Metal Dust Collection System

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Abstract— In today's world safety of operator is prime essential thing in much type of metal handling industries. The machines and equipment used in many firms are modern type of instrument but the all older machines and equipment are not yet decommissioned. Many type of old machines with or without upgrades are still operating but with less safety measures and less health assurance. To achieve this health assurance in metal handling industries like in Parth Tool Company we introduced this project. In such tool manufacturing companies metal dust production is very frequent in the workplace which is very unwanted. In many industries the dust collection system is not available for older machines. This reduces the health assurance of the operators. To overcome this problem our team introduces this project to the metal handling industries.
Key words: Metal Dust, Machines

I. Introduction

According to India's Central Statistical Office, over 38,20,000 workers in India are involved in the production of materials and products made of metals and their alloys; those workers are often exposed to dusts. The most frequently processed materials are bronze, brass, steel, aluminium alloys, zamak (zinc and aluminium alloys) and cast iron. The adverse effects of inhaling dust depend on both the chemical composition and the size of the dust particles. Operators of machines that process steel parts can be exposed to dusts containing iron, copper, nickel, manganese, magnesium and many other elements used in alloys. Processing parts made of brass can result in exposure to dusts containing copper, zinc, tin, lead, iron, manganese, etc. Special attention should be paid to the size of the inhaled particles that contain metals and their compounds. Fine dust particles released in processing metallic materials remain airborne for an extended period. Chronic exposure to dusts containing metals and their compounds can cause respiratory disorders. The size of the dust particles determines the location of their deposition in the respiratory system. In addition, the content of metals in individual particle size fractions of the dust can vary, and their bioavailability increases with the decreasing size of the dust particles they are contained in. For this reason, it is extremely important to know the content of metals in the dust fractions, which may be transferred to individual parts of the respiratory system, especially the gas exchange area in the lungs. We observed this problem in Parth Tool Company. Parth Tool Company is the firm that involved in metal cutting operation and manufacturing of high speed steel and carbide tools. Many of these products are grinded using optical profile grinding machine. In this firm some machines like optical profile grinders are spreading dust in the workplace. The machines are very old and they don't have in built dust collector. The workers in this firm are working in dusty environment which is not good for their health. To overcome this issue we are committed to install dust collection system for the optical profile grinding machine.

II. About Optical Profile Grinding Machine

A. Machine Specifications

- MODEL NAME: Petewe FPS 4v Optical Profile Grinding Machine
- YEAR OF MANUFACTURE: 1965
- OPTICAL MAGNIFICATION: 10x, 20x, (possibly 50x)
- PROJECTION AREA: 440 x 280 mm
- WEIGHT: 3,000 kg
- Adjustable diamond dressing device for achieving profiles
- Central lubrication system

B. Operation

1) OPG machine is used for finishing of tool profile
2) In this machine profile grinding is done by magnifying tool profile on the monitor by means of optics
3) It is finishing process hence scrap or chips formed are in the form metal dust particle
4) As the machine manufacturing is very old ,no metal dust exhaust is provided with machine and also without less accessories and sensors

C. Problems Arrived During Operation

1) During operation metal chips in the form of metal dust spread in the workplace ,floor and also on the body of operator
2) Also machine is not equipped with nc or cnc system and also with very less accessories it is not possible to operate it from a long distance
3) This metal dust particle are not good for the health of operator and other working staff in workplace
4) This metal dust collected from the floor is not further usefull due mixing up with other materials
5) These carbide chips with less or no impurity recycling get more economical and easier

III. Dust Collector

A dust collector is a system used to enhance the quality of air released from industrial and commercial processes by collecting dust and other impurities from air or gas. Designed to handle high-volume dust loads, a dust collector system consists of a blower, dust filter, a filter-cleaning system, and a dust receptacle or dust removal system. It is distinguished from air cleaners, which use disposable filters to remove dust

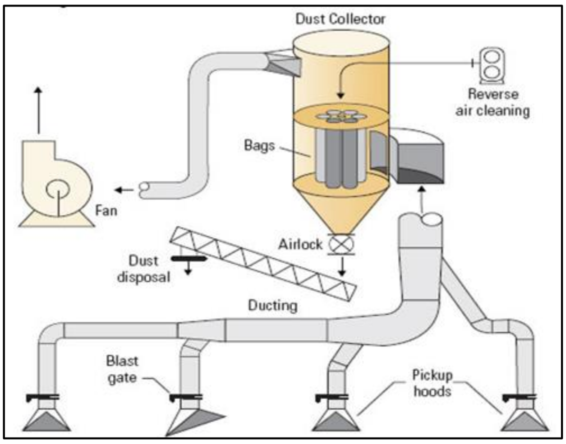

Fig. 1: Schematic Dig of General Dust Collector

A. Components of Metal Dust Collection System

1) Fan
2) Motor
3) Pickup hoods
4) Collecting bags

IV. DESIGN ANALYSIS

A. Finding Suction Air Velocity (V_s)

$$V_s = 2.055\omega \left\{ \frac{(\frac{b}{D_c})^{0.4}}{(1-(\frac{b}{D_c}))^{1/3}} \right\} D_c^{0.067} . V_i^{2/3}$$

$$\omega = [4g\mu \frac{\rho_p - \rho_f}{3\rho_f^2}]^{1/3}$$

Where,
V_s= air velocity, m/s
D_c= Cyclone diameter, m
μ = Fluid viscosity, Kg/ms
ω = Omega, m/s
Vi = Inlet velocity, m/s
P_p = Particle density, Kg/m3
b= Inlet width, m
g= Gravity, 9.81 m/s2
ρ_f= Fluid viscosity, Kg/m3

If velocity ratio≤1.25, cyclone will be have maximum collection efficiency.

If velocity ratio ≥ 1.36, it will be caused the entrainment.

B. Calculating Volumetric Flow Rate

Q=ab V_i
Where,
Q= Total gas flow rate, m^3/s
b= Inlet width, m
a= Inlet height, m
V_i= Inlet velocity, m/s

C. Calculating Natural Length, l

$$l = 2.3D_e \left[\frac{D_c^2}{ab}\right]^{1/3}$$

Where,
l= Natural length, m
D_e = Cyclone gas outlet diameter, m
D_c= Cyclone diameter, m
a= Inlet height, m
b= Inlet width, m

D. Calculating Vortex Exponent (n), Cyclone Configuration Factor (G), and Relaxation Time (τ)

$$n = 1 - [1 - (12D_c/2.5)^{0.14}][(T + 460)/530]^{0.3}$$

Where,
n= Vortex exponent
D_c = Cyclone diameter, m
T= Temperature, ^0C

$$G = 8K_c/K_a^2.K_b^2$$

$$K_a = \frac{a}{D_c}$$

$$K_b = \frac{b}{D_c}$$

$$vs = \frac{\left\{\pi\left[S - \frac{a}{2}\right]\left[D_c^2 - D_e^2\right]\right\}}{4}$$

$$K_c = \frac{2vs + (V_{nl} \text{ or } V_H)}{2D_c^3}$$

If l> (H-S),V_H is chosen for calculate K_c

$$V_H = \left[\frac{\pi D_c^2}{4}\right](h - s) + \left[\frac{\pi D_c^2}{4}\right]\left[\frac{H - h}{3}\right]\left[1 + \left(\frac{B}{D_c}\right) - \left(\frac{B^2}{D_c^2}\right)\right] - \left[\frac{\pi D_e^2}{4}\right](H - S)$$

If l< (H-S),V_{N1} is chosen for calculate K_C

$$V_{nl} = \left[\frac{\pi D_c^2}{4}\right](h - s) + \left[\frac{\pi D_c^2}{4}\right]\left[\frac{l + S - h}{3}\right]\left[1 + \left(\frac{d}{D_c}\right) - \left(\frac{d^2}{D_c^2}\right)\right] - \left[\frac{\pi D_e^2}{4}\right]l$$

Where,
G = Cyclone configuration factor
B = Cyclone dust outlet diameter, m
V_H = Volume below exit, m^3
h = Cylindrical height of cyclone, m
K_e= Cyclone volume constant
V_{n1} = Volume at natural length, m^3
H = Cyclone height, m
s = Gas outlet length, m
d = Diameter of central core at point where vertex turns, m
Vs = Annular volume above exit duct to middle or entrance duct, m^3

$$\tau = \frac{\rho_p (d_{pi})^2}{18\mu}$$

τ=Relaxation time, sec
d_P =Particle size,m
ρ_p= Particle density, Kg/m^3
μ= Fluid viscosity, Kg/ms
i= Subscript denoted interval in particle size range
4.5 Calculating Grade or Fractional efficiency

$$\eta_i = 1 - \exp\left\{-2\left[\left(\frac{G\tau Q}{D_c^3}\right)(n + 1)\right]^{\frac{0.5}{n+1}}\right\}$$

Where,
η_i= Grade efficiency, %
G = Cyclone configuration factor
τ= Relaxation time, sec
n = Vortex exponent
Q= Total gas flow rate, m^3/s

E. Calculating Overall Collection Efficiency

$\eta_T = \Sigma m_i \eta_i$

Where,
η_T = Overall collection efficiency (%)
m_i= Proportion of particle size range
η_I = Grade efficiency

F. Calculating Pressure Drop by using Equation as Follows

$\Delta P = 0.003\rho_F * V_i^2 * N_H$
$N_H = K(ab/D_e)$
Where,
ΔP = Pressure drop, in N/m^2
V_i= Inlet velocity, m/s
K = Empirical constant
ρ_2= Fluid density, Kg/m3
N_H= Number inlet velocity head
D_E= Cyclone gas outlet diameter, m
(K=7.5 for a cyclone with an inlet vane)
(K=16 for a normal tangential inlet)
After designing, dimensional proportions of cyclone have to be under the criteria Conditions,
$a \leq s$
$b < \frac{1}{2} (D_c - D_e)$
$s + l \leq H$
$s < h$
$h < H$
$\Delta P < 10$ in w g
$V_i / V_s \leq 1.35$

V. Selecting a Dust Collector

Dust collectors vary widely in design, operation, effectiveness, space requirements, construction, and capital, operating, and maintenance costs. Each type has advantages and disadvantages. However, the selection of a dust collector should be based on the following general factors:

A. Dust Concentration and Particle Size

For minerals processing operations, the dust concentration can range from 0.1 to 5.0 grains (0.32 g) of dust per cubic feet of air (0.23 to 11.44 grams per standard cubic meter), and the particle size can vary from 0.5 to 100 micrometer (µm) in diameter.

B. Degree of Dust Collection Required

The degree of dust collection required depends on its potential as a health hazard or public nuisance, the plant location, the allowable emission rate, the nature of the dust, its salvage value, and so forth. The selection of a collector should be based on the efficiency required and should consider the need for high-efficiency, high-cost equipment, such as electrostatic precipitators; highefficiency, moderate-cost equipment, such as baghouses or wet scrubbers; or lower cost, primary units, such as dry centrifugal collectors.

C. Characteristics of Airstream

The characteristics of the airstream can have a significant impact on collector selection. For example, cotton fabric filters cannot be used where air temperatures exceed 180 °F (82 °C). Also, condensation of steam or water vapor can blind bags. Various chemicals can attack fabric or metal and cause corrosion in wet scrubbers.

D. Characteristics of Dust

Moderate to heavy concentrations of many dusts (such as dust from silica sand or metal ores) can be abrasive to dry centrifugal collectors. Hygroscopic material can blind bag collectors. Sticky material can adhere to collector elements and plug passages. Some particle sizes and shapes may rule out certain types of fabric collectors. The combustible nature of many fine materials rules out the use of electrostatic precipitators.

E. Methods of Disposal

Methods of dust removal and disposal vary with the material, plant process, volume, and type of collector used. Collectors can unload continuously or in batches. Dry materials can create secondary dust problems during unloading and disposal that do not occur with wet collectors. Disposal of wet slurry or sludge can be an additional material-handling problem; sewer or water pollution problems can result if wastewater is not treated properly.

VI. Conclusion

To enhance the safety and health of machine operators, it is necessary to install a system which is capable of maintaining dustless atmosphere in the workplace. Because the dust in the metal handling industry is not a normal dust these are small particles of metal floating in the air and it is responsible for respiratory and visual disorders of the operator Also the machine design is very old and it is not upgraded with latest technologies according to change in time if this up gradation is not done furthermore then the machine became useless after some years. Our project is to install a metal dust collection system to collect dry or wet metal dust particle can be seen as a one forward footprint toward a machine upgrading. This upgrading not only gives the assurance to the help of operator but also a productivity improvement technique. Machine will collect dust automatically hence no more requirement of manual cleaning. These will reduce the time consumption to clean the machine and floor. The collected dust can be used as raw material for powder metallurgy product. In overall we can say that although it will consume more power, more space and more operational cost it will provide a good health assurance, good productivity and good ability of visual inspection during operation

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