

Swivelling Mechanism Design and Manufacturing

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ABSTRACT: This paper describes about the design and fabrication of various parts of a swiveling mechanism. Overall, this machine involves process like design, fabrication and assembly of different components etc. In India, we have lots of plants which are having the induction furnaces. The most threatening concern is Air pollution and pollutants which are emitted from the furnace. To control all the effects controlling the air pollution is mandatory work; for this Air Pollution Control (APC) system is installed. This APC system involves a Hood which is fixed over a furnace to guide the exhaust flue gases towards the filtrations bags. The stationary hood was the major problem, while pouring the raw material in furnace it was becoming an obstruction. Without moving a whole assembly a small revolving mechanism as swiveling mechanism is designed the installed. This has helped in moving the hood and making the process simple for the workers.

Keywords- Furnace/ Air pollution control unit/ Swiveling mechanism

1. INTRODUCTION

The Project we are willing to do is Swiveling Mechanism which is used in Induction furnace. This device is an important part which is located in the Induction furnace is used to turn the arm on the hood which is located just above the furnace. An Induction furnace is used where there is a capacity of 15 to 50 tons of steel is made. Here the hot fumes which comes out the furnace are guided towards the APC unit by ducts. When the capacity of furnace is fulfilled the hood position is changed from above the furnace to 90 degree position for the removal of molten metal from the furnace. This action of turning the hood from its original position to 90 degree is done by the Swiveling Mechanism or the Swiveling unit. The Swiveling Mechanism consist of number of engineering and manufacturing processes in it. The swiveling mechanism consist of a ring of gears on it which meshes with the pinion operated by a geared motor. When the molten metal is ready duel molten, with the help of the geared motor the pinion moves which is already meshed in the gear ring located on the mechanism. Due to this the unit moves thus transporting the hood carrying the dust collection system from its position. There are rollers installed on the inside of the unit which helps the easy movement of unit. When the hood is transported from the furnace to its next position the duct from the furnace gets exposed for the liquid metal for next process. The problems arise in the mechanism after installation were solved by us. The hood itself is acting as a cantilever beam it was creating more pressure on the inner bearings of the mechanism. Counterweights are attached and taper roller bearing are installed newly to solve the problem.

2. LITERATURE

A. Induction Melting Furnace is major steel producing technology using scrap & sponge iron (Directly Reduced Iron) as main raw material. This technology contributes significant steelmaking capacity in secondary steel sector in India. Process includes melting of various types of steel scrap in a pot. The energy required for the melting process is provided by electrical induction furnace. The feeding of raw material in the induction furnace is on intermittent basis. As one charge of scrap melts, slag is removed from the molten metal and certain alloys are added to achieve the desired grade of steel. Molten metal is then poured in to refractory lined buckets from where it is further poured in different sizes molds to get the desired size of steel. Ingot/Billet is allowed to cool down and then the product is separated from the molds.

B. Flue gases are generated during melting of scrap. The characteristics and volume of these gases mainly depends upon type of scrap used in the furnace, i.e. with the degree of contamination in the Scrap. These flue gases need proper treatment for removal of dust particles/gases before being discharged into the atmosphere. Steel scrap which comes from various sources and generally has contamination/coating etc. on it. When this scrap is heated contamination/coating etc. disintegrates from steel and comes out either as slag or becomes air borne, causing air pollution. The major source of Air Pollution is: Dust & Dirt Rust OIL & Grease Paint Galvanized Iron PVC Coated Steel.

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The major sources of Air Pollution are:

- Dust & Dirt
- Rust
- Oil & Grease
- Paint
- Galvanized Iron
- PVC Coated Steel

3. CONSTRUCTION AND WORKING OF SWEVELLING MECHANISM

The swiveling mechanism consists of the following components-

- Inner Shell
- Bottom Plate
- Bottom Flange
- Gear Mounting Bracket
- Vertical and Horizontal Bearings
- Rail
- Guide Rail
- Outer Shell
- Top Plate
- Top Flange
- Pinion
- Rack

A. Manufacturing:

A design of the mechanism is manufactured in the guidance of project engineer at Isha engineers and fabricators. The top plate, bottom plate, top flange, bottom flange and gear mounting bracket are cut on a pug cutting machine by the guidance of design engineer. 20 holes of 24mm diameter PCD are drilled on the top flange, top plate, bottom flange, bottom plate. The gear mounting bracket is welded on the bottom flange by double butt weld on arc welding machine. The inner shell is welded on the top plate through arc welding machine. The outer shell is manufactured by the same process as inner shell to the bottom plate. A guide rail is welded to the bottom plate as per the drawing provided by the engineer. This rail guide is stitch welded to the bottom plate. These rail guides are surface hardened to compensate the wear and friction caused by the vertical roller bearings. The development of the inner and outer shells designed as per the drawing. These plates are rolled on the rolling machine to the desired diameter. The ends of the plate are given v cuts for welding purposes. A circumferential welded joint is given to the ends of this shell. V cuts on the ends are given for the purpose of full penetration of the weld; an arc welding machine is used for this purpose. Guide flats for horizontal roller bearings. Two guide flats 20*5 are rolled on the rolling machine and stitched on the inner shell for the purpose of guiding the horizontal bearings. These flats are surface hardened to increase the hardness and to compensate the wear and friction caused by the horizontal roller bearings. 24 mm holes four numbers each are drilled on the outer shell for purpose of mounting horizontal as well as vertical bearings. A gear pinion is welded on the outer shell, this gear ring is welded to the outer shell. This gear ring is critically welded with help of an arc welding machine. A rack which is mounted on the shaft of the motor of 7.5 HP. This motor is mounted on the gear mounting bracket. The rack is coupled to the shaft of the motor. This rack meshes with pinion. The teeth of the pinion is surface hardened to improve the strength of the mesh. The hard material is used for the rack to avoid cracks or failure of teeth during the operation. It is always economical to surface harden the pinion teeth than the rack considering the size and cost of manufacturing.

B. Design

Design of gears

--Pinion Design

Number of teeth (Z) = 32

Pitch circle diameter (D) = 160

Pressure angle = 20

Module (m) = 5mm

$$\text{Circular Pitch (Pc)} = \frac{3.14 \times D}{Z} = 15.7079\text{mm}$$

$$\text{Diametric Pitch (Pd)} = \frac{Z}{D} = 0.2\text{mm}$$

$$\text{Addendum } = m = 5\text{mm}$$

$$\text{Deddendum} = 1.25 \times m = 6.25\text{mm}$$

$$\text{Tooth thickness} = 1.5708 \times m = 7.854\text{mm}$$

$$\text{Fillet radius} = 0.4 \times m = 2\text{mm}$$

$$\text{Working depth} = 2 \times m = 10\text{mm}$$

$$\text{Total depth} = 2.25 \times m = 11.25\text{mm}$$

$$\text{Top diameter} = \text{Addendum} + \text{PCD} = 2305\text{mm}$$

$$\text{Bottom diameter} = \text{PCD} - \text{Dedendum} = 2293.75\text{mm}$$

--Rack design

$$\text{Number of teeth (Z)} = 460$$

$$\text{Pitch circle diameter (D)} = 2300\text{mm}$$

$$\text{Pressure angle} = 20$$

$$\text{Module (m)} = 5\text{mm}$$

$$\text{Circular Pitch (Pc)} = \frac{3.14 \times D}{Z} = 15.7079\text{mm}$$

$$\text{Diametric Pitch (Pd)} = \frac{Z}{D} = 0.2\text{mm}$$

$$\text{Addendum } = m = 5\text{mm}$$

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Design of bearings.

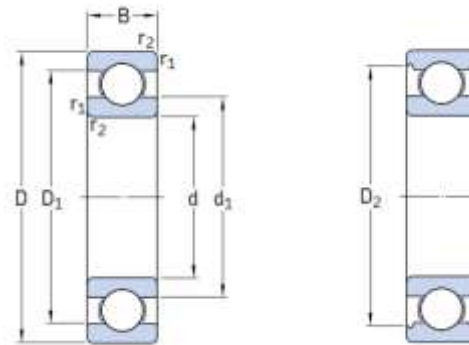


Fig – 3.1

- Diameter (d) = 65 mm
- Axial load (Fa) = 1000 N
- Radial load (Fr') = 10000 N ; Loading factor (fa) = 1.5
- Actual radial load (Fr) = Fr' * fa
 = 10000 * 1.5
 = 15000 N
- Equivalent static loading load (P0) :
 $P0 = 0.6 * Fr + 0.5 * Fa$
 = 0.6 * 15000 + 0.5 * 1000
 = 9500 N
 If P0 < Fr, then P0 = Fr = 15000 N

Table 3.1 – SKF single row deep groove bearing data

Principal dimensions			Basic load ratings		Fatigue load limit Pu	Speed ratings		Mass	Designation
d	D	B	C	C0		Reference speed	Limiting speed		
mm			kN		kN	r/min		kg	-
65	85	10	12,4	12,7	0,54	16 000	10 000	0,13	61813
	90	13	17,4	16	0,68	15 000	9 500	0,22	61913
	100	11	22,5	16,6	0,83	14 000	9 000	0,30	* 16013
	100	18	31,9	25	1,06	14 000	9 000	0,44	* 6013
	120	23	58,5	40,5	1,73	12 000	7 500	0,99	* 6213
	140	33	97,5	60	2,5	10 000	6 700	2,10	* 6313
	160	37	119	78	3,15	9 500	6 000	3,30	6413

By using above table,

- The bearing no. 61813 satisfied the given loading condition.
 C0 = 16 kN

- Basic rating life of a bearing according to ISO 281:1990 is
 $L10 = (C/P)^p$

Where, L10 = basic rating life (at 90 % reliability) millions of revolutions,
 p = exponent of the life equation
 = 3 for ball bearings and 10/3 for roller bearings

$$\begin{aligned}L10 &= (16/15)^P \\ &= (1.066)^3 \\ &= 1.213 \text{ million revolutions}\end{aligned}$$

- Selected bearing designation : 61913.

C. Working:

The top plate and the top flange are bolted together with 20 bolt of M24. The bottom plate and the bottom flange are also bolted together by 20 bolts of M24. This is done for a purpose of maintenance and prevention of accidents. The rack mounted on the input shaft of the motor acts as a driving member to the mechanism. The input shaft rotates the rack which is meshed with the pinion. The bearings which are mounted on the inner side of the outer shell helps in the circular motion of the outer shell. The horizontal and the vertical guide rails are attached to the inner shell and the bottom plate to ensure the right path of the bearings. These guide rails help in the orientation of the bearing and prevent run out during operation. The hood is attached to the top flange. This mechanism is used to change the position of the hood, when the induction furnace serves its purpose. When the position of the hood is changed to 90 degrees from the point of loading the process of loading of raw material in the furnace or unloading of molten metal from the furnace. When the furnace is in action the fumes created by the molten metal inside the furnace are directed inside the hood by the exhaust fans. Which further go to the bag filter unit. This mechanism is designed to withstand very high temperature.

Points to be noted:

1. We should ensure that proper maintenance and inspection of the gear and pinion teeth are done at a specific time interval.
2. We should ensure that the maintenance and inspection of the bearings are done to prevent failure of bearings.
3. The device is coated with a red oxide paint to avoid rusting of the entire unit.
4. We should ensure that the bolts are aligned properly on both the flanges to avoid misalignment of the unit.
5. The rate of failure of the rack is more than the pinion, so we need to ensure that the rack is inspected at regular time for cracks and wear. The rack should be manufactured at the end of its life.
6. Proper greasing and lubrication is supposed to be done on parts with excessive relative motion.
7. The exhaust fan and ducts behind the hood should be maintained for its optimum use.

Points to be avoided:

1. Disorientation of bearings.
2. Misalignment of rack and pinion
3. Misalignment of hood and the top of furnace during the heating process.

D. Conclusion

This work represents the design and manufacturing of swiveling mechanism for Air Pollution Control unit. The machine was fabricated with materials designated by the designer and manufacturer. It is used for changing the position of the hood which is used to absorb the fumes extracted from the induction furnace. The design gives major advantages in the application of the fumes extraction from the furnace. Our designed machine is as compact and weight efficient required for its application. It is easy to understand and work in different applications other than fumes extraction. The bearings are used for giving effortless motion to the outer shell. It is recommended for lubricating all the parts that give motion to the unit. It is also recommended to keep the unit rust free by proper painting with red oxide coats and lubrications.

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