Introduction

**FACT 1**

EASY OIL & GAS IS OVER, ALMOST EVERYWHERE

**FACT 2**

40% OF NATURAL GAS RESERVES ARE SOUR*

**SOUR HYDROCARBON DEFINITION**

OIL OR GAS CONTAINING HYDROGEN SULFIDE (H$_2$S) AND / OR CARBON DIOXIDE (CO$_2$)

ALSO CALLED “ACID”
Examples of Sour Fields in the Arab Region

- Harweel, Yibal Khuff and Greater Birba (Oman)
- North Field LNG (Qatar)
- Jurassic Sour Gas Fields (Kuwait)
- Wasit, Kidan and Karan (Saudi Arabia)
- Shah, Bab and Ghasha (UAE)
Hydrogen Sulphide (H₂S) Characteristics

- ‘Sour Gas’ is commonly present in natural gas and oil formations
- At low concentrations, it smells like rotten eggs
- EXTREMELY dangerous as it is heavier than air, impairs our ability to smell/detect with increasing concentration, and exposure to >500 ppm can be fatal!
- With respect to safety and product specifications, it must be removed from natural gas and petroleum products
- Thus, how do we safely rid ourselves of H₂S and make another potentially valuable product?

Reference: Info-graphic taken from H2S – The Killer from the Alberta Government
Sulphur Recovery – Claus Process

• Two-step reaction scheme overall
• A portion of the total $H_2S$ is burned in the Reaction Furnace to form $SO_2$ (Sulphur Dioxide)
• Then, the $H_2S$ and $SO_2$ react, at an optimal 2:1 ratio, to form elemental Sulphur ($S_x$) across the Claus Reactors
• After each catalytic stage, liquid sulphur is recovered in the Claus Condensers
• The remaining unreacted $H_2S$ and $SO_2$ then proceed to the next stage, where the equilibrium-limited Claus reaction continues in the presence of Claus catalyst
About 90% of sulphur produced or extracted is used to make sulphur dioxide, which is then converted to sulfuric acid. The majority of the acid is used in the production of phosphate fertilizers, which is a crucial component of the food and beverage industry.

Source: Utilization of Sulfur Wastes from Sour Gas and Crude Oil Production, Krishnan and Freeman, Integrated Environmental Solutions
Sulphur Dioxide is a colorless, water-soluble gas, with a strong odor

Sulphur Valorization – Sulphuric Acid ($H_2SO_4$)

Over 90% of Sulphur consumption is as Sulphuric Acid
Case Study: Sulphur-Extended Asphalt (SEA)

• Replacement for cement in binding asphalt or bitumen
• SEA has been used in dense-graded mixtures with sulphur/asphalt binder mass ratios from 20/80 to 40/60, and at times even up to 50/50
• Careful design of the mix, based on asphalt specs and temperature of the mix
• Role of Sulphur: Crystallizes in mixture when cooled (solid, stiffer filler)

Example:
• Shell’s Thiopave technology, for enhanced road construction
• Quick-melting pellets + organic compaction agent (wax)
Sulphur Valorization – Challenges

**COST**
Sweetening oil and gas can be costly, due to many processes required

**SAFETY**
Sulphur and its derivatives can be hazardous if not handled right

**MARKET**
Risk of over-supply of Sulphur, compared to demand growth

Many companies and research institutions are working to address those challenges
Sulphur Valorization – Food for Thought

Global sulphur supply outlook, 2011 -2017

Global incremental changes to supply by source, 2012 - 2017

- Oil sands
- Mined sulphur
- Gas
- Oil
- Other

Middle East
CIS
East Asia
North America
South America
Central America
South Asia
Africa
Central Europe
Western Europe
South East Asia

Middle East sulphur supply, 2011 -2017

- Iran
- 2011 – 1.7 Mt/y
- 2017 – 2.1 Mt/y

- Qatar
- 2011 – 2.0 Mt/y
- 2017 – 2.8 Mt/y

- Saudi Arabia
- 2011 – 3.5 Mt/y
- 2017 – 6.7 Mt/y

- UAE
- 2011 – 2.2 Mt/y
- 2017 – 6.0 Mt/y
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