Blast Furnace-8 with Effective Waste Heat Recovery Systems

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Abstract- *nowadays power system is facing dramatic changes and operational requirements regarding electric power as a result deregulation in power system has occurred. The growth in continuous electric load and high regional power transfer in a huge interconnected system leads us to a complex and less secure operational power system. The generation, distribution and transmission of power facilities of growing demand is not able to meet the new demands as per economic, environmental, technical and governmental regulation at the same time the growing demand of electronic loads have made quality of power system an critical issue. So now power system engineer needs more reliable and accurate solution of this challenging phase of our power system with more flexible and controllable manner.*

Keywords- CSTR-PID-ZN-Fuzzy-MRAM-MATLAB.

I. INTRODUCTION

The occurrence of power system disturbances, synchronous generator is not always able to respond quickly enough to make system stable. If control of high-speed reactive power is available, generator dropping or load shedding may be avoided during those disturbance hours.

Recent development in energy storage power electronic technologies is making things easier. Storage technologies include batteries, flywheels, superconducting energy storage system and ultra capacitor. All these technologies were initially envisioned for large-scale load leveling. But energy storage is nowadays seen more as a tool to enhance power system stability and power transfer and improves power quality of the power system. A huge amount of flue gas is being generated at the top of the furnace. With the help of turbine that flue gas is being utilized and a amount of energy is then generated through turbine, but the fluctuation of gas at the top of the blast furnace is responsible for the fluctuation of power generated through turbine. If reduction in fluctuation of top pressure of the blast furnace is maintained then the power quality of power generated through turbine can be done. Proposing equipment for the reduction of the fluctuation is main object of this paper. Meanwhile selecting flywheel for the reduction of the fluctuation of top pressure of the blast furnace is proposed. And respective work regarding this project is being done, meanwhile the result regarding this paper is still awaited.

II. FLYWHEEL

Flywheels are used to store energy for power system, when flywheel is coupled with an electric machine. Generally power convertors are used to drive the electric machine to operate in a wider range. Now the stored energy depends on the moment of inertia of a rotor and the square of the rotational velocity of a flywheel. And moment of inertia (I) depends on the radius, mass, height and length of the rotor. Energy is then transferred to the flywheel when the machine is in the mode of operation of motor, and charging the energy storage device. Eventually flywheel is discharged when electric machine regenerates through the drive or slowing the flywheel.

The capacity of energy storage of flywheel can be improved either by accelerating or increasing the moment of inertia of the flywheel.

Two strategies have been utilized in the advancement of the flywheel for power applications. Option one is to increase the inertia while using a steel mass with a large radius, with rotational velocity approximately 10,000 rpm. A standard motor and power electronic drive can be used as power conversion for this type of designs is available as uninterruptible power supply (UP's).

Option second is to produce flywheel with a lightweight rotor running at very high rotational velocity i.e. up to 100,000 rpm. This approach is concept and light weight energy storage device. Flywheel resist changes with their rotational speed, which helps the rotation of the shaft when a torque of fluctuation is exerted on it, by its power source such as piston-based engine, when an intermittent load is placed on it. Flywheel are used to produce very high power pulses for experiments, where drawing the power from the public network would produce spikes. Modern technology has enabled as a new application for the new equipment flywheel, in advanced flywheel energy storage system. The flywheel energy storage system stores energy in the form of kinetic energy. As hot flue rotates flywheel and energy is being stored in the batteries, and this energy is again feed back to the grid at the time of power on demand and an active power would be supplied to the grid.

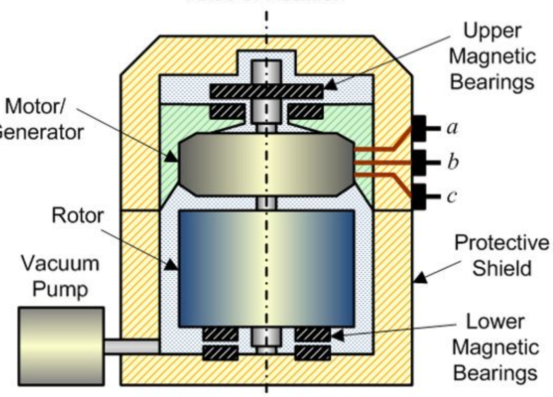

Figure 1 flywheel energy storage system

Energy storage systems-

The most important type of energy storage system for practical application of the proposed method is equalizing the output power of a TRT with stochastic nature of the input of the turbine are secondary electrochemical cells can flywheel.
Above all the advantages of the flywheel as compared to the electrochemical cells lead acid and lithium-ion batteries. They contain constant value of energetic capacity in the range of temperature -35^{0}c to +40^{0}c, covering all weather conditions on yearly basis and huge amount of charging and discharging cycle reaching mllions life span of 15-20 years and short duration of storage charging approxing the discharge time with the rated power. High charging rate enables the use of flue energy even in case of quick variation, no need of using faster energy storage devices such as energetic buffers. The kinetic energy storage system is characterized by the high efficiency from the range of 80%-86%. It should be noticed that it requires smaller space, a close setup of group of modules in a container which is ready for transportation to another location.
The feature of the kinetic energy storage system, is that it might be considered as a fault as compared to accumulator batteries have lower energy density in case of lead-acid batteries from the range of 50Wh/L to 100Wh/L, while lithium-ions are from 200Wh/L to 350Wh/L. another fault is that due to high degree of self-discharging which is several percent per hour. Nevertheless, these feature are not decisive for blast furnace flue gas, TRT system and the electric power grid, however storage is not required to characterized by large energetic storage capacity and charging-discharging process lasts below 1-hr usually not more then twenty minutes. The investment amount of flywheel, converted to unit power or capacity of storage is several times higher than that of the lead-acid or lithium-ion batteries. Hence, economically use of such system must be censed as their fault of the technology of kinetic storage.

$$W_{rot} = (1/2).J.w^2$$

Where the energy, W_{rot} stores rotational energy

- **Kinetic energy-**

$$J = m.r^2$$

Where J is said to be mass moment of inertia,
The amount stored energy in rotational mass can be varied by varying w. It can also be varied by varying J. As seen above J can we varied square of the radius i.e. r. Therefore, by varying J can be controlled and hence kinetic energy w_{rot}.

- **Angular momentum-**

$$L = J.w = m.r^2.w$$

The angular momentum, L describes the kinetic energy is retained in the rotational system.
As angular momentum changes, a torque T results kinetic energy, W_{rot} remains constant.

$$T = Dl/Dt$$

As the large torque can be achieved as if r changes, as L is a function of r^2.

- **Flywheel system-**

$$W_{tr} = F.s$$

As the moving object certain distance, s, requires a force F, then energy W_{tr} is produced.

$$F_{fwcf} = m_{fw}.R_{var}.w_{rot}^2$$

The centrifugal force is F_{fwcf}, in the flywheel system, where R_{var} is the distance between the weight and the center of the rotor.

$$W_{tr} = m_{fw}.\{(R_{fwmax} + R_{fwmin}).w^2/2\}.(R_{fwmax} - R_{fwmin})$$

Hence, moving the weight in the flywheel against the centrifugal force from the largest radius, R_{fw_max}, to the smallest radius, R_{fw_min}, which is translation energy.

III. VAPOUR ABSORPTION MACHINE

As shown in figure below after using flue gas for generating power the amount of hot flue gas is still remand. So here we are again utilizing those hot flue gas for air conditioning process such as vapour absorption machine.

Waste heat is heat, which can be further used for generating necessary things. Dumping it into the environment is totally wasting heat energy. His essential quantity of heat can be recycled in the process. Strategies for how o recover this heat depends on the particular temperature of the waste heat gases and their economy involved. Large quantity of hot flue gas is generated in the process of blast furnace, after the whole process and after generating electrical power the rest energy can be recovered through VAM. If any amount of waste heat is recovered in this process it will be directly reduce the amount of primary fuel used in the process. And the energy lost in waste gases can be fully recovered. Losses can be recovered by adopting such a suitable measures.

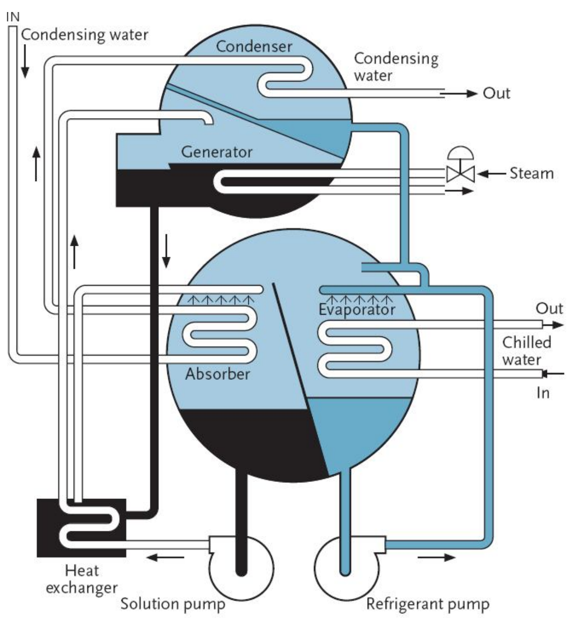

Figure 2 Vapour absorption machine.

Usually higher the temperature may cause higher quantity and higher cost to recover heat. There should be some useful measures of the recovered heat. The main objective of this work is to recover the waste heat available after use of flue gas to run vapour absorption refrigeration system this process replacing Freon-12 refrigerant which is main cause of ozone layer depilation and to reduce temperature of gas emission in the atmosphere which meanwhile causes global warming.

In order to run li-br VAM is main focus of heat recovery process, which is having a cooling capacity of 70 TR. Temperature of the blast furnace flue gas after process is very low which is 50^0C. As the temperature available is very low compared to the other plants. Only single set of VAM system does not requires much temperature and works on the range of temperature of 0^0C- 120^0C. For producing 70TR, 350 KW of heat is supplied for generator of the VAM so we design multi-pass to waste heat exchanger for recovering waste heat from the hot flue gas of the turbine for air conditioning effect.

- **Heat to be supplied to the generator of VAM**

The supplied heat to the generator of VAM can be found using this equation.

$$COP = Q_E/Q_G$$

Where Q_G is the supplied heat to the VAM generator and Q_E is the absorbed heat in the evaporator and COP is the coefficient of performance.

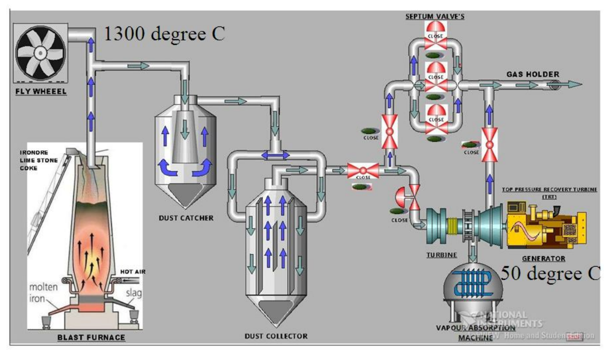

Figure 3 Blast furnace-8 with Flywheel and VAM for waste heat recovery.

- **Outlet temperature of flue gas**

Through this equation the outlet temperature of the flue gas is found out.

$$Q = mC_P.T = Mc_P(T_{IN}-T_{OUT})$$

Where Q is said to be heat transferred from the flue gas to the water, m is mass of rate of flow of flue gas, C_P is specific heat of flue gas, T_{IN} is the inlet temperature of the flue gas and T_{OUT} is the flue gas outlet temperature.

- **Logarithmic mean temperature difference(LMTD)**

The another important step is fiding LMTD of the heat exchanger, which can b found out by this equation
LMTD = $\Delta Tm = \Delta T_i - \Delta T_e/(\ln.\Delta T_i/\Delta T_e)$

Where,

$\Delta T_i = T_{h1} - T_{c2}$

$\Delta T_e = T_{h2} - T_{c1}$

Here T_{h1} and T_{h2} are inlet and outlet temperature of the flue gas and T_{C1} and T_{c2} are values of the water.

- **Surface area of the heat exchanger**

By using this equation area of the heat exchanger is found out.

Heat transfer, $Q = UFA\Delta T_m$

Where U is the heat transfer coefficient, in $W/m^2\,{}^0C$, A is the surface of heat exchanger in m^2 and ΔT_m is the LMTD in ${}^0C$ and F is correction factor.

- **Mass Flow Rate of Water through Heat Exchanger**

$Q = m\ Cpw\Delta T = m\ Cpw(Tout - Tin)$.

Where m is mass flow rate of the water in Kg/sec, Q is the heat transfer in KW, C_{pw} is the capacity of specific heat of water, T_{In} is the temperature of inlet water in ${}^0C$ and T_{out} is the temperature of outlet water in ${}^0C$.

- **Number of Tubes, Diameter and Length of the Pipe**

$A = \pi dLn$

Where d is the diameter of the n tubes, L is the length of the single tube.

Where,

D = 10cm
L = 2m
N = 11

- **Velocity of water through the pipes**

$m = \rho AcV$

Where ρ is the density of water in Kg/m^3, A_C is the cross sectional area of the heat exchanger, in m^2 and V is the velocity of water through heat exchanger in m/s

- **Energy saving**

Power required for operating VCM =78.2985 KW
Power required for operating VAM = 2% of
VCM =1.566 KW

Total Power Saved = 78.2985 – 1.566 = 76.732 KW.
Energy saved if air-conditioner works 12 hours per day = 76.732 × 12 = 920.784 KWhr = 920.784 Units/day.

IV. CONCLUSIONS

A consistent and constant inlet of flywheel and VAM can help recovering waste heat energy throughout the process. And the fluctuation of blast furnace gas inlet pressure may adversely affect the power generation but by using flywheel these incidence would occur rarely. As It will provide stored energy at the time of peak demand of power in the form of active power in the grid and hence fluctuation could hardly affect the generated power output. Although adopting these alternatives heat recovery process may help us moving towards green energy plus reducing primary fuel conservation during process.

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