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BADMINTON TRAINING MACHINE WITH IMPACT MECHANISM

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Abstract

In the current work, a newly machine was designed and fabricated for badminton training purpose. In the designing process, CATIA software was used to design and simulate the machine components. The design was based on direct impact method to launch the shuttle using spring as the source of the impact. Hook's law was used theoretically to determine the initial and the maximum lengths of the springs. The main feature of the machine is that can move in two axes (up and down, left and right). For the control system, infra-red sensor and touch switch were adapted in microcontroller. The final product was locally fabricated and proved that the machine can operate properly.

Keywords: Design, CATIA, Control, Badminton machine.

1. Introduction

Nowadays, badminton can consider as one of the famous sport in the world. Among sports, footwork is very important in the badminton games and among badminton skills and techniques, forehand smash are consider most powerful badminton technique [1]. Speeds sometimes are the key to win a sport competition especially racket sports. An issue related to that pushing the exercise speed to optimal to improve the functional performance. Sometimes, the training velocities are quite different to the actual movement velocity of sport specific task [2]. Racket is the best partner of a badminton player. The quality of the racket is directly affecting the performance of the player during the match. Racket stiffness and mass properties are possible to affect the impact phenomenon and restitution coefficient, besides, the vibration post-impact influence the player's perception of the racket and the response time of the player in fast rallies [3].

Nomenclatures

F	Impact force, N
K	Spring constant, N/m
M	Mass, kg
t	Time, s
v	Velocity, m/s
x	Spring pulling distance, m

Many sport such as tennis, table tennis, and baseball have their own training machine which can allow trainees train their skill individually. Tennis ball training machine is most common nowadays. The pitching mechanism is using two rollers run in high speed in different direction to each other, slightly compresses the ball, and ejected ball out from shooting hole [4]. In the table tennis, the shooting mechanism is basically using similar method as the tennis training machine. Where two rotary members disposed at opposite sides of shooting position and two unidirectional motors for rotating rotary members and throwing a table tennis ball from shooting position out of shooting hole [5]. For baseball training machine, it also has a similar design with previous mentioned machine. It uses two pneumatic tires rotates with different RPM to propel the ball [6].

According to the online resources, there are badminton training machines being created in Europe used by IBA (international badminton academy) [7]. This machine is called "Automatic shuttle feeder" (ASF). ASF can feed all over the court; no matter is drop shot, high ball, forehand drive, backhand drive and smash. ASF can basically fulfil two main trainings which are technical training and physical and reaction training. ASF's are using compressed air to launch the shuttle, so it needs an external compressor to supply compressor air for the machine. There are two interesting parts of this machine which is online downloading the latest training program and non-stop feeding. Non-stop feeding means that the machine can reload the shuttle while the machine is still running. This is excellent for the defensive training, multi-feed training and physical training [8].

In addition to this machine, there are also other types of badminton training machines invented in Hong Kong by Jonathan Taryoto. These machines are basically similar as the other sport training machine in consist two motor driven recoiling counter rotating wheel and grip the shuttlecock cap and propel the shuttlecock in the path of wheel plane [9].

For the current new machine, basically direct impact to launch the shuttle is used, where the springs are the source of the force. It can also feed all over the court. This machine is controlled by AT89S51. The trainee can control the machine at the other side of the court by remote control. This machine consists of 3 modes; manual, semi auto and auto modes.

2. Newly Design Product

The newly designed machine basically can be divided into 2 parts; structure part and control system part. Figure 1shows the fundamental structure of the machine.

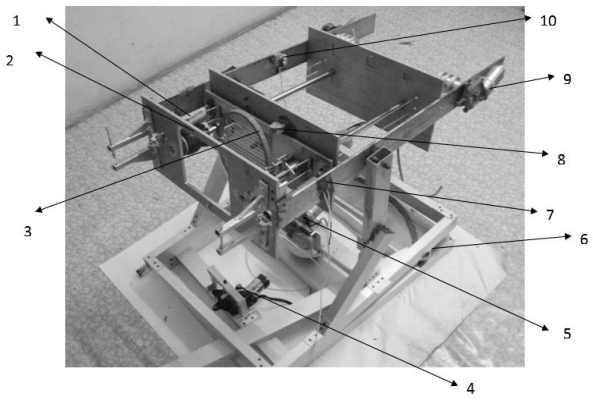

Fig. 1. Overall View of the Machine Structure.

1- Spring	6- Ball transfer
2- Shock absorber	7- IR feeding sensor
3- Racket	8- Touch switch
4- Left right control motor	9- Pull and release motor
5- Up down control motor	10- Up limit touch switch

The machine movements are basically controlled by window power motor. It consists of 4 movement direction which is up, down, left and right. The basic idea is to provide trainee all direction of shuttle feeding no matter is forehand drive, backhand drive, drop ball or smash.

The impact force is gained from the extension spring which each 15 kg. This value is obtained from the result of previous final year project. It is the maximum pulling force can be achieved by single arm of a normal man. The spring free length is 123 mm with the outer diameter of 27 mm when the spring length achieves 400 mm, the force will be up to 15 kg each spring. This was the maximum length of the spring.

In order to reduce the impact force on the structure, two miniature shock absorbers are applied on the front plate to reduce the direct impact force. The miniature shock absorbers are chosen based on the maximum impact force

The operating of machine is very simple. First, the pull and release motor releases the picking plate until the touch switch touches the shooting plate, then the center lock will be activated and locked the picking plate with the shooting plate. After that, the pull and release motor will pull both plates up to certain level which within the range (touch switch control the upper limit). The infra-red (IR) feeding sensor is waiting the shuttle drop from the feeding device which will install into the machine later on. Once the sensor senses the arrival of the shuttle, the center lock will inactivated and the spring on the center lock will lock to the initial point and release the shooting. The shooting plate will hit the shuttle with certain value of force which can be determined by calculating the length of the spring. After that, the picking plate will back to the initial picking level and redo the same procedure for second shuttle launched.

The left and right motor just simply control the left right movement of the machine. The ball transfer applies behind the machine is to reduce the friction, at the mean time. The rectangular bar in the front of the machine is to increase the friction so that the speed of turning can be reduced. There are two touch switch on left and right to make sure the left right movement work is under the range.

Same as the left and right motor, the up and down motor is used to control the up down movement of the machine. There are two touch switch sensors to make sure the movement is work under the range.

2.1. Impact Force

In order to avoid the direct impact force generated by springs bring bad effect on the structure, miniature shock absorbers are needed. So that the approximate impact force values are important in term of choosing the suitable miniature shock absorber for this machine.

Impact force value: Spring force = 147 N

Spring constant = 367.8 N/m

Spring maximum pulled distance = 400 mm = 0.4 m

Plate weight= 1.5 kg

Spring potential energy: $0.5Kx^2 = 0.5(367.8)(0.4^2) = 29.43$ Nm

Assuming there is frictionless between the bearing and the shaft

Potential energy = kinetic energy

29.43 Nm = $0.5mv^2$ and v =6.624 m/s
Maximum time of impact: $v = x/t$ and t = 0.0638 s

Thus the maximum impact force

$F = mv / t = (1.5 \times 6.624)/0.0638 = 147.3$ Nm/s

2.2. Finite element analysis

Once the basic design is completed, the software CATIA software is used to run some simulations on how the distribution force being act on the structure through finite element analysis (FEA). The following are obtained.

Figure 2 shows the Von Mises Stresses applied on the structure when the maximum impact force hits on the structure without installing the shock absorber. The maximum stresses shown are 0.300 MPa which are much lower than the yield strength of the aluminium (7-11 MPa), so it can be consider as safe and stable.

Figure 3 indicates the displacement after the impact on the structure. It is shown that the maximum displacement 0.000661 mm.

Based on both analyses, we can conclude that the structure is safe even without shock absorber. The application of the shock absorber is to enlarge the life time and precaution for the fatigue failure.

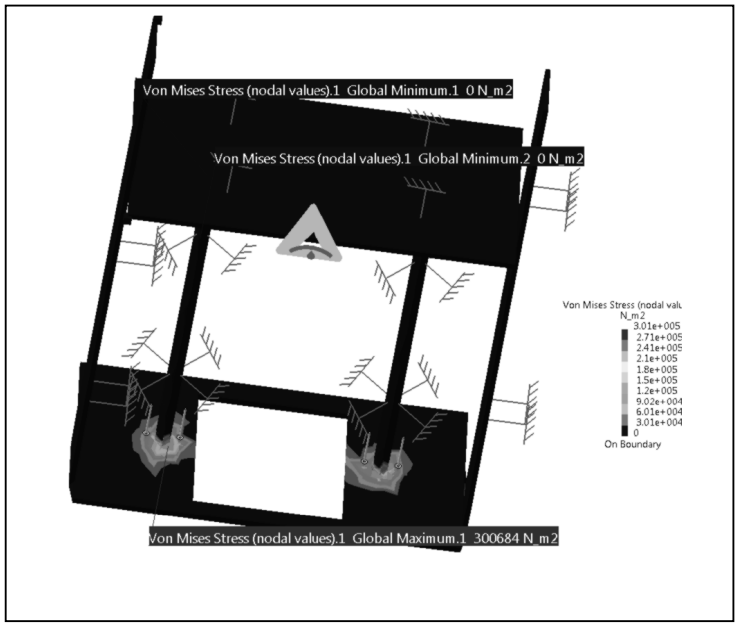

Fig. 2. Von Mises Stresses Applied on the Structure.

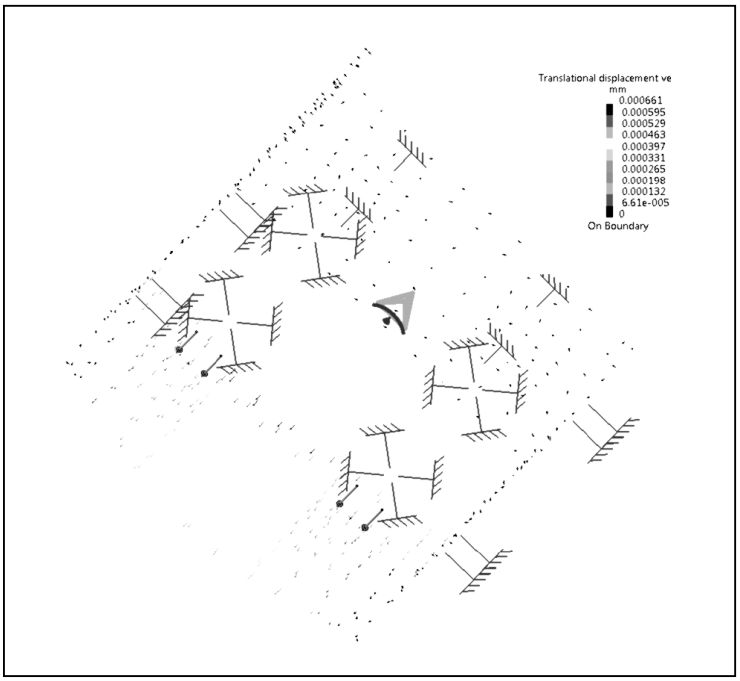

Fig. 3. Displacement of the Structure.

3. Control System

The control system is shown in Fig. 4. The sensor board consists of 4 set of IR sensors and 4set of chips LM 311 Voltage comparator. LM 311 is used to compare the voltage between two input pins, pin 2 and pin 3. Pin 2 are connecting to the receiver of IR sensor and Pin 3 is connecting to potentiometer (trimmer). When there are something blocking between the transmitter sensor and receiver sensor, or both sensor fail to sense each other, the voltage between Pin2 and Pin 3 will be different, and this will indicate the LM 311 to set low at output pin which is pin7. The output pin is connecting to the Microcontroller and LED, once pin7 is being set to low, the connecting Microcontroller port pin will be low too, and the Microcontroller can perform certain task according to the status of the related port pin. For example, the IR sensor is used to sense the incoming shuttle, once the shuttle being sensed the related pin will set to low, and Microcontroller will unlock the lock to release the shooting plate.

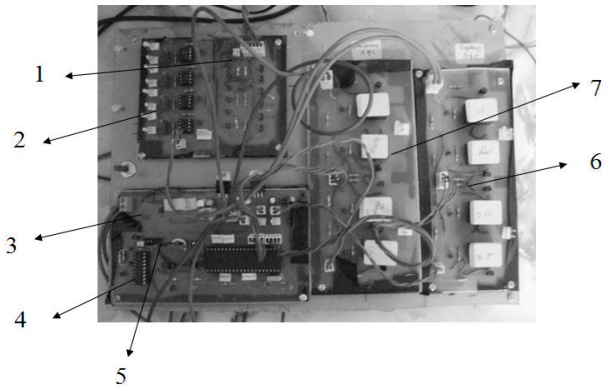

Fig. 4. Control Board.

1-Touch Switch Board	5-RF Module Receiver
2-Sensor board	6-24V Relay Board
3-Main Board	7-12V Relay
4- Receiver Decoder	

Touch switch board consists of 6 set of touch switches which are used to control the movement of the machine. When the touch switch being touch or trigger, the related port pin of the Microcontroller will be set to low, similar with the sensor board, once the Microcontroller senses the related port pin is being low, and then it will perform certain task according to the programming.

Remote control consists of 8 buttons, which is up down left right pull release shoot and reset button. The remote control is controlled by AT89C2051. The following case shows how the remote control is functioning. A set of programming codes is written first and downloaded into 2051, when the port pin P3.1 pulls to low status, the P1.0, P1.1, P1.2 and P1.3 will be set to high, low, low and low respectively. All these 4 pins are connect to the Address Data port pin8, pin9, pin10 and pin11 of chip HT12E which is the encoder to encode the data sent by the 2051. The encoder will encode the data and sent to transmitter. The transmitter will transmit the data signal to the receiver on the main board. The

decoder HT12D on the main board will decode the signal into high, low, low and low status and sent it to 8051. Once the 8051 receive such set of code, it will perform certain task that fulfils this set of code.

When the running machine is tested, the circuit showed a lot of noise. In order to reduce the noise, a capacitor on the motor is added and while the source is separated, which means that the power source for the motor and the main board are not combined. This is because the current after pass thought regulator is not sufficient to run 4 window power motors and a centre lock device.

4. Programming

Programming for this machine is not that very complicated. Basically, the language used for this project is C language, which is the first time (for the author) to combine C programming with the machine.

Basically the programming for remote controller is just using "if" and "else" structure, which mean that check all the button pressed. If a button pressed, the 2051 will automatically send a set of codes out of the transmitter. No button shares the same set of codes.

For main board programming, it is a bit complicated, because it needs to consider the sensor input and touch switch input. Basically, "if", "else", and "while" structures are used for the programming. Once the 8051 receives a set of data, it will check with the preset data by using "if" structure. Once match, it will run the content inside. Each if structure will have another "if" structure for the touch switch, this command is used to avoid exceed the available range. In order to avoid the performing wrong task for At 89S51 Microcontroller, a counter code is added on the Resourcing counter code to check the code received from transmitter for 1000 times before the micro controller performs certain task. Once the receiver receives one code that different as before, and then the counter will reset and start from 0. It takes only 8.3×10^{-5} s which will not affect the control quality.

5. Conclusions

A newly shuttle shooter machine is developed for badminton training purpose. It can be concluded that the machine is able to perform the training purpose. However, controlling the speed and human position were the advantage in this machine. It is recommended to consider these mentioned points to improve the control system by adapting image retrieve system.

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