# Cutter blade design for Shredder Machine

**Pratik Dattatraya Raut**
Department of Mechanical Engineering,
Dr. D.Y. Patil Institute of Technology,
Pimpri-Chinchwad, Pune, India.
patrickraut@gmail.com

**Siddharth Manoj Bhalgat**
Department of Mechanical Engineering,
Dr. D.Y. Patil Institute of Technology,
Pimpri-Chinchwad, Pune, India.
siddharthbhalgat7@gmail.com

DOI: 10.29322/IJSRP.10.06.2020.p102124
http://dx.doi.org/10.29322/IJSRP.10.06.2020.p102124

**ABSTRACT**

The focus of the project was to design a cutter blade for shredding machine such that it would be economical and effective in manufacturing also same time maintaining its efficiency. For serving this purpose we made some alteration in basic design for 6 teeth cutter blade with square shaped hole. The 6 teeth cutter blade is usually preferred to have a cutter blade angle in the range of 10°-20° for better efficiency. To achieve this arithmetically progressive angles, the cutter blades (with square shaped hole) are needed to be manufactured in different variants. For example, if 15° cutter blade angle is chosen, cutter blades where manufactured in 6 variants. First variant by keeping the reference angle of first teeth as 0° and then arithmetically progressing by 15°. Therefore, second variant as keeping the reference angle of first teeth as 30° and so on till 90° i.e. 6 variants are achieved. Manufacturing blades in variants has several disadvantages. To overcome these disadvantages, an alteration was made in basic design. This was achieved by making star shaped hole i.e. a square overlapping other with a rotation angle of 45°.

***Index Terms***- Cutter blade angle, Teeth angle, Rate of shredding, Shredded particles, particle size, Cutter to cutter clearance.

**Terminologies used-**

1) Cutter blade angle-

In an assembled blade pair, the angle made by cutting teeth of a blade with cutting teeth of adjacent blade is known as Cutting blade angle. Here it is denoted by "x". Shown in Figure 1.

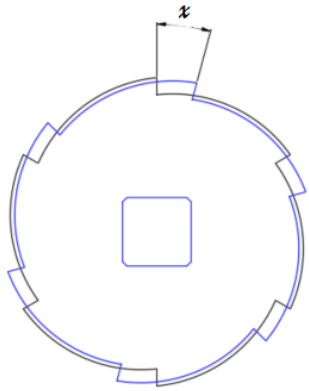



*Figure 1- Cutter blade angle*

2) Teeth angle-

It is defined as the angle made by a tooth on a blade with consecutive tooth on the same blade. Here it is denoted by "y". Shown in Figure 2.

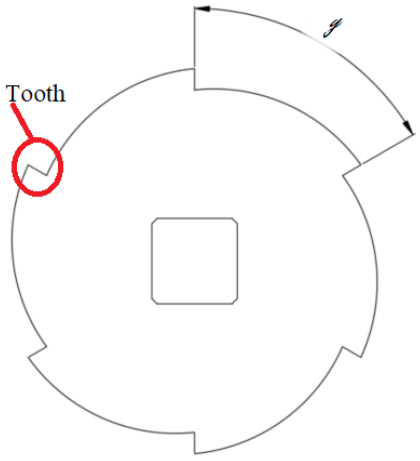



*Figure 2- Teeth angle*

3) Rate of Shredding-
Rate of shredding is basically defined as the quantity of shredded particles produced per unit time. The quantity is measured usually in mass or volume (whichever is suitable as per application).

4) Particle size-
It is the size of the resultant particles/chips following the shredding process. Any discussion will include length and width dimensions.

5) Cutter to cutter clearance-
The gap between overlapping cutters in the cutting chamber. Width of gap is set to obtain most effective shearing.

6) Reference angle-
The angle made by the first tooth of the cutter blade with the horizontal i.e. X-axis is known as reference angle. Show in Figure 3.

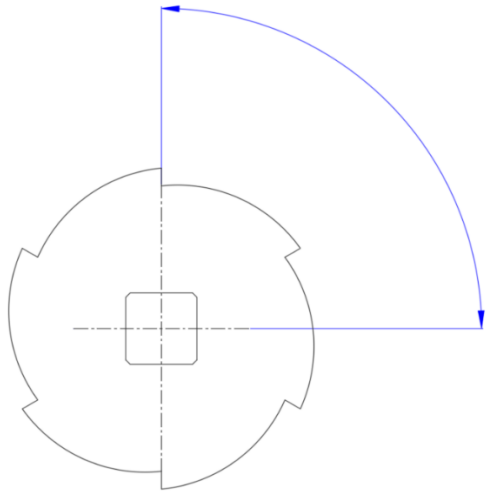


*Figure 3- Reference angle*

## INTRODUCTION

A Shredder machine is a mechanical device used to facilitate material reduction in a wide range of recycling applications. Industrial shredders efficiently support the recycling of plastic, e-waste, scrap, tire, etc. There are many types of shredders based on the material that needs to be processed.

WORKING-
The normal operation of a shredder generally entails directing material to be shredded between two sets of shredder blades arranged along two parallel axles. The shredder blades along opposite axles are interlaced with overlapping radii, and a cutting surface is formed at the interface of the two opposing sets of blades.

For different applications there are different requirements of shredded particles. In some applications it is required to have large shredded particle while some require medium sized, whereas some also may require finely shredded particles. The shredded particle size is mainly dependent on cutter to cutter clearance and cutter blade angle. While the Rate of shred depends upon the speed of rotation of cutter blades, teeth angle, number of teeth on a blade.

To obtain consistent particle size and better efficiency it is necessary to have uniformity in below listed things –

1) The Number of Teeth on each blade should be same
2) Cutter blade angle should be uniform throughout the assembly
3) Teeth angle should be same for each blade.
4) Cutter to cutter clearance must same throughout the assembly
5) Rotation speed of both shafts must be equal.

The number of teeth, cutter to cutter clearance and speed of rotation may vary as per application and various other factors, but the cutting blade angle commonly varies from 10° to 20°. Higher the number of teeth greater rate of shred is achieved but at the same time it increases the manufacturing time and cost of manufacturing.

## MODIFICATION IN CUTTER BLADE DESIGN

BACKGROUND-
In this project to achieve optimum rate of shred and particle size we selected to have 6 number of teeth on a blade. Therefore, teeth angle i.e. “y” was obviously 60° (360°/6=60°). Usually Industrial shredders have cutter blades with 1 to 3 no of teeth or 9 to 12. Also, they have a hexagonal shaped shaft and a hexagonal hole in the cutter blade. The cutter blade angle is usually achieved by progressively turning the hexagonal hole side of blade w.r.t to previous hexagonal hole side. But this technique doesn’t work in case of 6 teeth cutter blade, since the number of hexagonal side and number of teeth are same. Resultant of this cutter blade angle is not achieved uniformly during assembly.
As a solution to this cutter blades with 6 teeth are manufactured with square shaped hole. Cutter blades are manufactured majorly by two methods-

1) Laser or water jet cutting
2) Sheet Metal cutting (Punching/stamping)

In any of the above manufacturing methods a common technique is implied in which the reference angle of the first teeth is arithmetically progressed with a difference of cutting angle in consecutive blades as shown in figure no- 4.

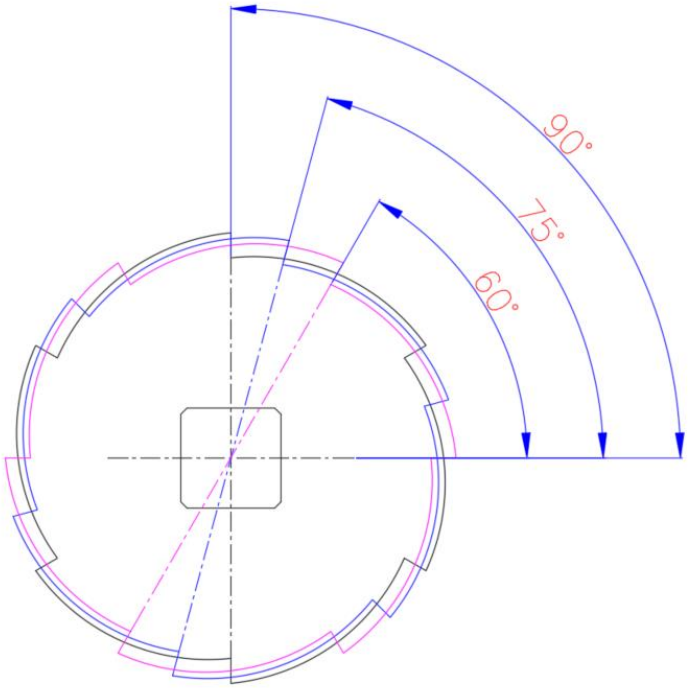



*Figure 4- Common manufacturing technique*

As we can see in the above figure, the reference angle for 1st blade is 90°, for 2nd blade is 75° and for 3rd blade is 60°. The reference angle is progressed with a common difference i.e. cutter blade angle which in this case is 15°. This difference is progressed till reference angle= 15°. At 0° the position in assembly be same as 90°, hence Cutter blades are manufactured in 6 variants for achieving the cutter blade angle.
This can be achieved in other way also by rotating the square hole in same manner, but it becomes complicated during assembly to find out reference angle of previous cutter blade hole. Hence, reference angle with blade teeth is very common method which is implied for manufacturing.

This technique of manufacturing blades in variants has some various disadvantages, some of them are listed below-

1) When cutter blade is damaged or gets worn out during operation it becomes very complicated for customer to find out the reference angle of that cutter blade. Moreover, it also becomes very difficult to manufacture that worn out blade as it will cost more for Job production.
2) To tackle this some manufacturers, manufacture these variants in bulk and store it. If proper storage not done, these blades rust and there needs additional work to remove the rust. Storage is also not a good idea because the return on investment is very less and no profit can be gained, since it costs more to store and maintain blades.

The above disadvantages can be easily overcome by a slight modification in Cutter blade designed.
This can be achieved by making two square holes, 1st with reference as 0° and 2nd with 45°. Shown in Figure 5.

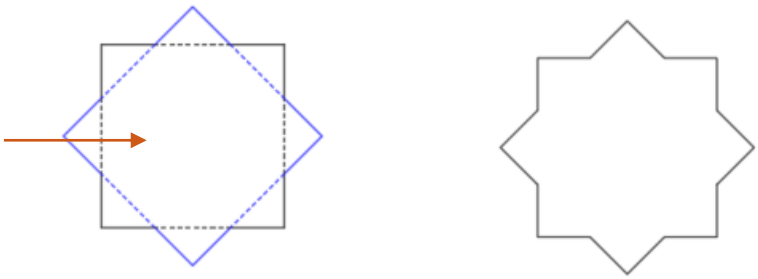


*Figure 5- Double square hole.*

To reduce the shear stress and thus to avoid the failure between hole and shaft a chamfer is provided to the square shape. Hence this chamfer is given to both, hole as well as shaft. Additionally, the chamfer assists in tighter grip in between hole and shaft. A 6 teeth cutter blade with double square can be seen in figure 6.

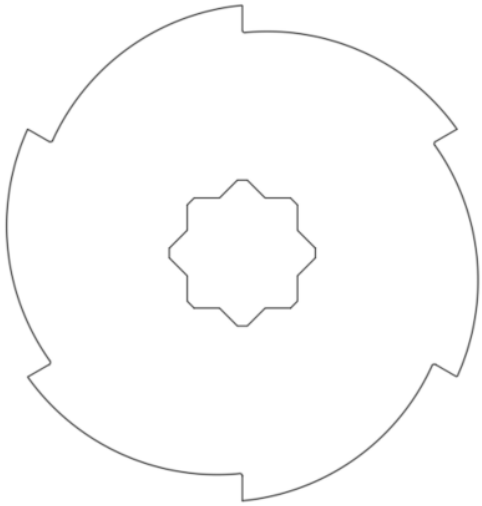
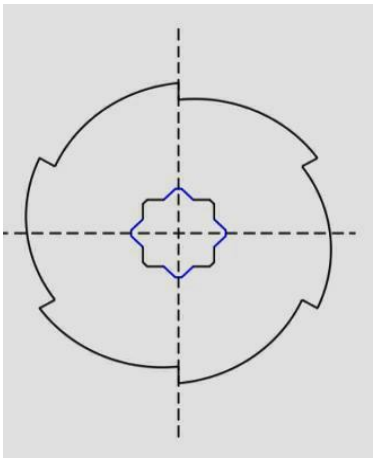


*Figure 6- Double square holed 6 teeth Cutter blade.*

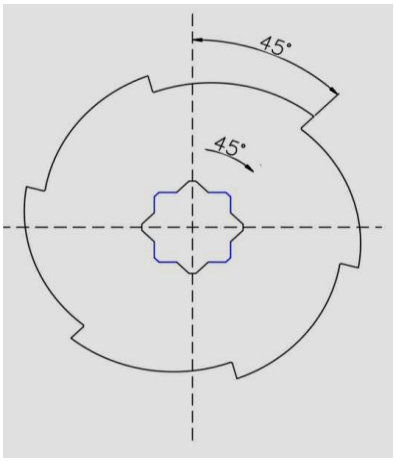
ASSEMBLY-

To achieve the 15° cutter blade angle, while assembling Cutter blade is to be inserted in to shaft with alternate squares in any single direction either anti-clockwise or clockwise way.

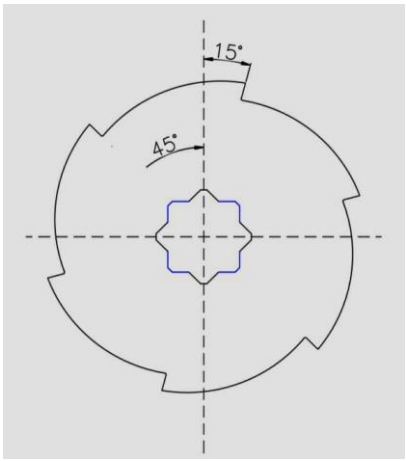
This method is illustrated by following series of figures.



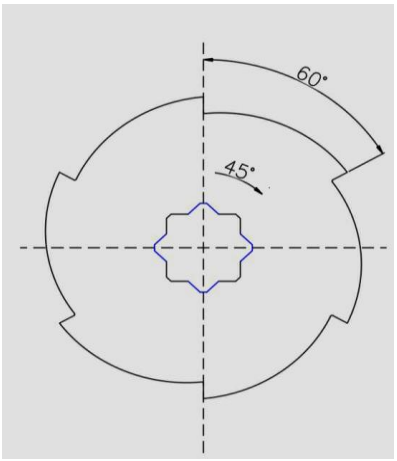
*Blade 1*



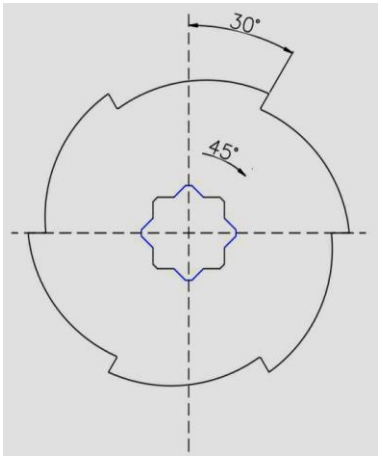

*Blade 4*



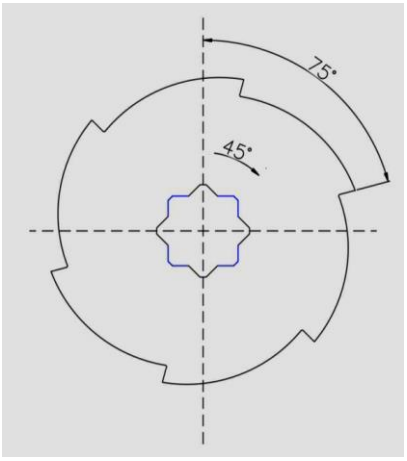

*Blade 2*



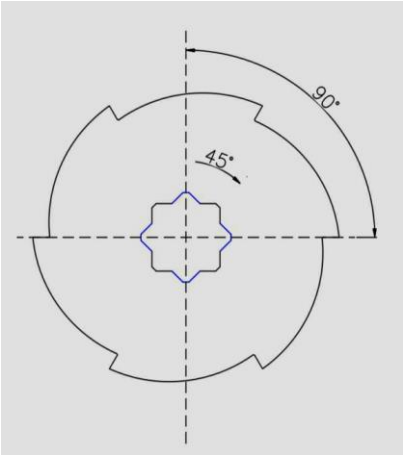

*Blade 5*



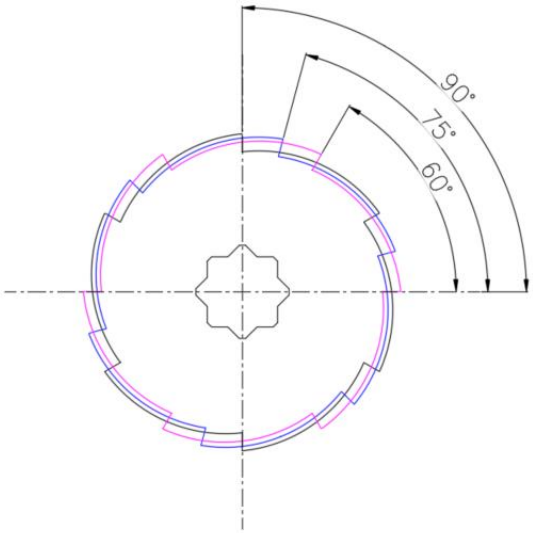

*Blade 3*




*Blade 6*




*Blade 7*




*Final Assembly*

**RESULTS AND FINDINGS-**

- It was earlier a complex task to manufacture and assemble cutter blades with implying the method of manufacturing by rotating reference angle method. Also it had disadvantages which are discussed above. With a simple modification in hole design we can overcome these disadvantages.
- Implying this modification, we can manufacture cutter blades in a single variant and still cutter blade angle is achieved.
- Mass production is hence possible resulting in cost reduction.
- Provides greater flexibilty in replacing the cutter blade (if worn out or damaged)
- This design modification has a limitation, that it can be used for 6 teeth blade where desired cutter blade angle is 15° obtained. Although, this combination of 6 number of teeth and 15° cutter blade angle is best suited for brittle and less ductile to high ductile materials.
  This design is best suited for below listed materials-
  a. Old tyres
  b. Plastic waste
  c. e-Waste
  d. Wet domestic garbage, Food waste
  e. Compost
  f. Dried leaves, wood, twigs.

- For heavy duty shredders, cutter blade size is very big. For such big cutter blades this manufacturing method becomes very useful since mass production of blades can be done. And because of no multiple variants replacement of blade is also easy.

**ACKNOWLEDGEMENT** –

I take this momentous opportunity to express my heartfelt gratitude and regards to Mr. S.N Kelkar Sir for providing me essential support, tools and mediums for Manufacturing my design idea and conducting its practical test.

**CONCLUSION-**

This manufacturing method is very economic while prodcuing the same effective output. It has a limitation that it can be implied only for 6 no. of teeth with 15° of cutter blade angle. It becomes very effective for manufacturing large Industrial shredders, since this combination gives an effective output with significantly reducing manufacturing cost.

**REFERENCES**

[1] United States Patent US0075.00629B2
Patent No.: US 7,500,629 B2 Abramson et al.