Integrated Novel Multi-Game Ball Throwing Machine: Design and Fabrication

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Abstract

Sporting arena is flooded with numerous bowling machines which are very expensive and unaffordable for ordinary sports persons. These machines are generally designed for specified dimensions of a ball and do not have the flexibility to accommodate different sizes of balls on the same machine. The purpose of this study was to design and fabricate a bowling machine in such a way that it can accommodate different sizes of balls, so that it can be used for different games like Cricket, Tennis, Softball and Baseball. It can also project the ball in desired direction. This machine will be very much cost effective and rugged in construction compared to the machines that are currently available in the market. The mechanismthat was employed for projecting the ball in this study was that "the ball is passed through gap between two rotating wheels(the gap is adjusted such that it is somewhat less than the diameter of the ball) and due to frictional force the ball is projected with some velocity (the velocity of the ball depends on the rotational speed of the wheels that can be varied)". The angle of projection of ball and also gap between the wheels can be adjusted with the help of rack and pinion mechanism. The balls can be fed to the machine using a fixed feeder and the machine projects the balls at a set interval of time, thereby enabling a batsman/player to practice himself without any aid or assistance once the angel and speed are set and balls are loaded. Since this is for multi game use, it can help to accommodate many disciplines with less cost and varied use.

Key Words: *Bowling Machine, Rack and Pinion, Projection, Velocity.*

INTRODUCTION

At the moment Cricket is considered as one of the utmost popular games in the World. Contemporary Technology can be employed for developing a cricket ball throwing machine with varied speed, swing and spin for the advantage of the practicing batsman ((Varhade et al, 2013, Roy et al., 2006). The Cricket Ball throwing machine affords consistent and accurate batting training for players of all levels without the necessity of a bowler (Justham & West,2009). It will be very useful at school, club and junior level where the standards of bowling are less consistent.From the observation of the college-cricket team players, it was established that they were struggling at the practice sessions and consequently at their main matches, all because of lack of practice with consistent bowling style. This apart, the procurement of a commercially available 'Cricket Bowling Machine' was hindered because of its 'high cost', both at purchase and its consequent maintenance (Mujumder & Krishnakanth, 2010). The literature and market survey reveals that there are many ball throwing machines available which fall into one of the following categories

(i)Pneumatically Operated Machines

(ii)Spring actuated machines

(iii)One or Multiple wheel rotating machines

The ball throwing machines of pneumatic type are pronounced in volume, high in manufacturing cost and not portable (Balachandran, 2016, Stokes, 1986, Whitaker, 1986). Second type of ball throwing machines uses a striking or throwing mechanism such as a spring or elastic material to project the ball (Winchester, 1999, Whitaker, 1986). In this mechanism difficulty is encountered in designing a suitable controllable deflection mechanism. In the third type the machine utilizes rotatory wheels which include a pneumatic tire mounted on rim that is supported in a rotatory shaft. They have also some limitations like maintaining appropriate inflation pressure to make sureconstant ball gripping action and control of wobble and erratic ball throwing (Fujio, 1984,Paulson, 1978).

Hence the idea here was to develop an economic machine which would serve the purpose of throwing the ball in multiple games such as Cricket, Tennis, Baseball and Softball with a feeder mechanism to avoid assistance of second person which would help the players for better performance.

LITERATURE SURVEY

Mahapatra et al, (2010) in their study on design of an improved cricket ball throwing machine used tripod & tri-axial precise tilting mechanism, wheel & motor holding and sliding mechanism as their major sub-assemblies. The mechanism which has been used is based on a pair of counter rotating rubber bonded ball ejecting wheels which are supported on rotating shafts. Tripod & tri-axial tilting mechanism is used to hold the base member and control the delivery point of the ball. Pitch axis indexer is used to control the length the length of the bowling. The distance between the rotating wheels can be adjusted using a rack and pinion mechanism. The ball is delivered through a chute until it touches the rotating wheels. The drive motors are electrical type preferably of PMDC type to regulate the extensive range of rotational speed of every wheel distinct of other. The swiftness of the ball depends on the rotational speed of the each wheel on condition that the space between the wheels is such that it gives a convenient gripping over the ball.

Singh et al, (2016)in theirinvestigation on design and fabrication of a ball projecting machine, developed a bowling machine at a low cost. They coupled two motors with the wheels and then it was installed on a cylindrical bar which was fittedon a base plate. A power screw was welded at bottom which fits inside a circular disc which carries corresponding threads. It's rotation about those threads will provide vertical lift and fall, also the rotation in the horizontal plane provides height adjustment and line change respectively. Finally three hollow cylindrical bars are welded at periphery of the circular plate holding power screw to form a tripod stand. The result is an efficiently working bowling machine which is relatively much cheap in manufacturing. It could project the ball at various speeds with desired spin/swing effect. Italso provides the facility to project various kinds of balls.

Kumar et al, (2015) proposed a bowling machine which contains a pair of counter-rotating ball ejecting wheels. They are fixed on a base for axial rotation in a conjoint plane, the space between the wheels actuality less than the diameter of a ball to be thrown. The base is supported on a bi-axial precise tilting mechanism. This tilting arrangement precisely adjust the delivery point of the ball with respect to two axis system i.e. yaw and pitch, thereby controlling the line and length of the ball. A virtual model of proposed cricket bowling machine has been developed in CAD/CAE

software in order to simulate different mechanical sub-assemblies of the machine using ADAMS (Automatic Dynamic Analysis of Mechanical Systems) software. Motion simulation of main sub-assemblies like two-axis tilting mechanism, ball auto feeding mechanism has been done to evaluate the function of mechanical assembly. It is seen that the functional simulation of the machine in virtual environment using CAD/CAE tools at early stage of development will eliminate the flaws and improve quality of product.

MATERIALS

After a deep and detailed review of available models and literature, the investigators come out with a hybrid model of ball throwing machine which can be applied to Cricket, Tennis, Baseball and Softball for training and benefit the players in improving batting skills in Cricket, receiving and returning ofServe skills in Tennis, ball hitting skills in Baseball and Softball.

The following are the components used for the fabrication of this multi-game ball throwing machine

PMDC Motors:

Basic shape of a PMDC (Perpetual Magnet Direct Current) Motor is almost similar to the shape of a regular DC motor. The principle on which any of the dc motor relies is similar, i.e. when a conductor bearing current is placed in a magnetic field, it is subjected to force. A PMDC (Perpetual Magnet Direct Current) Motor also works with the same principle.

FIG. 1 PMDC MOTOR

The PMDC motors that we have chosen for our study are Dynaflux D118 series. The motors are as shown in Fig. 1.

Selection of Wheels:

The wheels that were chosen for investigation are of pneumatic type made of nylon rubber. The periphery of the wheels contains necessary projections to induce a positive contact between the ball and the wheels. The diameter of the wheels was about 254mm and width approximately

90mm. A tyre is a circular envelop over the rim of a wheel which is meant to guard the rim and enhance the moving performance of a vehicle. Tires are widely used as a source of traction between the moving vehicles and the road on which the vehicles are moving. Tires also provide flexible padding that absorbs shocks during movement. The pneumatic tires which are widely used today are constituted of synthetic rubber, natural rubber, fabric and wire, along with carbon black and various chemical amalgams. The design of pneumatic tires mainly comprises of tread and a body. The tread functions in offering traction between the surfaces and the body provides containment for magnitude of compressed air. The wheels are directly mounted onto the motor shaft with the help of bushes and in order to ensure a positive movement between motor shaft and the wheela keyway has been slottedand covered with a square key.The upper part of the wheel is supported by deep groove ball bearing in orderto ensure stability. Balancing of both the wheels was done. The wheels are as shown in Fig. 2.

FIG. 2 BALL THROWING WHEELS

DC Drives

DC drives are DC motor speed control systems. Since the speed of a DC motor is directly proportional to armature voltage and inversely proportional to motor flux (which is a purpose of field current), either armature voltage or field current can be utilized to regulateswiftness.

Numerousbrands of DC motors are defined in the electric motor article. The electric motor article also designates electronic speed controls used with several types of DC motors.The DC Drives are as shown in Fig.3

FIG. 3 DC DRIVES FOR PMDC MOTORS

In order to obtain wide speed range of the motors DC drives that are manufactured by dynaflux of 'TDR-72' series have been chosen which are ideal for pmdc motors of 0.5HP capacity. This DC drive coverts the 220V AC current into 180V DC output which is supplied to the motor. The speed of the motor is obtained by fluctuating the voltage provided to the motor. The speed range obtained with the motor is 0-3000rpm and it can be done using the DC Drives mentioned above.

Scissors Jack:

In order to achieve tilting, the front edge of the base plate is hinged to the frame at its two corners with the help of bolts and nuts. Now, the other edge is moved up or down with the help of a jack in order to achieve tilting of the entire setup. This tilting is essential to adjust the position of ball projection. This tilting can be easily done with a mechanical jack.

FIG. 4 SCISSORS JACK

Scissor car jacks typically use mechanical advantage to permit a human to lift a vehicle by manual force alone.

Ball Feeder Mechanism:

The balls that are to be thrown with the bowling machine are to be fed at a constant frequency and this consistency in feeding of balls is achieved only with the help of a Ball Feeder Mechanism.The Ball Feeder Mechanism mainly consists of balls holder, a mechanism to allow the balls into the machine at a predetermined rate as set by the operator.

The various parameters that are to be taken into consideration in design of the ball feeder mechanism include the mechanism to hold sufficient number of balls and to be strong enough to withstand the balls. The mechanism should have the flexibility to feed balls at any set interval, in other words it should be able to deliver balls at different frequencies. The mechanism should be able to accommodate different balls like tennis ball, cricket ball, and baseball.

The investigators chose a PVC pipe of length approximately 800mm and 90mm outer diameter in order to accommodate different balls. The pipe was so chosen keeping in mind its reliability, availability, enough strength to hold at least 10 balls and the cost. The ball holder is kept at an inclination and is supported by bars onto the frame of the machine as in Fig. 5.

FIG. 5 BALL HOLDER WITH STEPPER MOTOR

Rack and Pinion

A rack and pinion is a kind of linear actuator that includes a brace of gears which change rotational motion into linear motion. A circular gear termed "the pinion" employs teeth on a linear "gear" bar called "the rack"; rotational motion applied to the pinion effects the rack to move relative to the pinion, thusconverting the rotational motion of the pinion into linear motion.This mechanism has been used inthe project for the adjustment of gap between both the rotatingwheelsfor ejecting out various sizes of balls such as Cricket ball, Tennis ball, Baseball and Softball.

FIG. 6 RACK AND PINION

PRINCIPLE AND FABRICATION

The proposed bowling machine uses two PMDC motors to drive the wheel. The wheels are of pneumatic type and 10inches in diameter which play a key role in ejecting the ball. The gripping

force of the wheels changes as distance between the wheels is varied and also depends upon the pressure of the air inside the tyres of the wheels.The key mechanism of the machine comprises of two heavy wheels 30 cm in diameter, fixed with solid or pneumatic rubber tyres, each operated by its individual electric motor. These are fixedto a frame in a way that the wheels are in the identical plane, about 7 cm separately for Cricket ball (marginally lesser than the diameter of a ball). Rack and Pinion here allows to vary the gap between the rotating wheels depending on the ball being used. A ball joint permits the machine anextensivevariety of movement. The entireassemblage is attached on a secure tripod or supplementary frame to facilitate the plane of the wheels to beapproximately at the height that a typical bowler would release the ball. A feeder feeds the ball across the wheels, projecting the ball outwards.

The motors are classicallydriven by a car battery or direct AC input may be given with the help of a DC drive which converts AC to DC, and turn in an opposite directions. A controller permits variation of the speed of each wheel, letting the machine to be slackenedfor less skilledplayer, or when the motors are not running at the similar speed, swing or spin of the ball can be simulated.

Fabrication of the bowling machine: Various steps involved in the fabrication of the bowling machine are described below.

Mounting of motors

The PMDC Motor that was selected rotates at variable speeds ranging from 0-3000rpm. Large amount of vibrations are developed while running if the motors are not properly and rigidly mounted. So a frame was designed for motor mounting which is made up of a plate of dimensions 240X220 and a circular plate of diameter 240mm and with a central hole of 50mm diameter and two supporting bars of hollow type squaring cross section of 20X20.

Mounting Wheels on Motors

The wheels were directly mounted on the motor shaft with the help of a circular bush specially machined such that on one end it is firmly fixed on the motor shaft, the other end is fitted firmly into the inner bore of the wheel. The bush is firmly fixed on the motor shaft with the help of a M6 grub screw. Similarly another

wheel is mounted on second motor with the help of a similarly machined bush. After mounting the wheels they are checked for balancing.

Fabrication of supporting frame with Scissors Jack

For this purpose a frame was fabricated with the help of angle bars of 1.5 inch width and 5mm thickness made of mild steel. Four such bars of 5feet height were placed and connected rigidly with the help of arc welding such that it exactly matches the dimensions of the base plate. Trolley wheels of sufficient capacity to with stand that load and locking were provided to arrest the movement of the wheels whenever required. The trolley wheels are perfectly fixed to the bottom of the frame.

The scissors jack is mounted on an angle bar with the help of nuts. The angle bar is supported on the frame at some distance from the top of the plate. Now, by operating the scissors jack the rear edge of the base plate is lifted and tilting of the setup is achieved.The final stage of fabrication was mounting the setup of ball throwing machine with motors and Ball feeder over the frame with Scissors jack to complete the task.

OPERATION AND UTILITY

Speeds of the motors obtained

The speeds of the motors can be varied in terms of the percentages with the help of the DC drive. The actual rotational speeds of the motors (in rpm) have been calculated with the help of a digital tachometer. The results are tabulated below.

Table 1: Rotational Speeds of the motors obtained

S.No.	Percentage of Speed on DC Drive (in %)	Speed of first Motor (in rpm)	Speed of Second Motor (in rpm)
1.	5	0	0
2.	10	279	286
3.	15	435	436
4.	20	596	589
5.	25	745	739
6.	30	902	896
7.	35	1040	1045

8.	40	1203	1194
9.	45	1348	1354
10.	50	1502	1496
11.	55	1660	1659
12.	60	1800	1798
13.	65	1956	1951
14.	70	2110	2106
15.	75	2259	2270
16.	80	2450	2441
17.	85	2559	2560
18.	90	2710	2706
19.	95	2880	2876
20.	100	3040	3046

Linear speeds of the balls obtained:

The linear velocity of the balls thrown by the bowling machine is calculated based on the diameter of the wheels and the rotational speed of the motors. The results are tabulated below.

Table 2: Linear Speeds of the Cricket ball obtained

S.No.	Speed of the motor (in %)	Rotational Speeds of the motors (in rpm)	Linear Velocity of the ball (in m/s)
1.	10	283	13.55
2.	20	593	28.39
3.	30	900	43.092
4.	40	1198	57.36
5.	50	1500	71.82
6.	60	1799	84.19
7.	70	2108	100.9
8.	80	2445	117.07
9.	90	2708	130.19
10.	100	3043	145.69

The analysis of the data shows that the linear velocity of the ball is gradually increased with increase in the rotational speed of the motors and the linear velocity of the ball also varies with the distance between the wheels. The above results are obtained when the distance between the wheels is approximately 90% of the diameter of the Cricket ball.

Utility in Cricket: This ball throwing machine can be effectively used in cricket as a bowling machine which can eject balls at different speeds and variations such as fast bowling, spin Bowling, swingers, bouncers and many more by the adjustment of tilting angle and variation in speeds of motors.

Utility in Tennis: In the game of Tennis this machine can be used in helping the players to practice receiving a serve at various speeds and angles of bounce with pace and spin. This also trains the players in returning the serve to opponent's court.

Utility in Baseball and Softball: Similar to the above two cases this ball throwing machine can be used for pitching the ball in training the players in Baseball and Softball from the required distance of pitching.

In all these cases there is no need of assistance as the ball feeder system itself can hold up to ten balls to deliver once the time gap is fixed as per the choice of the batsman or receiver.

CONCLUSIONS

The developed bowling machine can throw the ball at various speeds and angles. The speed of the ball can be varied by adjusting the distance between the wheels and also by increasing or decreasing the speed of the motors. The angle of projection of the ball can be varied by raising or lowering the jack. The ball feeder mechanism can hold at least 10 balls and feed them at a set interval. This bowling machine is suitable for practical applications for the benefit of the practicing receiver in the games like Cricket, Tennis, Baseball and Softball.

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