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Design of adjustable Sleeve Ring for Burner Combustion Head of 2 TPH Burner Capacity

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Abstract - *This project aims to develop an adjustable sleeve ring for burner combustion head of industrial oil burners of 2 TPH capacity. A rack and pinion mechanism will render to and fro motion of the ring. The position of the ring inside the head will depend upon the mass flow rate of air provided for combustion. When a large quantity of fuel is to be burned, the usual mass flow rate of air suffices for obtaining the desired air fuel ratio resulting in proper combustion. Reduction in mass flow rate of fuel demands diminishing the quantity of air supplied. In this case of low load, maximum air supplied to the combustion head should be used to maintain constant air fuel ratio.*

Key Words: Sleeve ring, Low load, Air fuel ratio, Rack and Pinion, Combustion Head

1. INTRODUCTION

A rotating diffuser plate creates turbulence ensuring proper mixing of air and fuel. But, during this process some amount of air escapes through the clearance between the plate and burner. In low load conditions this loss of air is crucial as it affects the overall performance of the burner. The sleeve ring will ensure minimum loss of air through the clearance, ensuring constant efficiency of burner even when operating under low load conditions. The sleeve ring, owing to it's tapered cross section will diverge the flow of air towards the diffuser plate, acting as a barrier to cover up the clearance. The sleeve ring will be connected to a rack of a rack and pinion mechanism via a rigid, L-shaped link. The link will be welded to the rack and the sleeve ring. To ensure frictionless motion of the ring inside the head, the ring will be provided with six spheres which will roll on the inner wall of the burner. The sleeve ring will be manufactured in 2 parts. The outer part will be ring shaped having 2mm thickness, and the inner part will have a tapered cross section. During low load conditions, the sleeve ring will be positioned close to the diffuser plate, ensuring minimum loss of air between the clearances mentioned above. During high load conditions, the ring will be positioned away from the plate, as certain amount of air loss is acceptable, as it has no adverse impact on the burner's efficiency.

2. LITERATURE REVIEW

Stainless steel is used for making the sleeve ring[1] because stainless steel can operate at higher temperatures when carbon and low-alloyed steel do not provide adequate corrosion resistance or strength. Stainless steel can be used in applications in which high-temperature corrosion or high-temperature strength is required. The term "high-temperature corrosion" is not very accurate. It generally concerns "dry" corrosion, usually by gases, and what is high for one material may be low for another. However, in the case of stainless steel it can often be taken to mean 500°C and higher. Under these conditions, the surface alteration produced on stainless steel is usually fairly uniform. Stainless steel also has high strength, high hardness with a superior microstructure that extends fatigue life by as much 100% (double) in certain applications. Hence, stainless steel is selected for making of the sleeve ring.

Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. [2] This mechanism is used to convert the rotation of the pinion into linear motion of the rack which with the help of links moves the sleeve ring linearly inside the burner. Rack and pinion combinations are often used as part of a simple linear actuator, where the rotation of a shaft powered by hand or by a motor is converted to linear motion. The rack carries the full load of the actuator directly and so the driving pinion is usually small, so that the gear ratio reduces the torque required. The advantages of using rack and pinion mechanism are cheap, compact, and robust, it is the easiest way to convert rotation motion into linear motion and it gives easier and more compact control on motion of the sleeve ring.

Fig -1: Industrial Burner

3. CALCULATIONS AND DESIGN

Given: Motor Speed=1 rpm

Motor Torque= 15 Nm

Design of pinion: [3]

Considering; number of teeth on Pinion = 18

Calculations:

The material selected is Plain Carbon Steel (PCS) of Grade 50C4

Based on the given data,

Power (P) = $\frac{2\pi NT}{60000}$ = 1.570 kW

Pitch line velocity (v) = $\frac{\pi DN}{60000} = \frac{\pi*(18*m)*1}{60000}$ = 9.424*10^{-4}*m, ms^{-1}

Tangential force (F_t) = H.P.* $\frac{75}{V} = \frac{167.1264}{m}$ kgf

Velocity factor (C_v) = $\frac{3+v}{3}$

Bending force (F_b) = σ_b * b * $\frac{y}{P_d}$

Effective force (F_{eff}) = F_t*C_V = 2751.932*m^2, kgf

Now,

$F_{eff} = N_f*\sigma_b$

Substituting the values, we get

6.3001*m^3- (3.1413*10^{-4})*m^{-1} = 0

On solving above equation, we get

m = 6 mm

PCD=108 mm

v = 0.3392 $mmin^{-1}$

b = 10*m = 6 cm

C = 11440*0.05 = 572 mm

To prevent gear from failure,

Bending force (F_b) ≥Dynamic force (F_d)

Dynamic force (F_d) = F_t*C_V = 279.928 N

Bending force (F_b) = 990.6956 N

Therefore,

990.6956 ≥ 279.92

Hence, the design is safe

Design of Rack:

Based on values obtained for pinion, dimensions for rack were obtained using following equations:

Circular Pitch (P_c) = π*m = π*6 = 18.849 mm

Base Pitch (P_b) = Pc*cosØ = 18.849 * cos(20) = 17.71 mm

Length to be traversed by sleeve ring = 70 mm

Hence, Length of Rack = 80 mm

No. of teeth for 80 mm length = 4

We know that, to prevent gear from failure,

Bending force (F_b) ≥Dynamic force (F_d)

Dynamic force (F_d) = F_t*C_V = 279.928 N

Bending force (F_b) = 990.6956 N

Therefore,

990.6956 ≥ 279.928

Hence, the design is safe

Checking for pinion gear safety: [4]

PCD = 4.25 inch

$d_p = \frac{N}{PCD} = \frac{18}{4.25}$ = 4.233 inch

v = $\frac{\pi*4.23*1}{12}$ = 1.108 ft/min

Transmitted load (W^t) = $\frac{33000H}{v} = \frac{33000*0.00202}{1.108}$ = 60.1624 lbf

$\sigma = W^t K_o K_v K_s \frac{PCD}{F} (\frac{K_m K_b}{J}) \frac{C_f}{I}$

C_f = 1

Q_v = 5

B = $0.25(12 - Q_v)^{\frac{2}{3}}$ = 0.91

A = 50+56(1-B) = 54.769

$K_v = \left(\frac{A+\sqrt{v}}{A}\right)^2$ = 1.0174

I = $\frac{\cos 20^\circ \sin 20^\circ}{2} = \frac{2.33}{2.33+1}$ = 0.11

$C_p = \left(\frac{1}{\sqrt{\left[\pi\left(1-\frac{v^2}{q_g}\right)\right]}}\right)^2$ = 5477

$\sigma_c = C_p (W^t K_o K_v K_s \frac{K_m}{d_p*F} \frac{C_f}{I})^{1/2}$ =

$5477\,(60.1624 * 1.5 * 1 * 0.03695 * (\frac{1.1316}{4.233*0.23122} * \frac{1}{0.11})^{1/2}$

= 32079.369 psi

S_c = 170000

Z_w = 1

$(S_h)_p = [\frac{S_c Z_w / K_t K_R}{\sigma_c}] = \frac{170000*1/1*1.5}{32079.369}$ = 3.5329

S_F = 84.6815

$(S_H)^2$ = 12.48

Therefore,

Since, $(S_H)^2 < S_F$

Hence, the design is safe in wear failure.

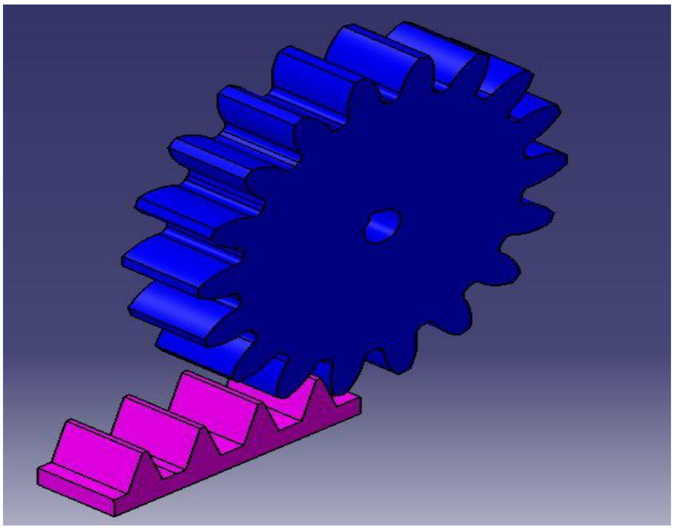

Fig -2: Rack and Pinion

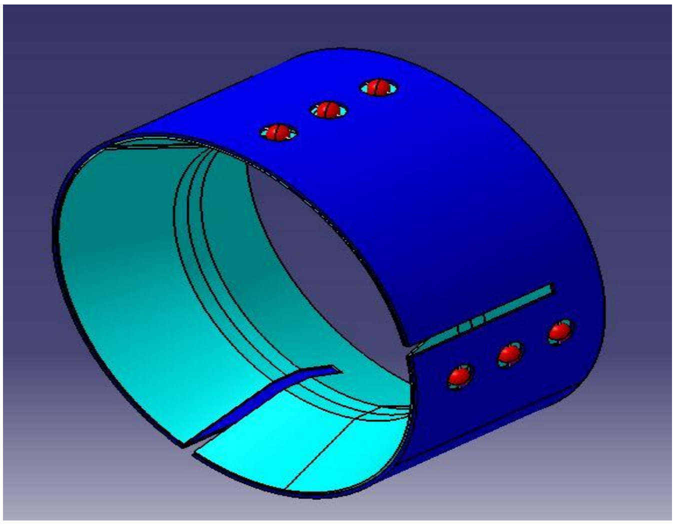

Fig -2: Sleeve Ring Sub-Assembly

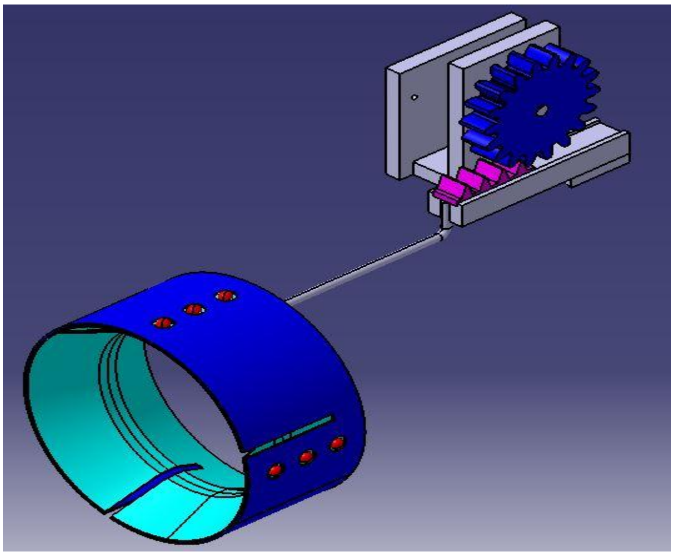

Fig -2: Complete Assembly

4. CONCLUSION

In this paper, we have designed a rack and pinion mechanism for facilitating linear motion of sleeve ring inside a burner combustion head of 2 TPH capacity. This mechanism will offer precise control over movement of sleeve ring, ensuring desired output from the burner.

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