

DEVELOPMENT OF MUSHROOM SPAWN BOTTLE CUTTER-SPAWN CAKE SHREDDER

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ABSTRACT

Spawn bottle cutting and spawn cake shredding machine has been developed to save the farm labor and operating cost for mushroom growing farmers. The prototype can cut the bottom and side of the bottle while shredding the spawn cake by one farmer. The cutting plastic shell is done by two couples of high speed disc saws that can cut cross section and lengthwise two side of the bottle, while spawn cake shredding is done by spike teathed rotating drum and wiremesh concave.

The optimum speed of cutting disc saw was observed 1,700rpm both the cross cutting saw and lengthwise cutting saw in consideration of the cutting accuracy. And the location for the instalation of cross cutting disc saw was considered as around 4mm above the table bottom, while the optimum clearance between two edges of lengthwise cutting disc saw was showed 86mm. For the sawdust spawn cake shredder, proper size of spawn sawdust granule was observed in the 15×15mm size wiremesh concave with the shredding drum speed of 500rpm. The prototype can be reduce 73 per cent of working hours with the working cost reduction of 49 per cent compare with those of conventional operation.

Key words : Mushroom, Spawn bottle, Spawn cake

INTRODUCTION

Commercial mushroom spawn is being cultured and handled in plastic bottle by spawn production companies, therefore mushroom cultivation farmers have to cut plastic shell of bottle and to shred the spawn cake after removal of the plastic shell.

The spawn cake shredding operation should be processed proper size of granule, further more, the spawning operation must be completed within short period to avoid contamination from the infection of viruses. However, mushroom spawn bottle cutting and spawn cake shredding operation rely on manual, so it is regarded as time consuming farm operation for mushroom growing farmers.

In practical, *Pleurotus Ostreatus* spawn require around 600 bottles of sawdust spawn for the one unit of ordinary size mushroom growing house if there is the spawn application 3 pounds per square meter of growing bed.

The size of sawdust spawn granular need proper size in consideration of vigorous growth of mycelium and the total yield of mushroom.

The study was aimed to find out the effective way of cut plastic spawn containers and how to make the optimum size of sawdust spawn cake by designing efficient simple and low cost machine.

MATERIALS AND METHODS

Outline of testing devices

Mushroom spawn cake shredding operation is consist of bottle cutting and spawn cake shredding process. Therefore spawn bottle cutting apparatus and mushroom spawn cake shredding apparatus were designed and assembled as shown in Fig 1 for the bottle cutting and cake shredding test.

Spawn bottle cutting unit is a kind of power disc saw which was empirically designed from the conventional working model, is consist of a pair of bottom-cutting saws and a pair of lengthwise cutting saws.

The disc saw was adopted V-belt driven power train system from electric motor, two pairs of clockwise and counter clockwise rotating saws can cut the bottom of bottle and can cut-open the lengthwise of bottle.

A variable speed electric motor was adopted as the power source for testing the different stage of working accuracy, and a accumulation watt-hour meter was attached for the acquisition of power requirement.

The disc saw, as a core part for cutting device, was adopted H-type tungsten carbide tipped disc saw with the diameter of 200mm, thickness of 1.5mm tipped edge of 80each, which is widely using cutting device for carpenter's portable electric wood saw and for power weeding machine in Korea.

Mushroom spawn cake shredding unit is shapped as the power thresher which is consit of shredding spike teeth drum, wire-mesh concave and the upper drum case cover with the inlet hopper.

The choice of material for test was full matured, bottled sawdust spawn in the plastic container size(D×H×T) of 95×165×0.4mm.

Method

In order to find out the proper way of cutting the container, optimum cutting speed of disc saws, setting height of saw and setting clearance between the couple of saws were observed by the comparation of cut working accuracy.

The rotation speed of saw disc was tested in the RPM range from 1100 to 1900 at the condition of its closs cutting and cut-open lengthwise cutting. The height of disc saws from the upper table was set in the range from 2 to 8mm under the disc saw clearance of 2mm, while the clearnce of disc saws between a pair of disc saws was set in the range from 76 to 86mm under the disc saws height of 48mm from upper table.

For the spawn cake shredding unit, two type of concave with the size of 10×10 mm and 15×15mm were tested to idetify the its feasible in view of the proper size of sawdust spawn cake granular.

The working accuracy of spawn bottle cutting unit was measured in the conception of obtaining the smooth cutting profile and smooth condition of work. Therefore the working accuracy was denoted as the number of crack per length of 10mm. Another choice of decision was regarded as shredding loss during operation, so the shredding loss was calculated by per cent from the total weight of sawdust spawn cake. The size of spawn cake granular was analysed by wiremeshed test sieves with the size of 4×4, 10×10 and 13×13mm. The working performance was measured and converted as the capacity for one unit of ordinary mushroom growing house.

RESULTS AND DISCUSSION

Design Factors for Mushroom Spawn Bottle Cutter

Cutting accuracy of plastic spawn bottle in the bottom cutting and lengthwise cutting by the variation of revolution speed(R.P.M.) of disc saw was shown in Fig. 5.

The cutting accuracy of cut section both the side cutting and bottom cutting was enhanced as increased the revolution speed of disc saw within the range from 1100rpm to 1900rpm. However the changes of enhanced trend of cutting accuracy was not so much improved by increasing the cutting speed beyond the 1700rpm. Therefore optimum speed of disc saw was regarded as 1700rpm for both the bottom cutting and side open-cut because the excessive high speed rotation is not necessarily in the bottle cutting system.

The vertical set position of disc saw from the bottom of table was tested to identify the effect on loss of sawdust spawn by the position of four level in the range from 2mm to 8mm. The 2 mm in the height of vertical set position was not succeeded, because the shell of cut plastic was not separated from the main body of bottle.

The sawdust spawn loss was showed increasing tendency as increased the cutting height from feeding table in the range from 4.5% to 11.1%, however the cutting accuracy in the cross cutting of bottle was showed almost constant level as shown in the Fig. 6. Therefore, the optimum level of vertical set position of disc saw from the bottom of table in the cross cutting of bottle was regarded as around 4mm in consideration of sawdust spawn loss and cutting accuracy of plastic spawn bottle.

On the other hand, effect on the sawdust spawn loss and cutting accuracy of plastic spawn bottle by the variation of cutting distance between two saw blades in the lengthwise cutting of bottle is shown in the Fig. 7.

The sawdust spawn loss was showed decreasing tendency as increased the distance between edge of disc saw in the range from 1.8% to 0.5%, but the cutting accuracy in the lengthwise open-cutting was showed almost constant level. So, the optimum level of distance between two disc saws was regarded as around 4mm in view of the sawdust spawn loss and cutting accuracy of bottle.

Design Factors for spawn cake shredder

Many technical reports indicate that the importance of the granular size of

shredded sawdust spawn cake. Mushroom growing researchers suggested that the proper size of shredded spawn cake granular should not be exceeded more larger than the size of soybean, and the size should be fall between the size of red bean and soybean with the dominance portion.

Two types spawn cake shredding unit by the type of concave size ie., $10 \times 10\text{mm}$ and $15 \times 15\text{mm}$ wiremesh, had tested under the different speed of the shredding drum as shown in the Fig. 8 for $10 \times 10\text{mm}$ concave and Fig. 9 for $15 \times 15\text{mm}$ concave.

The proportion of diameter size of shredded spawn cake granular between 4mm and 10mm shredded by the $10 \times 10\text{mm}$ wiremesh concave was showed decreasing tendency as increase the revolution speed(RPM) of shredding drum, while the proportion of diameter size less than 4mm shredded spawn cake granular in the same type concave was showed increasing tendency in the range from 40% to 50% as increase the revolution speed of the shredding drum.

In the case of the wiremesh size of $15 \times 15\text{mm}$, it was decreased the shredded very small size granular of less than 4mm in diameter, but adversely it was increased the shredded medium size granular diameter of $4 \sim 10\text{mm}$ and large size granular diameter of more than 10mm sawdust spawn granular compared with that of the wiremesh size of $10 \times 10\text{mm}$.

The obtained proportion of medium size granular between 4mm and 10mm was enough level in the range from 61.7% to 64.1%, while very small granular ie., less than 4mm was very small portion as much as around 30%, and very large granular diameter of larger than 10mm was showed very small portion in the shredding drum-speed between 500 and 600rpm. Accordingly, obtained maximum proportion of medium size shredded granular and minimum proportion of very small size granular and large size granular could be regarded as the shredding drum speed between 500 to 600rpm in the wiremesh size of $15 \times 15\text{mm}$.

Fabrication of prototype

Prototype was fabricated and set the proper position of disc saw as well as the use of choosen V-pully to regulate the optimum speed of revolution based under the experimental results.

The prototype was fabricated two unit of machine, spawn bottle cutter and spawn cake shredder as shown in the Fig. 10, Fig. 11 and Table 1.

How to operate the prototype spawn bottle cutter is cut the cross section of bottom of bottle by seize and bring the bottle to the front of operator with upright position, then seize the bottle with hand and bring it to the bottle guide cylinder and push into the cylinder so that it cut two side of bottle shell.

Operator should bring the lump of spawn cake into the hopper of spawn cake shredder so as to shred the spawn cake. Power source of spawn bottle cutter was adopted 0.75KW single phase electric motor and the spawn cake shredder was adopted 0.40KW electric motor.

Working performance

The working efficiency of the prototype was 54.2minutes for spawn bottle cutting and it was 44.5minutes for spawn cake shredding by a worker required in a

mushroom growing house, and total requirement was observed 54.9minutes in combined two operations by two workers for the spawning in a ordinary size mushroom growing house as shown in the Table 2.

The prototype had six time higher capacity compare with that of manual operation, and it was four time higher capacity than the manual cutting with shredder shredding operation.

The power requirement was showed 0.75KW in bottle cutting, 0.40KW in spawn cake shredding and 0.95KW in the combined operation.

The processing loss of sawdust spawn was observed 5.1 percent, however it can mostly be reused in practical situation.

Economic Effect

The cost of the bottle cutting and spawn cake shredding operation by conventional system was 44.06 US dollars for one unit of ordinary size mushroom growing house, however the improved that working system by prototype was lower level as much as 22.4 US dollars for the same condition.

CONCLUSION

This study was aimed to develop a spawn bottle cutter-spawn cake shredder to assist speedy spawn inoculation operation for mushroom growing farms. The spawn bottle cutting mechanism was adopted two couple of disc saw cutting by bottom cutting and lengthwise cutting. The revolution speed of disc saw was affected on the cutting accuracy, and the setting height and the clearance of disc saw was affected on the spawn cake loss.

In addition, the revolution speed of shredding drum and the size of concave wiremesh of the spawn cake shredding unit were dominant factors effected on the spawn cake shredding work. The spawn bottle cutter-spawn cake shredder was fabricated base on the design factors, and tested the performance of prototype with the evaluation on economic analysis.

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Table 1. Specification of prototype

Items	Specification
< Spawn bottle cutter >	
○ Size (L×W×H)	1050×560×915mm
○ Weight	60kg
○ Cross cutting saw	
- diameter×thickness	200×1.5mm, 80 tipped
- height from table	4mm
○ Lengthwise cutting saw	
- diameter×thickness	200×1.5mm, 80 tipped
- clearance between edge of saws	86mm
○ Power source	Single phase motor, 750W
< Spawn cake shredder >	
○ Size (L×W×H)	485×425×1110mm
○ Weight	20kg
○ Shredding device	
- Size of drum (D×L)	80×400mm
- Size of cutting blade (L×W)	70×20mm
- Rotational clearance of knives	20mm
○ Concave	
- Type of concave	Wiremesh, surrounded angle of 180°
- Size of mesh (W×L)	15×15mm
○ Power source	Single phase motor, 400W

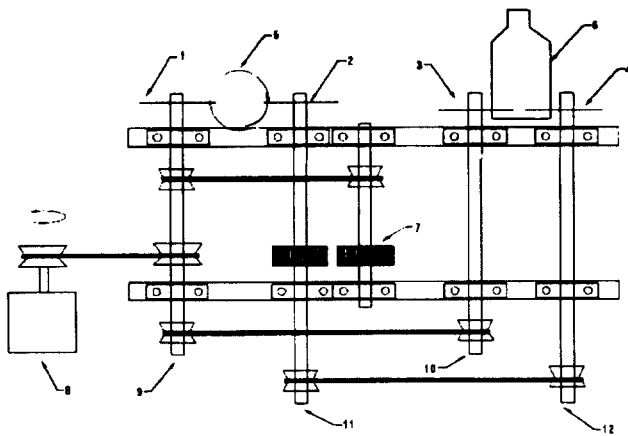
Table 2. Working performance of prototype .

Items	Bottle cutting	Cake shredding	Cutting+ shredding	Conventional* (A) (B)	
Working efficiency(min/700bottle)	54.2	44.5	109.8	660	405
Power requirement (kw)	0.72	0.40	0.95	-	-
Hourly capacity (kg/hr)	477.0	554.6	446.4	41.4	67.4
Sawdust spawn loss(%)	4.5	0.6	5.1	-	-

* Method "A" used manual cutter and sieve shredding, method "B" used manual cutter and shredder shredding.

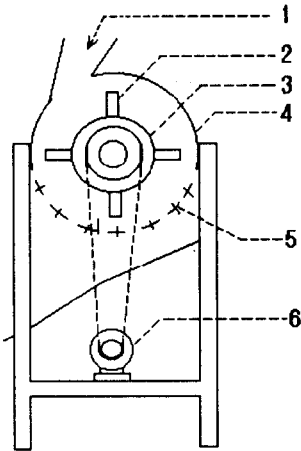
Table 3. Cost analysis of spawn bottle cutter-spawn cake shredder.

Item	Conventional (Manual+Shredder)		Prototype
Purchasing cost (US\$)	250		1,000
Life span (years)	7		7
Annual use (hours)	30		30
Annual fixed cost (US\$/yr)	52.99		211.96
Hourly fixed cost(US\$/hr)	17.66		7.06
Hourly variable cost (US\$/hr)	5.13	0.04	5.17
Total cost per hour (US\$/hr)	5.13	17.70	12.23
Work efficiency(hr/700bottles)	6.0	0.75	1.83
Cost requirement(US\$/700bottles)	30.79	13.27	22.39
Total cost (US\$/700bottles)	44.06		22.39
Index	100		50.8



- 1, 2 Lengthwise cutting saw
- 8 Speed control motor
- 3, 4 Cross cutting saw
- 9, 10 Counter clockwiserotating shaft
- 5, 6 Spawn bottle
- 11,12 Clockwise rotating shaft
- 7 Spur gear

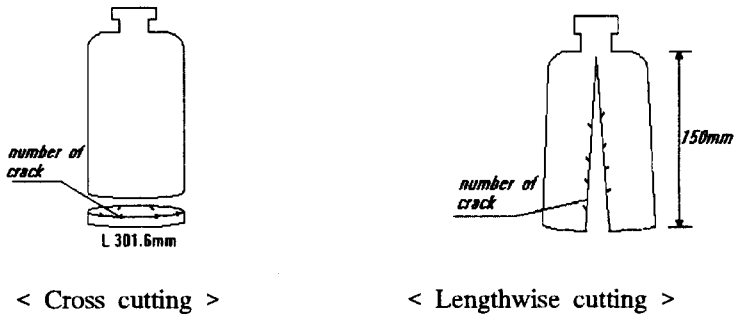
(Spawn bottle cutting unit)



- 1 Hopper
- 2 Cutting knives
- 3 Drum shaft
- 4 Cylinder cover
- 5 Concave
- 6 Speed control motor

(Mushroom spawn cake shredding unit)

Fig. 1. Schematic drawing for testing device



< Cross cutting >

< Lengthwise cutting >

Fig. 2. Cutting method of plastic spawn bottle

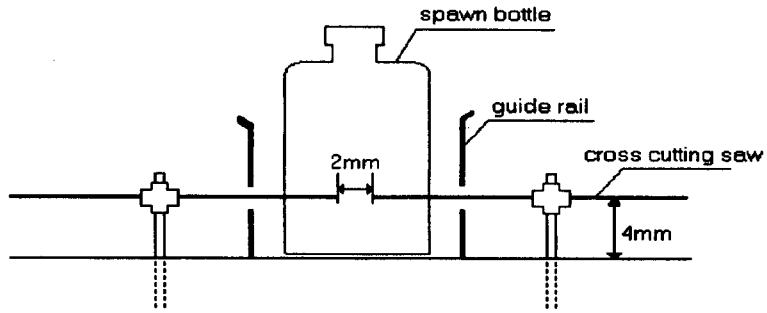


Fig. 3. Cross cutting device

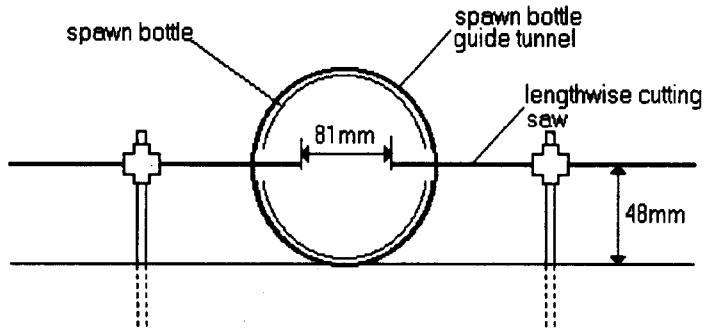


Fig. 4. Lengthwise cutting device

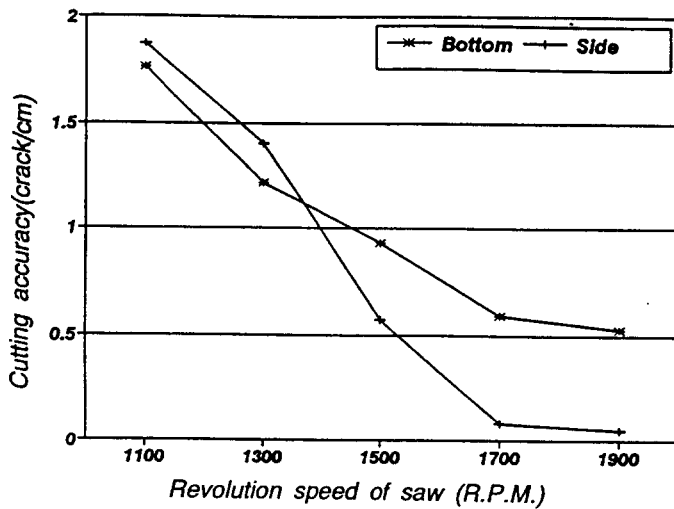


Fig. 5. Cutting accuracy of plastic spawn bottle in the bottom cutting and lengthwise cutting by the variation of revolution speed (R.P.M.) of disc saw

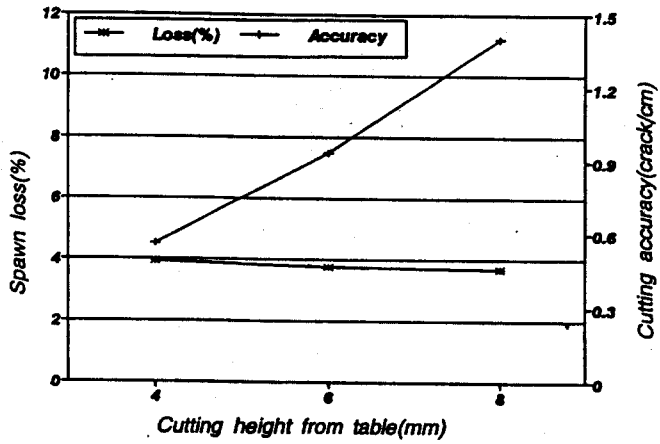


Fig. 6. Sawdust spawn loss and cutting accuracy of plastic spawn bottle by the variation of cutting height of disc saw from the upper table in the cross cutting of bottle.

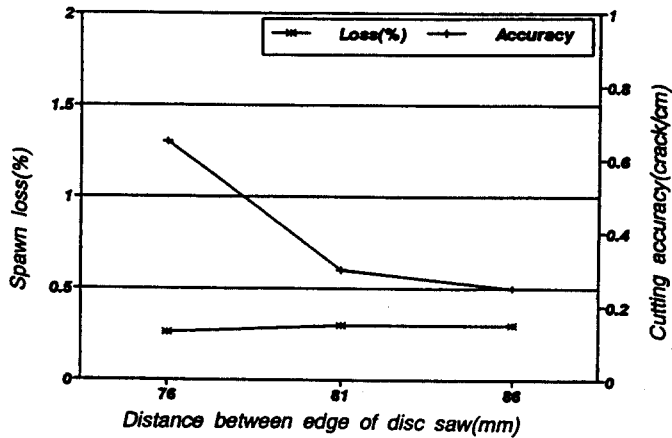


Fig. 7. Sawdust spawn loss and cutting accuracy of plastic spawn bottle by the variation of cutting distance between disc saw blades in the lengthwise cutting of bottle.

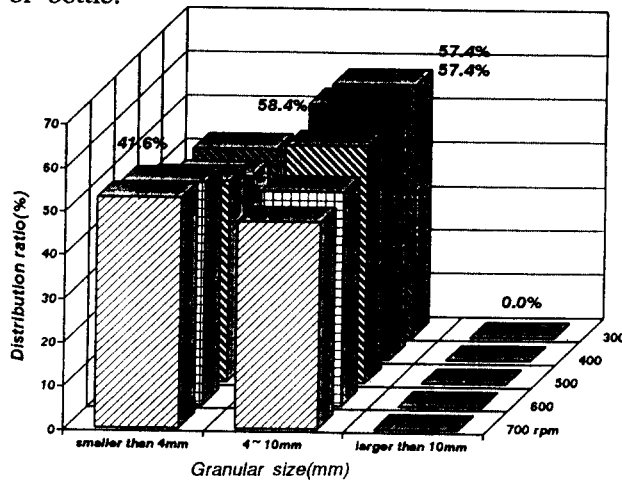


Fig. 8. Distribution rate of shredded spawn cake granule by the variation of revolution speed of drum shaft in the 10×10mm size wiremesh concave

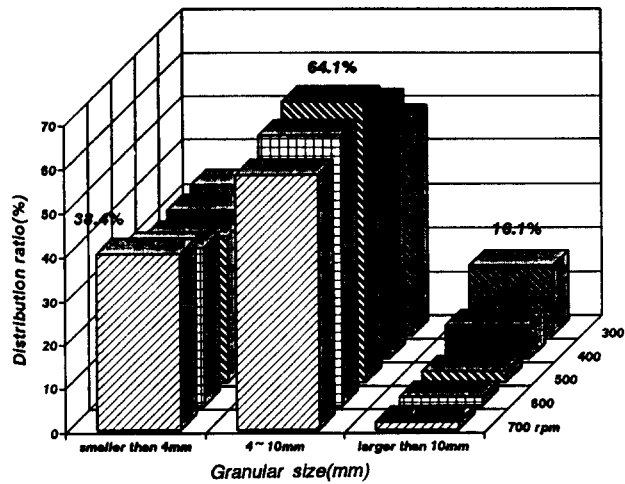


Fig. 9. Distribution rate of shredded spawn cake granule by the variation of revolution speed of drum shaft in the 15×15mm size wiremesh concave

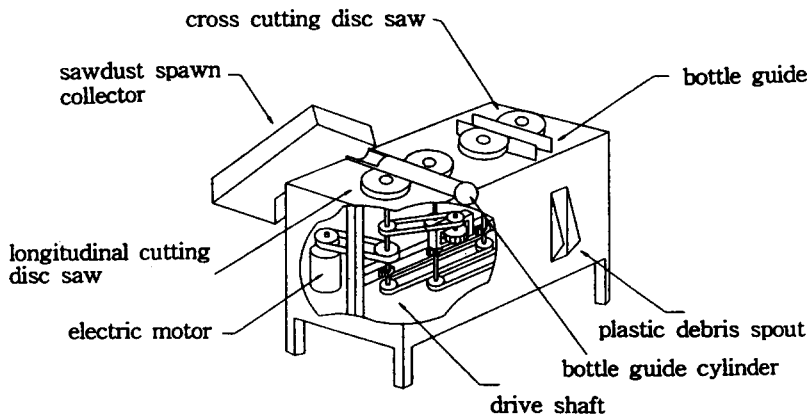


Fig. 10. Cutaway view of prototype spawn bottle cutter

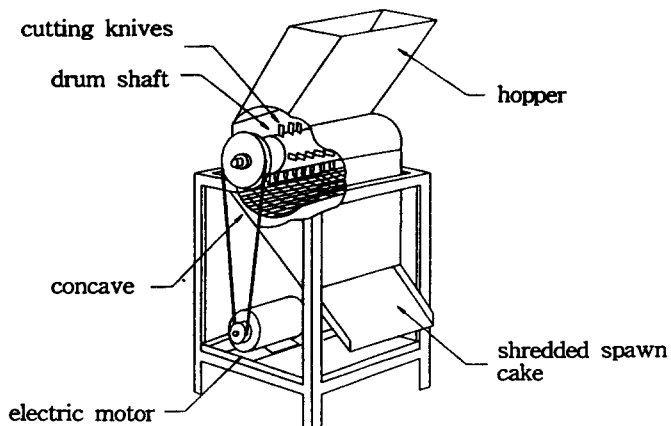


Fig.11. Cutaway view of prototype spawn cake shredder