NOMENCLATURE

C_A = Concentration of reactant A mol / lit.

Contact Time = volume of catalyst bed / volumetric flow rate

DME = Di Methyl Ether .

E = Activation Energy of the Reaction J / mol .

F = Molar Flow Rate mol . / h .

GHSV = Gas Hourly Space Velocity h^{-1}

GTL = Gas – to – Liquid

ΔH = Enthalpy of Reaction k J / mol .

k = Reaction Rate Constant

k_o = Frequency or Pre – Exponential Factor

Mpa = Mega Pascal

MR = Membrane Reactor

n = Order of Reaction

N_A = no. of moles A left un reacted

N_{Ao} = Initial no. moles A

P = Pressure atm .

R = The Universal Gas Constant 0.082 lit . atm .

RWGS = Reverse Water Gas Shift Reaction .

SEM = Scanning Electron Microscope .

SMSI = Strong Metal Support Interaction

T = Temperature ^{o}C

TG = Thermal Gravimetric Analysis .

TOF = Turn Over Frequency

TPR = Temperature Programmed Reduction

TR = Tubular Reactor

V_0 = Initial Volume of Reactants

W = Weight of Catalyst gm .

WGSR = Water Gas Shift Reaction

WHSV = Weight Hourly Space Velocity $ccg^{-1}h^{-1}$

X_A = Conversion

XANES = X – Ray Absorption Near – Edge Structure

τ' = Weight – Time Term $kg.h\ lit^{-1}$

ϵ_A = change in the system volume between no conversion and complete conversion .

AIM OF THE WORK

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This work aims to study the reforming of Egyptian natural gas rather than pure methane (as usually reported in literature) by carbon dioxide .

Three proposed noble metals namely Rh , Ru and Ir supported on γ- alumina in the ratio 0.5 % by wt are used as catalysts .

The effect of reaction conditions ; temperatures , space velocities are studied at different levels in order to optimize the reaction parameters .

Finally the reaction kinetics for the reforming of CO_2 and methane using the different catalysts are studied .

ABSTRACT

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Elsalamony, Radwa Abbas. On Reforming of Natural Gas by Carbon dioxide to Produce Synthesis Gas. MSc, Egyptian Petroleum Research Institute , 2005.

Reforming of natural gas with carbon dioxide to synthesis gas (H_2 + CO) has been investigated over rhodium , ruthenium and iridium (0.5 wt %) supported on γ – alumina catalyst . The catalysts were prepared from the corresponding metal salts by the impregnation technique . 2 gm of each catalyst were tested in a tubular flow reactor 13 mm diameter and 120 mm length . The catalyst's activity was investigated at three reaction temperatures namely 600 , 700 and 800°C , and different weight hourly space velocities 18000 , 36000 , 45000 and 60000 $cc.g^{-1}.h^{-1}$. Both major and minor components in the natural gas were determined using high sensitive gas chromatographic techniques .

All the catalysts showed reactivity towards the reforming reaction but with varying degrees.

Generally ; the activity of the reforming reaction towards all natural gas components increased with increasing temperature and decreasing space velocity i.e. increasing contact time . From the results obtained, the optimum reforming conditions for each catalyst w.r.t . natural gas components could be established .

In addition , the optimum conditions for obtaining the maximum H_2 / CO ratio were also evaluated for the investigated catalysts .

The maximum ratio for Rh / γ- Al_2O_3 catalyst was at 700°C and 36000 cc g^{-1} h^{-1} , for Ru / γ- Al_2O_3 catalyst was at 800°C and 18000 cc g^{-1} h^{-1} and for Ir / γ- Al_2O_3 catalyst was at 700°C and 36000 cc g^{-1} h^{-1} .

All three catalyst obeyed the 1st order reaction rate assumption w.r.t. both reactants CO_2 and CH_4 under all reaction temperatures . The dependence of the

reaction rate constant on temperature was determined by the Arrhinius' plot . The average activation energy for CO_2 was 46.25E3 J / mol. and that of CH_4 was ٣١.٥٢E3 J / mol ,

Key words :-
natural gas , CO_2 , Rh , Ru , Ir , $\gamma - Al_2O_3$, CO_2 reforming of CH_4 , heavy components , chromatograph , space velocity , temperature , kinetics .