

## Speed Variation in Savonius Rotors with Respect to Overlap

K.K. Sharma<sup>1</sup> and R. Gupta<sup>2</sup>

<sup>1</sup>*Deptt of Mechanical Engg, N.I.T., Silchar, India.*

<sup>2</sup>*R. Gupta, N.I.T., Srinagar, India.*

### Abstract

Three models of savonius rotors like two-bladed Savonius rotors , three-bladed Savonius rotors , and two bladed two-stage savonius rotors(having provision for varying overlap in each type of rotor) had been tested in a wind tunnel of 30cm\*30cm\*3meter. And the rotational speed of savonius rotors (RPM) is measured in each type of rotors by varying the overlap in (a) two-bladed Savonius rotor like 9.38%,10.87%,13.87%,15.38%,18.38%,19.87% and 22.87% and the max rpm (4463rpm) is obtained at 9.38 % overlap and next lowest rpm (4267rpm) is obtained at 15.38% overlap.(b)In three bladed Savonius rotor where overlap is varied like 9.38% , 10.87% 12.38% , 13.87% ,15.38% ,16.38% ,18.38%,19.87%,21.38%,22.87%,24.37% and 25.87%. and the maximum rotational speed obtained is 3854 rpm at 10.87%. (c)In two bladed two-stage savonius rotor (having 90 degree phase difference) 3181 rpm is obtained at 15.38%(where overlap in lower savonius rotor is increased seven times) .In addition relative study of speed augmentation or power augmentation is also being studied by putting the concentrator or shielding around the rotor.

### 1. Introduction

The 'Savonius' type of vertical axis wind rotor was developed initially by S.J.Savonius[ 1] in 1929 , but the concept never became popular because of its low efficiency. However it has the following advantages over the horizontal axis type of machines :

1. Simple construction
2. Lack of necessity for over speed control
3. Acceptance of wind from any direction without orientation.
4. Inexpensive.

The above advantage can make it a suitable turbine for small scale application in rural and remote places where electricity is scarce. The idea of designing the vertical axis wind mill by Savonius [1] used a rotor formed by cutting a Flettner cylinder from top to bottom and then moving the two semi-cylindrical surfaces sideways along the cutting plane so that the cross-section resembled the letter "S". Savonius tested more than 30 different models of his S-rotor in a wind tunnel tests and reported encouraging results. After the completion of the wind tunnel tests, Savonius conducted further tests in natural wind. He reported that the S-rotor ran at a higher speed in the natural wind than the wind tunnel for the same wind speed. The best of his rotor models had an efficiency of 31%, while the maximum reported efficiency for the full-scale prototype was 37%. Following Savonius, Bach(2) made some investigations of the Savonius rotor and related machines, with the best measured efficiency 24%. Between the 1960s and 1990s, Newman(3), Ushiyama and Nagai(4) conducted several tests on this kind of machine. The best measured efficiency in the model was 33%, reported by Macpherson, while the maximum power coefficient by Newman [3] was 0.20. On the basis of his model test, Newman (3) concluded that the full-scale performance of the rotor cannot be estimated from the model test results because of wind tunnel interference, but model tests can be used to assess the relative merits of each rotor. Sharma et al. [5] conducted experiments on model of overlapped Savonius rotor in wind-tunnel. The overlap was varied between 1.8cm to 5.1 cm. Sharma et al [5] got encouraging results. They got the efficiency 52%. Blackwell B.F. et al [6] studied the performances of fifteen configurations of three bucket model S-rotors in wind tunnel conditions. The best of his model rotors produced an efficiency of 18%. They also conducted that the three-bucket S-rotor had increased starting torque. Biswas et al [6] conducted model tests on three-bucket S-rotor taking tunnel blockage into consideration.

## 2. Physical Model

Three types of models of Savonius rotor had been fabricated like (a) two-bladed Savonius rotor.(Fig.9) (b) Three-bladed Savonius rotor.(Fig.8)(c) two-bladed two-stage Savonius rotor.(Fig.3.)The buckets of the rotor were 8 cm in chord, 3 mm thickness and 20 cm in height. Rotor was fixed using nut and bolt arrangement. Ball bearing Ball bearing was used to support the central shaft of the rotors at the base. Washers and nuts having knurled surfaces were used to change the overlap. Overlap is the distance of the inner edge of the bucket from the axis of rotation assuming the arc is carried to the full semi-circle. The central shaft of the rotors was 1.5 cm in diameter and 25 cm in length. The base was 7 cm wide and 2.4 cm thick. The models were tested in wind-tunnel of 30cm\*30cm\*3meter.(Fig.10.)At the end of the wind-tunnel there is a gate whose opening is varied like 5cm, 7cm, 10cm, 15cm, 20 cm, 25 cm.

### **3. Experimentation**

(a) In two-bladed Savonius rotor the overlap is varied like 9.38%,10.87%,13.87%,15.38%,18.38%,19.87% and 22.87% and the max rpm (4463rpm)is obtained at 9.38% overlap and the next rpm(4267 rpm) is obtained at 15.38% overlap.

(b) In three-bladed Savonius rotor the overlap is varied like 9.38% , 10.87% 12.38% , 13.87% ,15.38% ,16.38% ,18.38%,19.87%,21.38%,22.87%,24.37% and 25.87%. and the maximum rpm 3854 rpm is obtained at 10.87% overlap.

(c)In two-bladed two-stage Savonius rotors the overlap is varied like 9.38% , 10.87% , 12.38% , 13.87% , 15.38% ,16.38% , 19.87% .(Overlap is varied in the lower Savonius rotor with the help of nuts and bolts.)

### **4. Conclusions**

For Two-Bladed Savonius Rotors it has been concluded that

(a)In two-bladed Savonius rotors the maximum rotational speed is obtained as 3816.rpm at 9.38.%overlap and the next lowest rotational speed 3803 rpm is obtained at15.38% overlap at 5cm gate opening. (Fig:1) (b)In two-bladed Savonius rotors the maximum rotational speed is obtained as 4153rpm at 9.38%overlap and the next lowest rotational speed 3952 rpm is obtained at15.38.% overlap at 7 cm gate opening. (Fig:2)

From the combined diagram (fig:3) of RPM vs %overlap is given in fig:3 for all the 8 overlap as given above.From that Fig. it is clear that

(c) In two-bladed Savonius rotors the maximum rotational speed is obtained as 4353rpm at 9.38%overlap and the next lowest rotational speed4204rpm is obtained at 15.38% overlap at 10cm gate opening. (Fig:3) (d) In two-bladed Savonius rotors the maximum rotational speed is obtained as4443.rpm at 9.38%overlap and the next lowest rotational speed 4267rpm is obtained at 15.38% overlap at 15cm gate opening. (Fig :3) (e) In two-bladed Savonius rotors the maximum rotational speed is obtained as 4463rpm at 9.38%overlap and the next lowest rotational speed 4247rpm is obtained at 15.38% overlap at 20cm gate opening. (Fig :3)

(f) In two-bladed Savonius rotors the maximum rotational speed is obtained as 4383.rpm at 9.38%overlap and the next lowest rotational speed 4134rpm is obtained at15.38% overlap at 25 cm gate opening. (Fig:3) For Three-Bladed Savonius Rotors it has been concluded that (a) In three -bladed Savonius rotors the maximum rotational speed is obtained as3466rpm at 10.87%overlap at 5cm gate opening. (Fig :4)

(b)In three-bladed Savonius rotors the maximum rotational speed is obtained as3644.rpm at 10.87%overlap at 7cm gate opening. (Fig:5)From the combined diagram (fig:6) of RPM vs 12 overlaps as described above for three bladed savonius turbine is given in Fig:6. is clear that (c)In three-bladed Savonius rotors the maximum rotational speed is obtained as3782.rpm at 10.87%overlap at 10 cm gate opening. (Fig:6) (d)In three-bladed Savonius rotors the maximum rotational speed is obtained as3854.rpm at 10.87%overlap at 15cm gate opening. (Fig:6) (e)In three-bladed Savonius rotors the maximum rotational speed is obtained as 3854.rpm at

10.87% overlap at 20cm gate opening. (Fig :6) (f) In three-bladed Savonius rotors the maximum rotational speed is obtained as 3782rpm at 10.38% overlap at 25cm gate opening. (Fig:6)

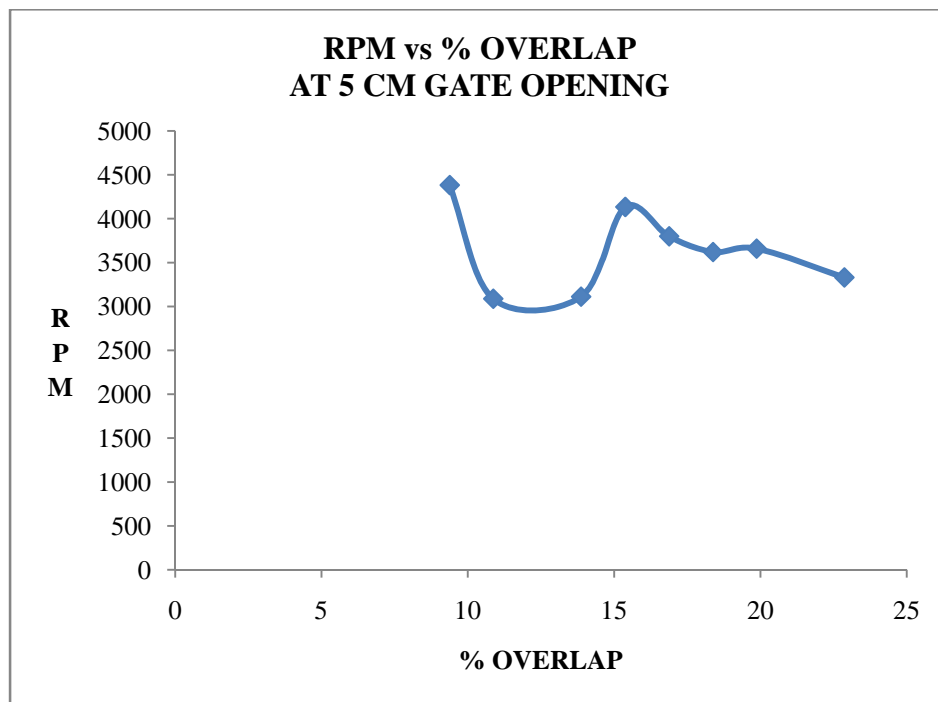
For Two-Bladed Two-Stage Savonius Rotor(When overlap is varied in lower savonius rotor)

RPM vs % OVERLAP is given in Fig. 7 for two-bladed two-stage savonius rotors it has been concluded that (a) For two-bladed two-stage Savonius rotors the maximum rotational speed is obtained as 2966rpm at 15.38% overlap at 5cm gate opening. (Fig:7) (b) For two-bladed two-stage Savonius rotors the maximum rotational speed is obtained as 3066rpm at 15.38% overlap at 7cm gate opening. (Fig :7) (c)

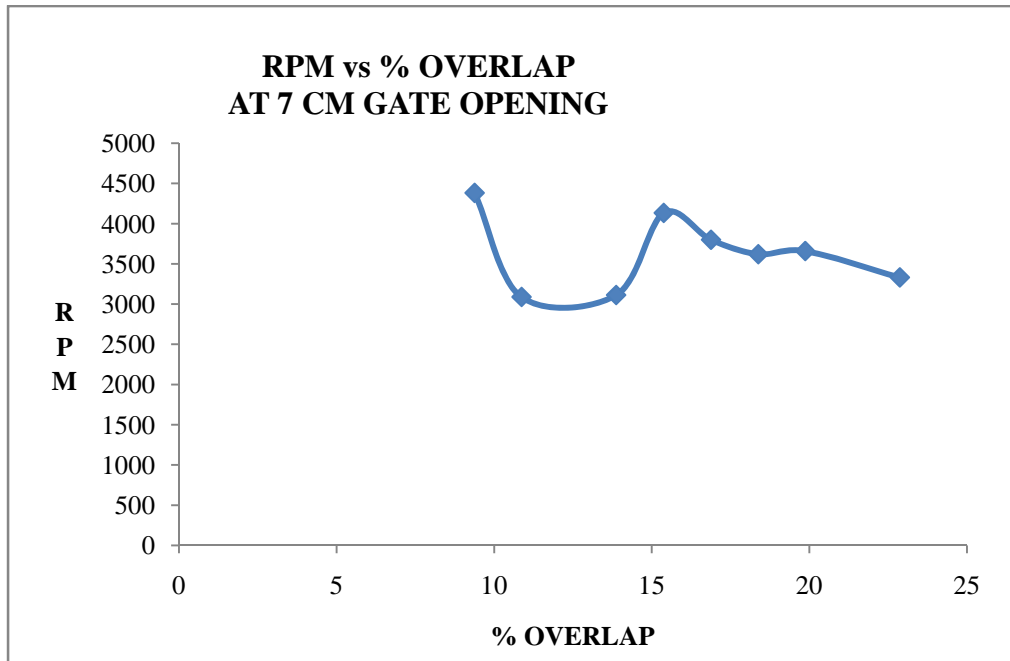
For two-bladed two-stage Savonius rotors the maximum rotational speed is obtained as 3165rpm at 15.38% overlap at 7cm gate opening. (Fig:7)

(d) For two-bladed two-stage Savonius rotors the maximum rotational speed is obtained as 3146rpm at 15.38% overlap at 7cm gate opening. (Fig:7)

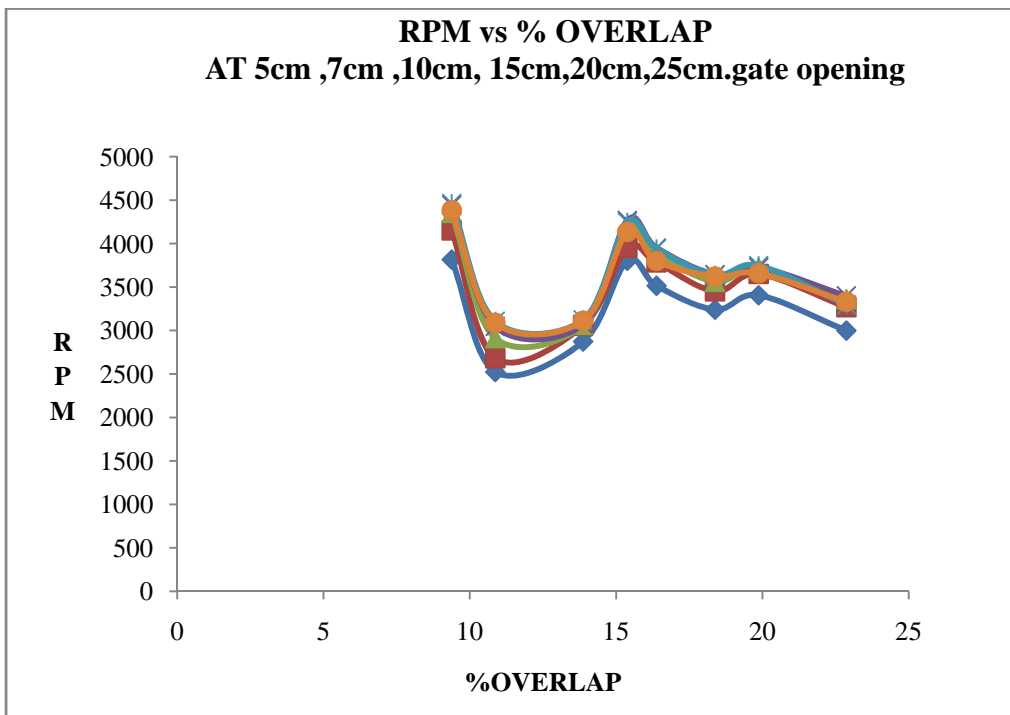
(e) For two-bladed two-stage Savonius rotors the maximum rotational speed is obtained as 3181rpm at 15.38% overlap at 7cm gate opening. (Fig:7) (f) For two-bladed two-stage Savonius rotors the maximum rotational speed is obtained as 3142rpm at 16.88% overlap at 7cm gate opening (Fig:7)



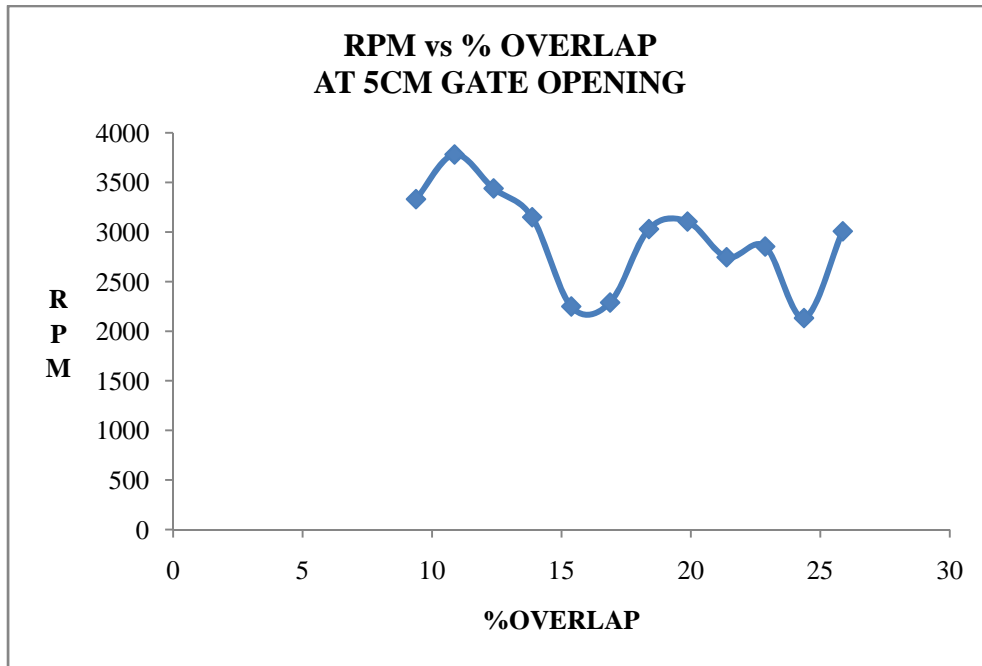
**Fig. 1:** RPM vs % OVERLAP AT 5 CM GATE OPENING  
(For two-bladed Savonius rotor)



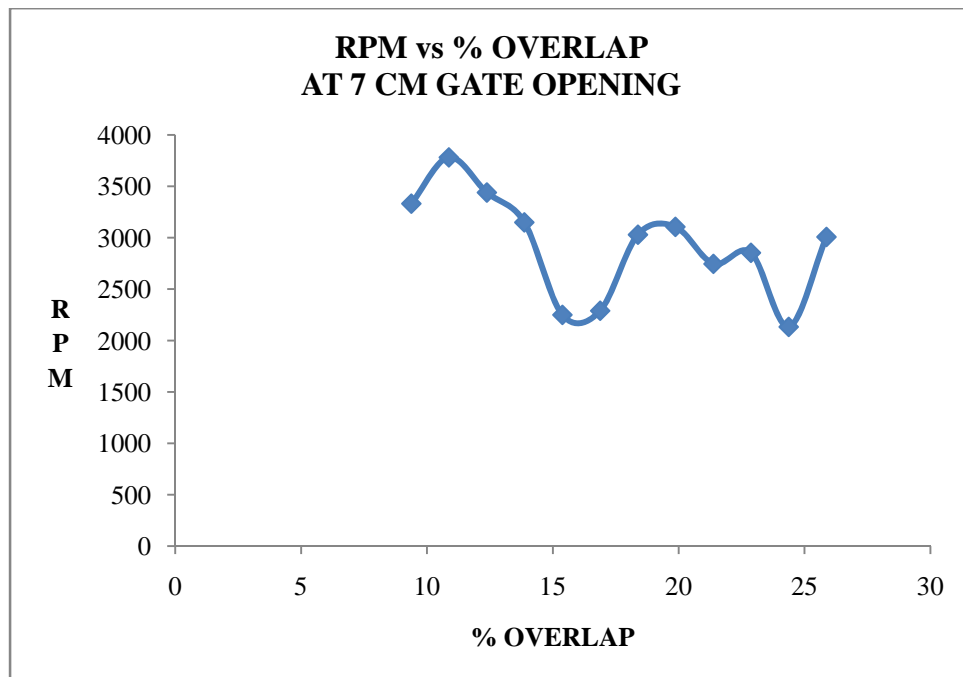
**Fig. 2:** RPM vs % OVERLAP AT 7 CM GATE OPENING  
(For two-bladed Savonius rotor)



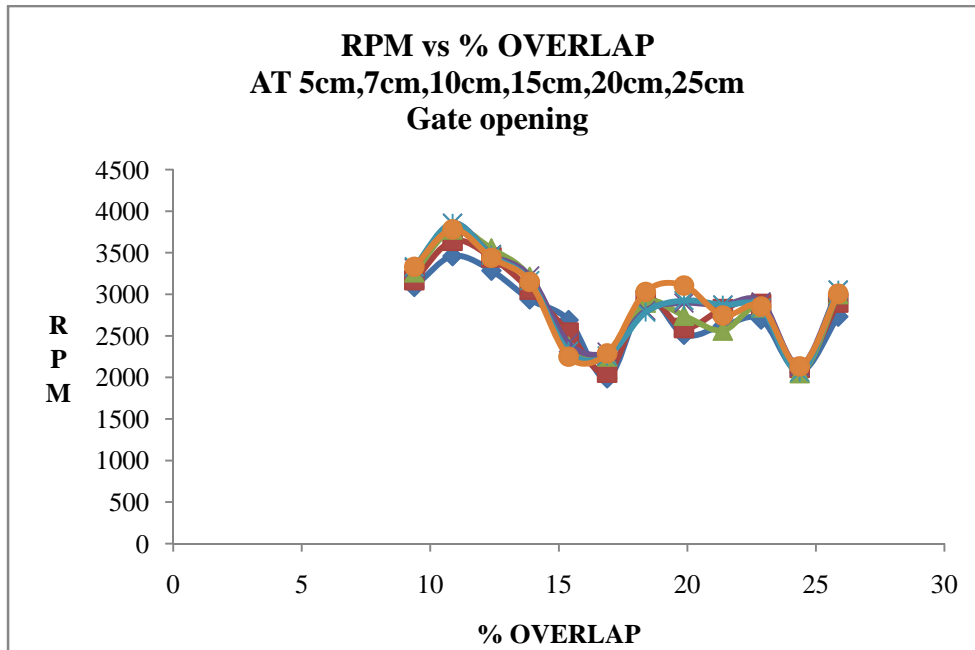
**Fig. 3:** RPM vs % OVERLAP AT 5cm ,7cm ,10cm, 15cm,20cm,25cm.gate opening  
(For two-bladed Savonius rotor)



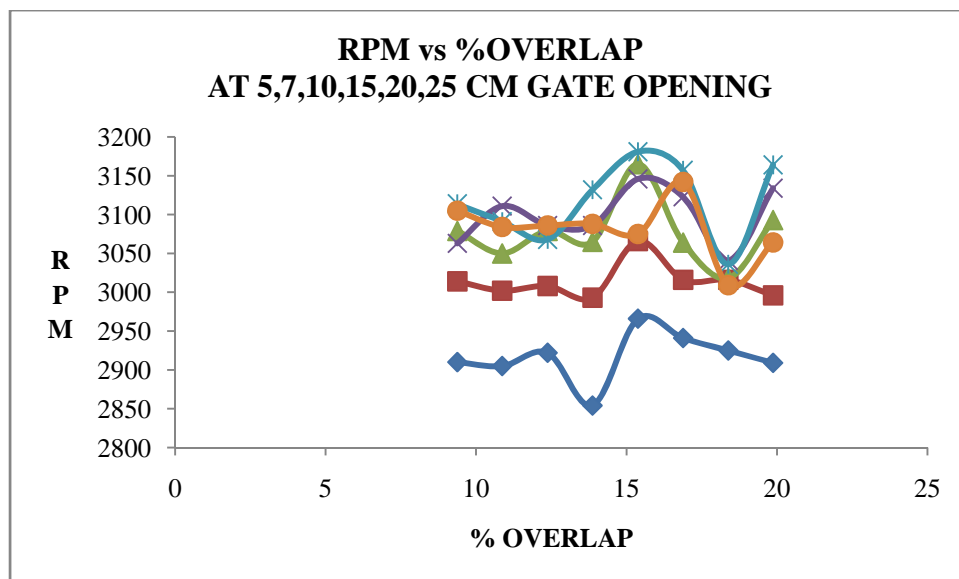
**Fig. 4:** RPM vs % OVERLAP AT 5CM GATE OPENING  
(For three-bladed Savonius rotor)



**Fig. 5:** RPM vs % OVERLAP AT 7 CM GATE OPENING  
(For three bladed Savonius rotor)



**Fig. 6:** RPM vs % OVERLAP AT 5cm,7cm,10cm,15cm,20cm,25cm Gate opening (For three bladed Savonius rotor)



**Fig. 7:** RPM vs OVERLAP (for two-bladed two-stage savonius rotor (when overlap is changed at lower savonius rotor))

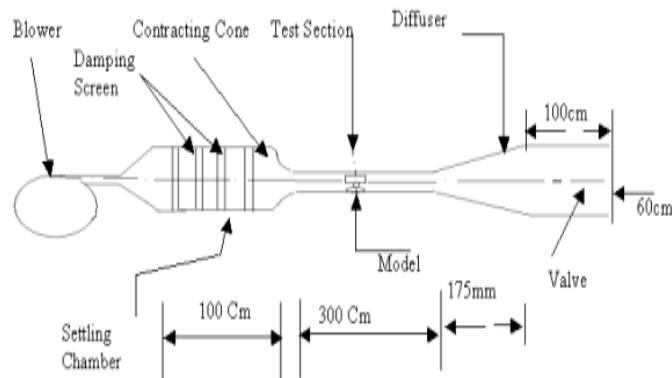
Relative variation in rotational speed of above all three types of rotor can be seen in fig 1 to fig 13 , it can be seen that there is an optimum value of overlap where rotational speed is maximum. More research in speed or power augmentation is needed.



**Fig. 8:** Three-bladed Savonius rotor



**Fig. 9:** Two-bladed Savonius rotor



**Fig. 10:** Subsonic Wind tunnel.

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