400 to 1800, have a projection angle of 0 to 8 degrees, indicating a flatter trajectory characteristic of spin bowling.

The data highlights the machine's ability to simulate a wide range of bowling styles and speeds, providing cricketers with diverse practice opportunities. The cricket bowling machine features an innovative gear system enabling a wide range of bowling variations. This system propels six balls sequentially, each delivered with a 10-second interval. The mechanical design ensures consistent and accurate delivery, replicating various bowling styles such as spin, swing, and pace. This capability provides batsmen with a comprehensive training experience, allowing them to practice against different types of deliveries in a controlled environment. The machine's efficient delivery mechanism and timed intervals between balls simulate real-game scenarios, enhancing the training regimen for cricketers and improving their ability to face diverse bowling challenges.

## CONCLUSION

The cricket bowling machine has been designed and developed considering the complex process that requires various factors to ensure its effectiveness and safety. The machine accurately replicates different types of deliveries, such as fast bowling, swing bowling and spin bowling, while also being durable and easy to use.

In the initial stages of design, extensive research has been conducted to understand the requirements of a cricket bowling machine. This includes studying the mechanics of bowling, analyzing the trajectory of the ball, and identifying the key components needed to replicate different types of deliveries. Computer-aided design (CAD) software has been used to model the machine and simulate its performance under various conditions. The development phase involves the fabrication and assembly of the machine based on the design specifications. This includes selecting materials that are durable and lightweight, as well as integrating sensors and actuators to control the machine's operation. The machine is put through rigorous trials to meet performance standards and safe to use in delivering different types of balls, as well as its reliability and durability over time.

In conclusion, the design and development of a cricket bowling machine is a complex and challenging process that requires expertise in mechanical engineering, electronics, and software development. By carefully considering the requirements and using advanced technology, innovative cricket bowling machine can be created that enhances the training experience for cricketers and helps them improve their skills.

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