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Design and Fabrication of a Ball Projecting Machine

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Abstract
To make a ball projecting machine which pitches various kinds of balls either soft, leather, baseball or tennis ball at desired line and length as required. It can throw the ball at predetermined speed with required spin/swing effect. Problem with the existing machines is that they are very expensive and because of very low competition they ask for extremely huge price. The project began from the research phase with the identification of basic components used in the making of bowling machine. A thorough review of the theory and operations involved in a bowling machine were studied. A basic design was plotted and after review final design was made. Fabrication was done which involved operations on lathe, milling, grinding, welding machines etc. First 2 motors were coupled with the wheels, and then it was installed on a cylindrical bar which was installed on a base plate. A drive is used which is connected with the motors. The first worm and worm wheel set is installed on the rotating shaft on top of the base plate. Second similar set is installed at bottom. A power screw is welded at bottom which allows which fits inside a circular disc which carries corresponding threads. Its rotation about those threads would provide vertical lift and fall, also rotation in horizontal plane providing 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 efficient working bowling machine which is relatively much cheap in manufacturing. It could project the ball at various speeds with desired spin/swing effect. It also provides the facility to project various kinds of balls.

1. Introduction

Problem with the existing machine is that they are very expensive and because of very low competition they ask for extremely huge price. Also only selective operations can be performed on each machine. Usually machines are limited to a particular kind of ball either soft or hard.

To make a low cost bowling machine that could imitate an actual bowler and swing and spin. It has to be much more accurate in its precision regarding line and length. It should be a professional ball pitching machine that could be used for professional practice as well as for entertainment. It should be portable and carry a power source to practice in grounds. It should be safe to operate and steady while working.

A survey was done for all operations of a ball projecting machine perform. First at core included the types of ball projection ways. There can be many ways to project balls. Few are: squeeze project the ball from rotating wheels, Project the ball by the action of compressed air etc. On the basis of merits and demerits of each, manufacturing ease and complexity in achieving same output the most suitable one- operation through wheels. Various catalogues were searched and made results for bowling machine depicting the type of wheels used. I surveyed he market about the type of wheels, and motors available. I manually tested the make and operation of two bowling machines at abc public school and Dhyanchand sports complex, Delhi. Other important functions the machine was required to perform were: To alter line and length of where the ball pitches, imparting spin/swing to the ball.

The design of the machine had to be made to accomplish major mechanisms which were essential requirements of the machine. Those are altering line mechanism, altering length, and mechanism to facilitate ball swing effect. 2 additional mechanisms which were an add on feature but made the machine more versatile were mechanism to adjust machine height and mechanism to provide flexibility of bowling balls of different diameter. This meant that machine had to have more than 3 degrees of freedom as the main wheels motor frame which had to project ball should be able to touch any point in 3d space. The most critical part of the machine was wheel and motor set which had to revolve at an rpm of 200 and more. Their operational dynamics and 3d movement in space meant their installation had to most rigid and was the most critical part of the design. This posed a major challenge as the weight of the components and rotational dynamics because of rotating parts at high velocity made it a requirement to have a strong supporting structure. Thus the mechanisms were selected in a way which required less space and could be linked easily with each other.

Fabrication process had to be sequentially done. The motor and had were coupled first as their dynamic imbalance would have resulted into vibrations. The coupling was precisely cut, rims were balanced, and coupling was precision fit on the motor shaft. Then the structure was installed on a rotating shaft. The shaft was fitted with a worm and worm wheel set for movement. This was the installation of length mechanism. This rotating shaft was

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installed on a base plate. Now the swing mechanism was installed. A worm and worm wheel drive were assembled cased inside a gear box. This was welded with the main base plate. Metal bars were welded to form a tripod stand. The drives were connected with the motor. It was then connected to an ac power source through an extension cable. Fabrication mainly involved drilling, threading, welding, turning and facing operations on lathe, grinding and assembly operations.

A ball projecting machine can be used both for professional purposes and entertainment purpose. It can be used in sports coaching clubs, academies for practice of the players. Any batter seeking professional practice can buy this. It can also be bought for casual play and entertainment of children.

2. Design Methodology

Let us take for example 2 wheels for projecting ball. Both the wheels would be in a single plane after alignment. So there are two options. 1) Keep the wheels plane vertical. 2) Keep the wheels plane horizontal. For the ball to spin /swing the revolutions on the ball are imparted through difference in revolutions of the wheels. For vertical plane both wheels are erected vertically on top of another. The ball projected from a vertical plane leads to the ball either rising more or staying lower than usual because of direction of rotation. It is so because the direction of revolutions on the ball is either in or against the direction of motion. It speeds up the ball and makes it to rise if in the direction of motion or slowdown and lower it's trajectory if it is in opposite direction to that of motion. It is not mostly practiced. Whereas in horizontal plane the revolutions lead to drifting ball toward right or left to the player which is much common requirement while practicing. Hence tilting of wheels in operation becomes significantly less. The 2 sets of wheel and motor combination have to be installed on a firm base to provide flexibility to move entire setup.

For change in length, the wheels coupled with motor, setup to form horizontal plane is installed on a cylindrical bar. This bar revolves on its axis through a worm and worm wheel mechanism. It is two gears in mesh, one simple gear and the one is driving gear. The horizontal plane of 2 rotating wheels faces the batsman and the ball is projected from between the wheels. The plane of the wheels tilts from horizontal position to a different plane some angle about vertical. The plane bends or rotates at the corresponding zero degree angle from the horizontal towards or away from the batsman which alters ball's length of pitching. I is so because the ball is now projected at a different angle of projection.

This entire setup is installed on a base plate which is welded with a gear box. The gear box contains worm and worm wheel drive cased inside welded rectangular plates providing openings for the shafts of both worm and worm wheel. The diving gear which is worm is used for manual operation. The driven worm is so connected with base plate that it tilts it. It happens through worm wheel's rotation which is on a horizontal axis. Correspondingly the plate rotates or tilts or plane of wheels incline towards left or right. This tilt is visible as tilting towards right or left of the batter. As the balls seam is inclined with the projection plane, tilting provides for the ball to land its seam at an angle made with the horizontal. The angle is such so that ball lands on some part of seam. This was desired result and thus worm and wheel drive was chosen to be installed beneath base pate to rotate entire setup. Thus to keep it balanced on tilting, the gear box is welded right at center of base plate. Gear specifications are of standard gears with the only parameters required were predefined inner diameter and number of rotations to achieve a desired angle in tilting. The inner diameter corresponds to the shaft diameter on which is installed. Shafts calculations are done as per bending strength according to according to shaft diameter.

The above entire setup is installed on a power screw passing through its corresponding sized nut. The rotation of power screw helps in rotating the setup about its axis and hence changing line.

Fig. 1 – Power screw for altering line

Base plate thickness, cylindrical bar taken and stands and other mechanical components involved trial and error, R&D. Material used is mild steel as it is easily available and cost effective with good strength and ease of machining. Worm and worm wheel drives were used. They were used because it restricts motion in one direction that is only the driving gear which is worm drive and the other is worm wheel (simple gear). But the worm wheel can't drive the driving gear which is worm. It serves purpose because the load of 2 motors and wheels setup weighs approximately 20kg's and does not rotate the axis or cylindrical bar in return.

3. Fabrication

First the most important components were fabricated, since precision machining was required in this area. Two wheels of diameter 16 inches including rims of a standard auto rickshaw example Bajaj are coupled with the motor. Wheels are balanced using balancing machine. The tire pressure is set to 17 pounds. They are coupled with the help of an axle of the corresponding auto rickshaw. The side of an axle having 4 bolts fixed on a circular disc goes inside the rim and is locked using nut. The shaft at other end of the axle is partly cut and bored as per the motor's shaft diameter. It is hammer fitted onto the motor shaft.

Motors used are permanent magnet dc (PMDC) motors of 2 poles (2880 rpm) and 220v dc of 0.5 hp. A dc drive with digital panel displaying rpm is used. It is manufactured according to motor specifications with desired result being

variation in rpm. The 2 wires from motor were inserted into DC (+ -) ports on drive. The drive was plugged into standard AC source.

Motors are mounted on mild steel plates. Rectangular plates used were of size 175*125* 10 mm. They are drilled and tapped as per drilled and threaded holes in motor. Motor holes are aligned with those and are locked through LN nut using LN keys. Spring washers are used to dampen vibrations.

A hollow cylindrical bar- 750 mm length, 60mm diameter and thickness 10mm was used. Worm and worm wheel set was used. Cylindrical bar was slotted and made flat at circumference. One slot is of 125mm. One of the motor plates is welded onto it. One slot is of 170 mm. Worm gear with inner diameter of 60mm was hammer fitted on the main cylindrical shaft to its center. Correspondingly, second gear was mounted in mesh with first on base plate.

Two hollow rectangular channels are made in second plate. For the corresponding two holes are drilled in cylindrical bar on flat slotted surface of diameter 12mm and tapped (threads are made). Second plate is placed on slotted surface and rectangular slotted channels are aligned on top of these holes and screw of diameter 12mm are screwed into these holes. The tightened screws hold the plate in a firm position. Loosen these screws and slide the plate horizontally along bars length to vary gap between tires according to balls diameter.

Refer figure 2, a base plate of 790*275*10mm is cut. 2 rectangular plates of 110*80*10mm are machined. 2 circular disks of diameter 80mm, thickness 20mm are bored with diameter of 60.5mm. The main cylindrical rod on which motor wheel set up is installed will go inside these bores. These circular disks are welded on top of the rectangular plates. 2 metal strips of 120*20*10mm are welded below the rectangular plates. 2 holes of diameter 10mm are made on both the edges of each metal strip and at two ends across length at the center across width length. Each metal strip is welded below the rectangular plates. The base plate is drilled with pair of holes of diameter 10mm at its two ends matching.

Refer to figure 1, another worm and worm wheel set is installed in mesh in the gear box. Worm gear's inner diameter is 30 mm and outer diameter is 70 mm. Worm gear

Fig. 2(a) – Mechanism to slide motor plate to vary gap between wheels

Fig. 2(b) – Mechanism to slide motor plate to vary gap between wheels

is hammer fitted onto a shaft which passes through circular bores in metal plates on both sides. Second gear is installed in mesh with the worm gear. This assembly is installed in metal box with worm wheel shaft protruding outside is fitted with a knob for performing manual operation. The shaft from worm gear is welded with two rectangular blocks of dimension 50*20*10mm at its two ends.

These metal blocks are further welded at the bottom of base plate at its center. Driving the worm rotates worm gear and in turn tilts the plate. Refer figure 2, three hollow cylindrical bars of diameter 50mm, length 1500mm are cut using gas cutter or lathe. A circular disc is of diameter 200mm, thickness 15mm is bored with diameter of 25.4mm (1 inch). It is kept at the bottom. The three rods are welded at periphery of a circular metal disc. A test weld is made first on the joints. It is an inverted setup. After that the structure is erected straight and gap is corrected between legs of the stand. Final welding is done. The power screw welded to gear box at the bottom goes into the circular disc. Hollow cylindrical bars are taken as they have more compressive strength.

4. Other Important Instructions

Test run was conducted under standard operating conditions on a cricket pitch in college ground. Tennis balls were taken for testing. The following were the results from testing: The following reasons were found out for vibrations:

1. Play between meshing parts between gears.
2. Thickness of plate should be more.
3. Absence of locking mechanisms for gears.
4. Rotating knobs quickly without steady instead steadily for high speeds instantly.
5. Balancing of rims

This is a speed chart after installing wheels of diameter 400mm below is the speed performance chart of the bowling machine.

There is a variation of approximately 7km/hr with increase in motor rpm by 100. This is neglecting air resistance. In actual practice speed may decrease by 3-4 km/hr.

Soft balls wear away after some time because of friction of the wheels. Hard balls have better life expectancy.

Fig. 3 – Complete ball projecting machine

Table1 – Speed chart as per motor rpm

RPM	SPEED (km/hr)
1000	75.2
1100	83
1200	90.4
1300	98
1400	105.5
1500	113
1600	120.5
1700	128
1800	135.7
1900	143.2
2000	150.7

5. Conclusions

The bowling machine was constructed using wheels as a mode to project balls. They were efficient in delivering balls at same pace and at desired spot. It used 2 worm and worm wheel mechanisms, a nut bolt mechanism for adjusting length and height. Installation of worm and worm wheels required absolute precision. It is an efficiently performing pitching machine with consistent accuracy in pitching. The balls speed accuracy depends on the motor drive. The better the squeeze action on the ball better is the speed for given rpm. Amount of drift varies for different balls with difference in speed ratio of wheels being same because of different ball surfaces. There can be dynamic unbalance which leads to vibration because of high rotational energy of the wheels. On amount of accuracy and spin/swing movement of the ball machine is much more accurate and efficient than a human being in performing the same. The tires used will wear away with time so you have to grind it or scrub it with sand paper. A proper locking mechanisms is required for the mechanisms because the machine jolts back when the ball is pushed between wheels. The tilt to impart spin/swing works best at around 35 degrees from the vertical. Soft balls like tennis can wear away with time when passed between wheels.

All the mechanisms provided efficient use of machines different features. Few problems were faced because of significant play between gears mesh. It performed very well for both soft balls as well as hard balls. It was portable and easy to assemble because of smart designing. It performed all the operations including imparting spin/swing on the ball, line and length change successfully.

For future improvements the design could be modified to perform automatically using motors and actuators and a PLC circuit to drive the same.

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