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Design Consideration & Issue with Centrifugal Fan

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Abstract: *Centrifugal fan is a device that utilizes the mechanical energy of a rotating impeller to produce both movement of the air and an increase in its total pressure. The great majority of fans used in mining are driven by electric motors, although internal combustion engines may be employed, particularly as a standby on surface fans. Compressed air or water turbines may be used to drive small fans in abnormally gassy or hot conditions, or where an electrical power supply is unavailable.*
The centrifugal fan may have one of four impeller designs.
1. Airfoil
2. Backward inclined-backward curved
3. Radial (paddle)
4. Forward curved
Most of the times for high pressure fans overhung design is considered. But arrangement should be taken extra care because of the reasons discussed as under.
Keywords: *Centrifugal fan, Types of centrifugal fan, Arrangement, Overhung, Vibration.*

I. Introduction

A driving force that causes a body to move in a circular path, for example, a centrifugal fan, centrifugal separator, or centrifugal pump, is known as centrifugal force.

In centrifugal fan, the gas flows initially in an axial direction toward the impeller. After this, in a part of the impeller blade, the gas flow becomes radial. To force the air to flow through the impeller blades of a centrifugal fan, a tangential force is needed.

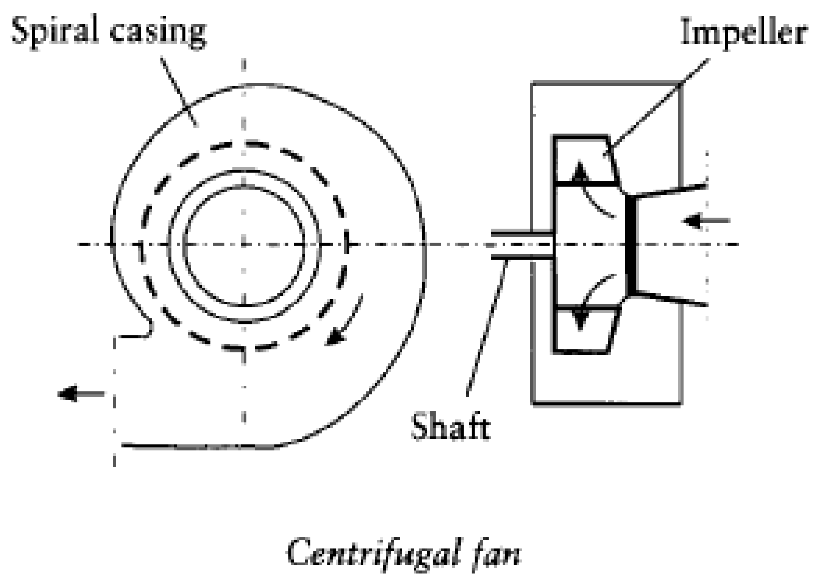


Fig. 1 Centrifugal fan

There are different types of centrifugal fan based on drive arrangement as per AMCA out of which our focus area is for Arr 8 SWSI (Single Width Single Inlet)

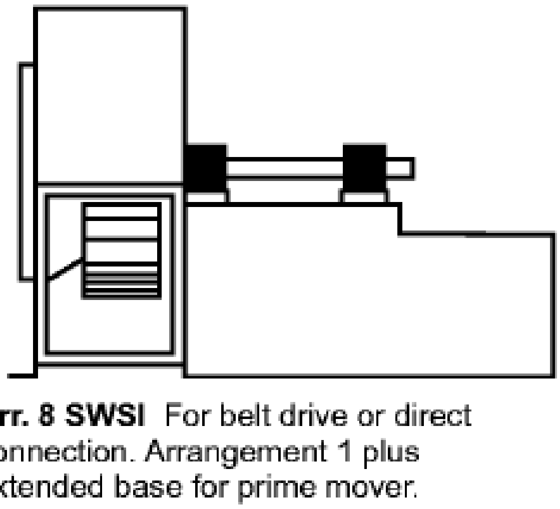
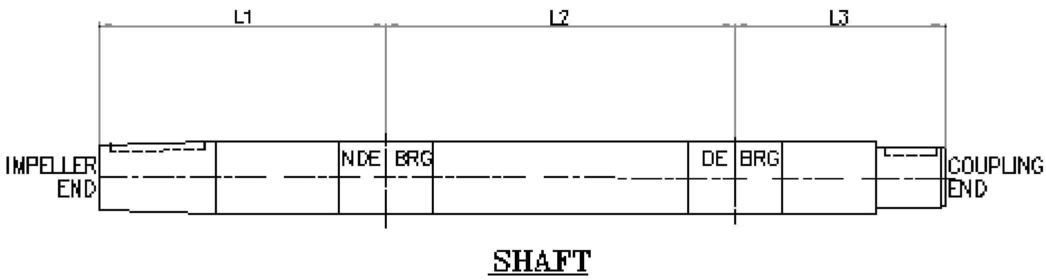


Fig. 2 For belt drive or direct connection. Arrangement 1 plus extended base for prime mover

When one consider the centrifugal fan design for overhung construction should take extra care because the centre distance between the DE (Drive End) & NDE (Non Drive End) should be in proper range otherwise same is causing the severe vibration. A typical table is attached here for the reference.



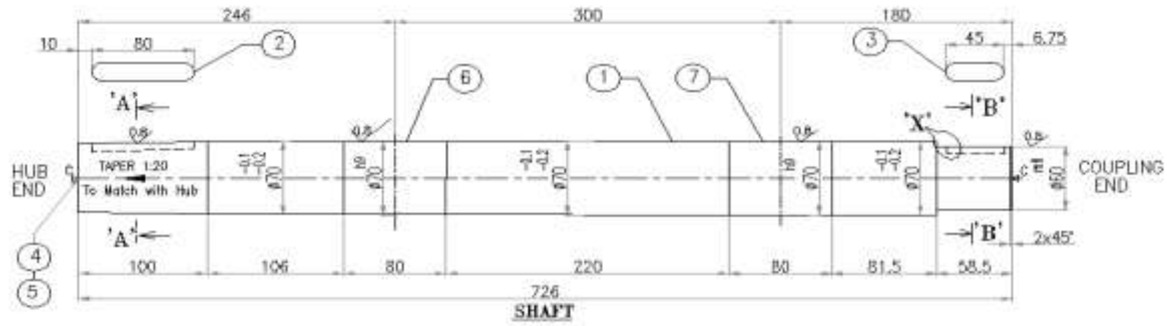
L1/L2	<0.3	<0.5	<0.7
Nc/N	1.25	1.35	1.45

Where,
Nc = Critical speed of shaft
N = Rated speed of shaft
As per the above table for overhung construction L1/L2 should be <0.7 otherwise severe vibration problem exist.
In later stage we will do the case study so that we can conclude.

II. Case Study

Below is the shaft drg. of overhung arrangement fan. As per Venti Oelde- Germany & Batliboi Ltd.- Mumbai , Nc (critical speed) of shaft calculated by software is 3982 rpm whereas N (rated speed) of shaft is 2980 rpm.
From the above table given L1/L2= 0.82, which indicates that Nc/N > 1.45.

Take the ratio of above Nc/N = 1.33<1.45, hence same will not perform within the vibration limit as per VDI 2056.
To avoid the situation following actions may be taken,
a) Increasing shaft diameter.
b) Increasing the centre distance between the NDE & DE bearings.
Option –a is costly choice.
Option-b is not causing any extra cost impact, hence this will be best choice.



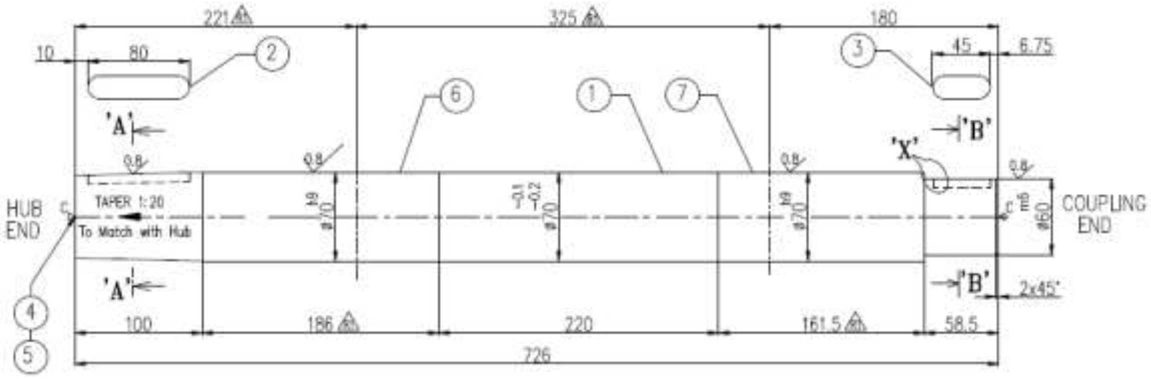
SHAFT

Pos. No.	DESCRIPTION	SIZE	MATL/MAKE	QTY.
7.4	LOCATING RING	FRB10/140	MASTA	1
7.3	PLUMMER BLOCK	SN516TC	MASTA	1
7.2	ADAPTOR SLEEVE	H316	MASTA	1
7.1	BEARING	22216 K/C3	SKF	1
7	DE BEARING ASSL'Y LOCATING	–	–	–
6.3	PLUMMER BLOCK	SN516TC	MASTA	1
6.2	ADAPTOR SLEEVE	H316	MASTA	1
6.1	BEARING	22216 K/C3	SKF	1
6	NDE BRG ASSL'Y – NON-LOCATING		–	–
5	KEEP PLATE(Hub)	120 ODx22 IDx10thk	IS:2062	1
4	HEX. BOLT+PL. WSR.+SP. WSR	M20x60 LG.	IS:1364	1SET
3	PARALLEL KEY (DE)	18x11x45 LG.	EN8	1
2	PARALLEL KEY (HUB)	18x11x80 LG.	EN8	1
1	SHAFT	ø70x726 LG.	EN8	1

Vibration level measured with above details as under.

Direction	Vibration-(mm/s)	
	DE Brg.	NDE Brg.
Axial	4.9	5.3
Vertical	6.8	7.3
Horizontal	5.9	6.9

Now consider the below attached revised shaft drg. in which only the centre distance has changed.



Nc (critical speed) of shaft calculated by software is 4470 rpm.
From the above table given L1/L2= 0.68, which indicates that Nc/N > 1.45.
Take the ratio of above Nc/N = 1.50>1.45, hence same will perform within the vibration limit as per VDI 2056. Refer the table given below.

Direction	Vibration-(mm/s)	
	DE Brg.	NDE Brg.
Axial	3.7	3.9
Vertical	4	4.1
Horizontal	3.8	3.9

One can also calculate the critical speed of the shaft by the formula given below if don't have availability of the software at their end.

$Nc = 163d^2/l \sqrt{(Mi(l+L2))}$

Where,
d= dia of shaft in 'cm'
Mi= mass of impeller in 'kg'
l= overhung length of shaft from CG if impeller to NDE bearing in 'm'
L2= centre distance between the NDE & DE bearings in 'm'

III. Conclusion

With above case study, we may conclude that shaft with R1 marked made as per the option 'b' is giving the vibration results within limit when compared with the older shaft. Again the study is based on the L1 & L2 distances taken in consideration for both the options discussed above.

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