International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
NATIONAL CONFERENCE on Developments, Advances & Trends in Engineering Sciences
(NCDATES- 09th & 10th January 2015)

RESEARCH ARTICLE OPEN ACCESS

Review on Catalytic Scavenging Effect of FerroceneIn Fuel Combustion

Madhu S, P G Scholar
Department of Mechanical Engineering MRCE, Maisammaguda, Telangana, India.

Abstract
The soot suppressing property of Ferrocene ($Fe(C_5H_5)_2$) catalytic action, lightened a method for the mechanical coke clean up which increase the efficiency of the fuel and life time of the furnace, combustion chamber without effecting the process but energizing the purpose. The metastable Ferrocene nucleate enables further burn of the coke.Ferrocene effectively reduces the emissions of carbonaceous particles. Experimentalresults [1] show that ferrocene can increase the combustion rate effectively and reduce the kindlingtemperature of the fuel.
Key words: Fuel additive, catalysis, scavenging, ferrocene,

I. INTRODUCTION

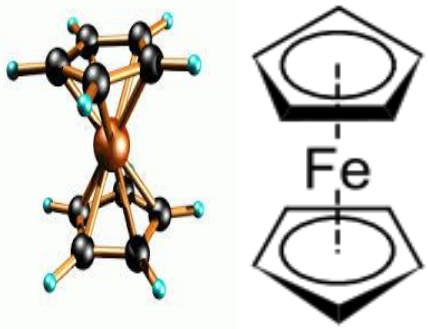
Power generation involving combustion of the fuel produces deposits like soot and slag which stands as a shield for further heat transfer and depresses the combustion efficiency.Boilers and engines are delivered clean with no soot and slag which is a mixture of solid carbon, ash and molten ash that sticks to the fire side of the chamber and ill-effect the process byIncreasing temperature of the furnace wall, reducing co efficient of heat transfer,Increasing exit gas temperature,Increasing fan/blowers requirement,High operating and maintenancecost.There are different reasons for the development of soot while burning the fuel:

- Freezing the chemical reaction
- Insufficient atomization of fuel oil
- High moisture content in the fuel
- Erratic feeding of solid fuels
- Dripping burner

Ethylene installations require coke cleaning for every 1-3 months which lasts 70-80 hours or even longer each time. A method in which fuel is added with inorganic combustion supporting agents are shown to have the advantages of high catalysis efficiency and locost[2-3]. However in industrial practice they are very difficult to be mixed with combustion air and injected in to the devices. Therefore an organic combustion supporting agent is selected for its nature to vaporize easily under industrial temperature, efficient catalyst, non-toxic, non pollutant, stable at high temperature and low cost.

The properties[1] of Ferrocene such as boiling point above 100^0C, stability at higher temperatures about 400^0C, good catalyst, non-toxic and comparatively cheaper made it flexible to use as one of the important fuel additives.

Organometallic Compound $Fe(C_5H_5)_2$

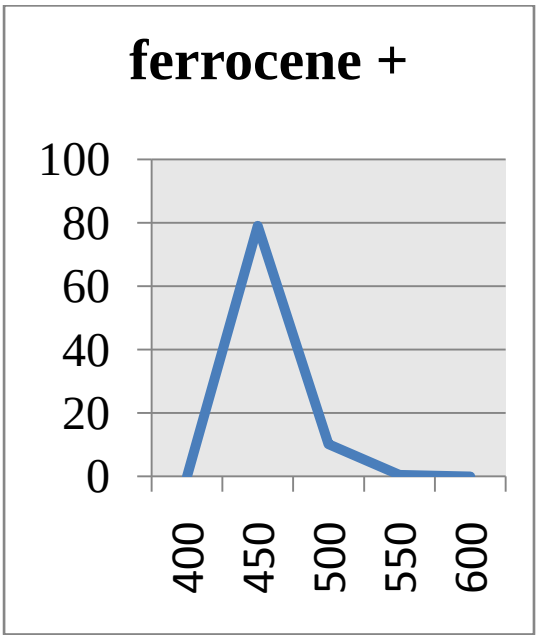


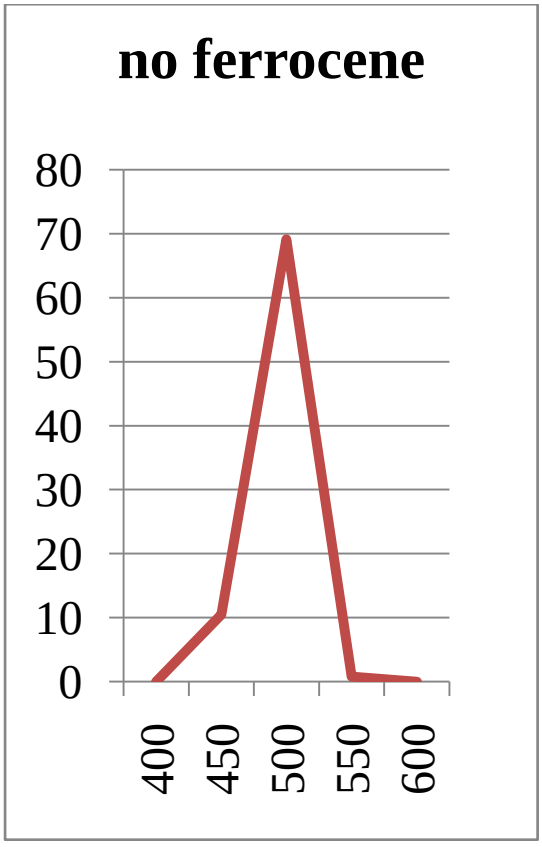
II. EXPERIMENTS[1][2][3]:

Min Xu[1] conducted an experiment and the analysis of petrochemical (ethylene) coke found to be :

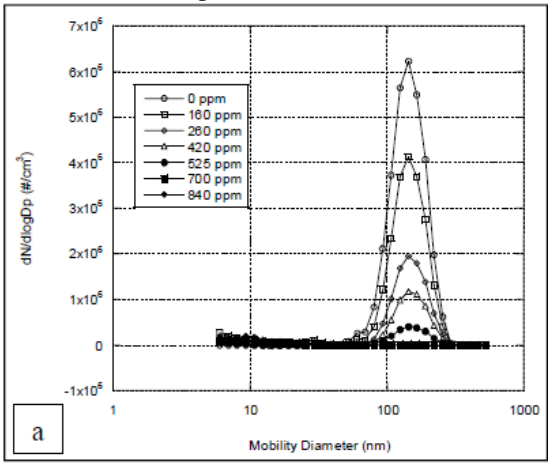
ELEMENT	C	H	S	N	Ash
Weight%	98.13	0.58	0.92	<0.3	0.07

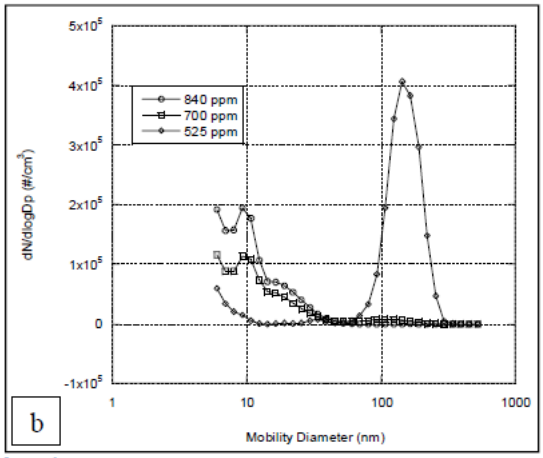
The ash % is observed to be very less. The coke is burnt under certain conditions with and without ferrocene then the kindling temperature of coke is observed by using graphs between weight loss ratio and temperature.





When ferrocene is added the kindling temperature is reduced by 50^0C. In the experiment conducted by N.B.Swanson[2] ethylene and ferrocene doped ethylene is made to flow through two different lines and controlled by individual mass flow controller. Particulate physical characteristics of the laminar diffusion flame was observed where the addition of iron to the system clearly reduces the amount of soot being emitted from the flame.

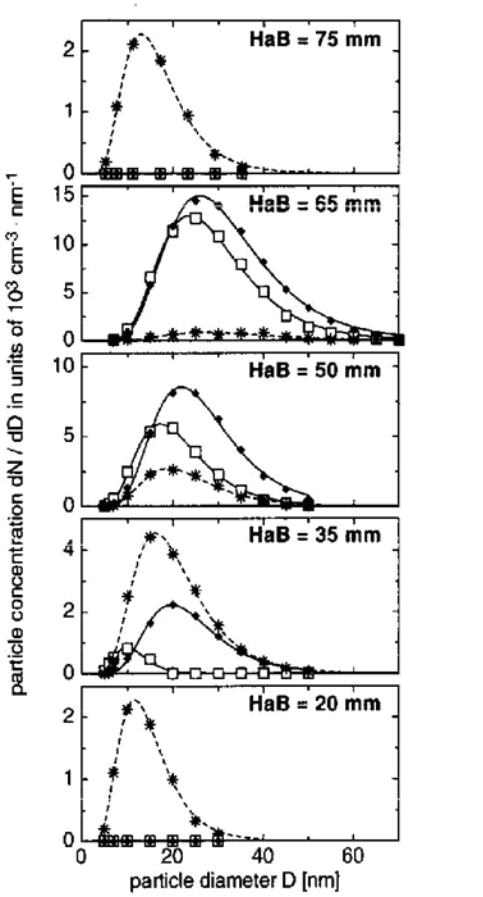




M.Kasper[3] showed that in a ferrocene doped diffusion flame, iron oxide indeed nucleates before soot inception and subsequently serves as soot formation nuclei it is observed by means of photoelectric charging of the particles in their natural gaseous environment. The laminar methane diffusion flame with ferrocenevapour addition, the first particles appear earlier than in the unseeded flame.Due to photoelectric activity [3] these particles were seemed to be iron oxide act as condensation nuclei for the carbonaceous particles. The fast drop of the photoelectric activity at burnout of the soot particles suggests that the carbonaceous matter condensed on the iron oxide nuclei surface was burnt. Experiments with an acetylene diffusion flame show that iron oxide incorporated in the soot particles acts as catalyst to promote soot burnout at the tip of the flame. In this phenomena of particle size distributions in a 70 mm high methane/argon diffusion flame seeded and unseeded with ferrocene vapor is observed as the iron oxide nuclei appearing in the seeded flame are distinguished by their very low

photoelectric activity.(HaB=height above burner mouth).

Methane/Argon flame



III. Action of Ferrocene

The catalytic action of ferrocenecabe explained as:

Nucleates before and after soot inception

$Fe(tr)L \longrightarrow [Fe(tr)]^+ + L^-$

$[Fe(tr)]^+ + O_2 \longrightarrow [Fe(tr)_mO_n]^-$

$[Fe(tr)_mO_n]^- + C(soot) \longrightarrow [CmOn]^+ + Fe(tr)$

$[CmOn]^+ + O_2CO_2 \longrightarrow$

The transition metal ion Fe^{2+} attach to the surface of the coke particles and the internal surface of the tiny holes at the coke surface, which makes the coke active surface increasing. The transition metal ion Fe^{2+}reacts with the oxygen in the gas flow and forms the meta-stable oxidized state; The meta-stable oxidized state acts as anoxygen carrier, letting the oxygen travels to the surface of the coke particle by absorption process. The coke particle breaks to nano-scale carbon clusters and the coke combustion process can be extremely accelerated and fromsCO_2. The deoxidized Fe element reacts with the oxygen in the flew again and repeats the above catalysis process. During this reaction circle, the transition metal ion fe^{2+} has the function of oxygen transferring At the last phase of coke combustion process, some Fe^{2+} ion transferred to steady state ferric oxidized state, and the catalysis activity decreases correspondingly.

IV. Conclusion:

By observing the results of the various experiments it is very clear that ferrocene functions as a good catalyst by carrying the oxygen near to the soot and acts as a scavenger by clearing the soot from the flame. It energises the combustion process by breaking the solid structure of the coke/soot enable it for further burnout.

References:

[1] Effect of ferroceneon catalysis combustion , Indian journal of heat and mass transfer by Min Xu, Ying Zou&HuixinWeng

[2] The effects of ferrocene concentration on soot in an ethylene laminar diffusion flame, 7th USNational Technical meeting of the Combustion Institute by N.B.Swanson,T.L.B.Yelverton, W.P.Linak, W.L.Roberts.

[3] The effect of ferrocene addition on particle formation and burnout in combustion process byM.Kasper, K.Sattler, K.Siegmann and U.Matter

[4] Effect of soot blowing system in boiler furnace on cycle efficiency and cost saving, International journal of engineering research & technology by Shivrajkumar B

[5] A comparision of online backpass cleaning technologies: Detonation, acoustic and conventional steam or air soot blowing, Energy central.

[6] A note on The soot and scale problems by Dr.Albrechtkaupp.