MSAR® - An alternative to HFO for Power, Marine & Own use.

MSAR® (Multiphase Superfine Atomised Residue)
1. **About Quadrise & MSAR®**
2. Benefits of emulsion fuels
3. Marine & Power MSAR® Projects Update
Introduction to Quadrise & MSAR®

Quadrise:
- UK Listed plc with ~€100 Million market cap
- Experienced team – ex BP/PDVSA/Shell/Conoco
- Global alliance with AkzoNobel
- Technology Licensor / Project Implementer / Operator

MSAR®:
- A proprietary oil-in-water emulsion technology & fuel
- Converts refinery residues into a stable, synthetic fuel oil
- Low capex method of improving refinery margins
- Implemented in typically <12 months
- Technology proven and verified at commercial scale

Projects:
- Marine MSAR® with Maersk Line & Cepsa
- Power MSAR® for the Kingdom of Saudi Arabia
- Other projects with select Oil Majors (Marine & Power)

MSAR® stands for Multiphase Superfine Atomised Residue
Oil-in-water emulsion fuel technology & Quadrise

- **1980’s**
  - Development of HIPR technology
  - Development of ORIMULSION®-100

- **1990’s**
  - Introduction and continued use of ORIMULSION®-400
  - Wind down of ORIMULSION®
  - Commercialisation of ORIMULSION®-100 by BITOR

- **2000’s**
  - Formation of QUADRISE
  - Development of fuel MSAR® with AkzoNobel
  - Development of Power MSAR®
  - Development of Marine MSAR®
  - Power MSAR® commercialisation
  - Marine MSAR® commercialisation

- **2010’s**
  - Next generation development
  - Significant advances via system design & fuel formulations during the last decade
  - Focus on residue-based fuel performance and application capabilities

- **60 Million tons of oil-in-water emulsion fuel sales globally**

- **Large scale world-wide use**

- **PDVSA developed from collaborative research between**

- **Power/Marine MSAR®**

- **60 Million tons of oil-in-water emulsion fuel sales globally**
What is MSAR® fuel?

MSAR® is an ‘Oil-in-Water’ emulsion system consisting of tiny droplets of heavy hydrocarbons (asphaltenic residuals) dispersed in water using proprietary additives and a colloid mill.

“Typically”:

~70% Residue + <1% Additives + ~29% Water

MSAR® technology produces a low viscosity fuel from high viscosity residuals using water and additives, instead of expensive oil diluents...

MSAR® is a stable and superior pre-atomised fuel with enhanced combustion features...
- High Carbon Conversion
- Up to 50% reduction in NO$_x$
The MSAR® production process is proven and simple:

1) Residues are taken from refinery rundownss and cooled to under 200°C to achieve the required viscosity (typically 300-400cSt).

2) Water, which can be derived from several utility or waste-water sources, is added to the residue stream.

3) Special surfactants and chemicals are added to stabilise the emulsion for long-term storage and transport, and to promote complete combustion.

4) The mixture is processed in a proprietary MMU to a high hydrocarbon content (typically ~70%) super-stable oil-in-water fuel (100-500cSt at 50°C).
Through an extensive feedback programme of fuel formulation and testing at lab, pilot and field scale, the fuel’s key performance parameters are evaluated and optimised

R&D is focused on producing a fuel that is ‘fit for purpose’, not just a pre-requisite set of specifications at the point of production

Key to the application of emulsion fuel is the required functionality. MSAR® as an end product is primarily a fuel oil substitute, not simply a standard emulsion

MSAR® Formulation and Performance Testing
Investment in MSAR® RD&I and Service Centres

• **Quadrise Research Facility (QRF) UK – Recently Expanded**
  - Product development to enhance economics & efficiency
  - Fuel emulsion testing from lab to industrial scale
  - Central service centre for operations support

• **Research University of Surrey – Research Collaboration**
  - Centre for Petroleum & Surface Chemistry, formerly with BP
  - 1st class facilities – ideally equipped ($7m hardware + expertise)
  - Primary research aligned to business needs

**Stenungsund – Joint R&D and IP**
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Economic drivers for MSAR®

MSAR® creates value by blending residuals directly with water + <1% additives, thereby saving distillate fuels for higher value applications

Traditional refinery process

- 50% Refinery output
- 30% HFO
- 20% Residual fuels

Every barrel of higher value premium fuel used to create HFO is sold at a discount to crude oil

- High value transport fuels
- High value fuels used to dilute HFO
- Residual fuels

This refinery on MSAR®

- 70% Refinery output
- 30% MSAR®

An additional 20% of high value fuel can be sold at the market rate

- Water & <1% chemicals

Other MSAR® benefits:

- Modular scalable units
- Low capital cost
- Rapid execution (<12 mths)

Modular scalable units Low capital cost Rapid execution (<12 mths)
MSAR® Refinery Economics: Benefits are shared

1. **For the Refinery:**
   - Premium fuel output + profit increases
   - Low capex: <<$10 Million
   - Fast payback (<12 months) and high IRRs

2. **For the End User:**
   - Lower fuel costs
   - Lower NOx / ash

3. **For Quadrise and AkzoNobel:**
   - Quadrise is the project “Integrator” (Refinery and End User)
   - Sales of Licenses, Additives & Services
Example retrofit of 1xMSAR® module:

HFO blend today to make 380cSt:
57%w Residue + 43%w LCO => HFO380

Calculated Residue “netback” = $35/mt based on HFO value less LCO distillates...

MSAR production cost (Opex only):
= Residue + Additives + Water
= 70% x $35/mt + $35/mt (Additives etc)
= $60/mt MSAR®

Energy equivalent cost of HFO vs MSAR® (NCV):
= $150 / 40.5 * 27.3 GJ/mt = $101/mt

Potential savings for Stakeholders:
= $41/mt x 350,000mt/a MSAR®
= up to $14.5M/a

NB. Excludes additional CapEx (~$5M), fixed OpEx, logistics, etc.
Refining Economics – in relation to MSAR®

Medium Term View

• Crude prices directionally increase with supply / demand rebalancing and this will directionally increase the spread between fuel oil and middle distillates.

• Key uncertainty is around the Global marine bunker fuel oil spec change from 3.5 to 0.5%wt S in 2020/25 has led to a lack of action on investment:
  ➢ Decision due at IMO MEPC 70 on 24-28 October. Implement 2020 or 2025?
  ➢ Marine fuel market is ~200 million tpy of fuel oil worldwide. If the majority of this demand rapidly shifts to a 0.5% sulphur gasoil-based fuel in 2020 then the fuel oil to distillate spreads will increase significantly.
  ➢ Traditional refinery based residue upgrade options take significant Capex and require several years to implement so little time now before 2020.
  ➢ Vessel based scrubbing is compatible with MSAR®.
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Marine MSAR® with Cepsa & Mærsk: Outline

Milestones:

- Land-based 2-stroke engine tests at MAN/Mitsui & Wärtsilä
- First seaborne vessel test on residue OIW emulsion fuel (MSAR®)
- “Proof Of Concept” completed in 2014 (MAN / Wärtsilä) on operational Mærsk vessels
- Operational trial approved by Mærsk and Cepsa end 3Q 2015
- Operational “LONO” trial commenced in summer 2016
A 6KBPD MSAR® system is installed at the 240,000 BPD Gibraltar - San Roque Refinery.

“Fast-track” Timetable:

- Triparty agreement to proceed signed end 3Q 2015
- FEED and Detailed Engineering completed Q1 2016, civils started
- Mechanical and E&I works completed & unit commissioned end Q2 2016
- LONO volumes commenced summer 2016 for ~4,000 run hours of testing
- Commercial MSAR® volumes post-LONO in 2017, subject to results
• Tie-ins and lines for residue supply/return to the Visbreaker
• New buffer tanks for VB residue & MSAR®
• New MSAR® unit & support infrastructure
• New tie-ins to existing pipework
• Cleaning & preparation of 14,000m³ tank
• Use of existing oil jetty
Site available, Civils started Mar’16

MSAR unit & equipment delivered Apr’16

Mechanical and E&I erection & integration Apr-May’16
Commissioned Jun’16

Trial proceeding as planned per refinery and vessel schedules.
Quadrise is providing extensive Operational Support & Quality Control covering from VBR supply, through MSAR loading at the Jetty and follow up on the vessel.

Quality Control Plan developed in conjunction with Cepsa & Maersk and supported by on-site Quadrise Laboratory & QRF.
Power MSAR® in the Kingdom of Saudi Arabia

The Market:

- Very high energy consumption per capita, subsidised for the domestic market.
- Fuel mix for power: 56% Oil-based (43M t/a), 44% Gas

For MSAR®:

- Scope: Replace crude oil / HFO use for power with MSAR®
- Working through local partner and with KSA majors

Major emulsion fuel experience and conversions:

- Significant worldwide emulsion fuel experience
- >60 million tons emulsion fuel fired: 50MWth to 770MWe
- Proven long term handling, storage & shipping
- Experience applied to MSAR® improvements
- Fuel handling design understood & solutions demonstrated
Power MSAR® in the Kingdom of Saudi Arabia

400MWe Demonstration Trial (Refinery – Power MSAR® - Major Utility):

• West coast candidates established:
  • Major integrated 400KB/D refinery & largest oil-fired power generation facility in KSA

• Scope of demonstration:
  • Refinery production of MSAR®, coastal supply to modern 400MWe baseload unit
  • 2-3 month commercial trial, plus potential follow-on opportunities

• Project timetable:
  • Preliminary client approvals and refinery tie-ins completed
  • MOU signed and Trial agreements in negotiation
  • Basic Engineering activities have commenced
Projects: Pipeline (Others)

Quadrise has a targeted business development programme to build awareness and interest with both potential producers & consumers.

Global oil majors at multiple sites for MSAR® production
• Lab & plant scale tests of residues continuing with various Candidates for expanding marine MSAR® to additional bunker hubs & associated power opportunities.

YTL PowerSeraya refuelling (Singapore)
• Former Orimulsion® consumer – 750MWe = 1.8M mt/a
• MOU to supply MSAR® supply candidates

Refinery Refuelling
• Working with a number of refiners to explore opportunities

Upstream Applications
• Potential applications to monetise viscous crude / bitumen assets
Conclusions

- MSAR® is a disruptive technology in the oil sector
- Substantial final stage commercial trials in both the marine fuel and power generation markets with major global clients
- Quadrise planning commercial operations during 2017
- Executive and management team has unique emulsion fuel experience and can assist with all phases of the project from production through consumption
- MSAR® technology is IP protected jointly with AkzoNobel
Lower cost synthetic fuel oil
for Power generation, Marine fuels, Refinery & Oilfield Applications

Thank You