From Wellstream to Forecourt – “Interpret” A Total Quality Solution

Dr Frederick Stubbins

24/05/2018
TOTAL QUALITY. **ASSURED.**

- **Total Quality Assurance**
  end-to-end on a global scale

- **Global market leader in Assurance**
  3000+ Auditors, 100,000 Audits annually

- **Global market leader in Testing, Inspection and Certification**
  1,000+ sites, 100+ countries

- **Innovative and bespoke quality solutions**
  for our clients, 24/7

- **Constantly evolving our services**
  to help customers manage increasingly complex risks

- **FTSE 100 company**
  in the support services sector

- **Market capitalization**
  over £6 billion

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DELIVERING TOTAL QUALITY SOLUTIONS

OUR SECTORS

Products
Trade
Resources

OUR SERVICES

Assurance
Testing
Inspection
Certification

...THROUGH A DEPTH AND BREADTH OF ATIC SERVICES

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INTERPRET – LINKING LABORATORY WITH OPERATIONS

• InBlend – Crude Quality
• InFlow – Organic Deposition
• InProcess – Smart Analytics

• Domain Experts
• Knowledge and experience
• Strong Global Network
INBLEND - NIR CHEMOMETRICS (FAST AND PRACTICAL)

Scan
Spectra
Tracking
Prediction

Modelling Process

<table>
<thead>
<tr>
<th>SampleID</th>
<th>Date</th>
<th>R...</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS0066</td>
<td>16/06/2011...</td>
<td>3</td>
</tr>
<tr>
<td>CS0068</td>
<td>16/06/2011...</td>
<td>6</td>
</tr>
<tr>
<td>CS0070</td>
<td>16/06/2011...</td>
<td>9</td>
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<td>CS0072</td>
<td>16/06/2011...</td>
<td>3</td>
</tr>
<tr>
<td>CS0073</td>
<td>16/06/2011...</td>
<td>2</td>
</tr>
</tbody>
</table>
Interpret matches NIR spectra to data property files:

The basic postulate is that the same spectrum equates to same properties.
PREDICTIONS

• Clustering algorithms

• Model selects most appropriate neighbours

• Spectra and properties are blended

• Linear and non-linear mixing rules

Property $X = f(\text{Prop}[N_1, N_2, N_3, N_4])$
INFLOW - ASSESSING BLEND STABILITY

- Blend Crudes
- Use NIR
- Consider Time
- Track Quality
- Patented Approach

Paraffinic Condensate + Heavy Crude?
INTERTEK SOLUTIONS FOR TOTAL QUALITY ASSURANCE

Upstream operations
- Safety training
- Supplier audits
- Flow assurance
- Business Assurance
- Interpret

Transportation
- Pipeline Integrity assurance
- Metering and calibration
- Pipeline volume and flow measurement
- Interpret

Refining and distribution
- Safety training
- Asset Integrity Management
- Business Assurance
- Interpret

Trading and logistics
- Asset integrity Management
- Interpret

Retail operations
- Global supply chain
- Management Systems training
- Quality, Safety assurance
- 2nd party audits
- Interpret

Consumer
- Product comparison
- NPD process consulting
- Corporate Social Responsibility
- Interpret

Assurance
- Emissions control
- Geological services
- Production support
- Equipment, machinery testing
- Life safety and security equipment testing
- Interpret

Testing
- Crude and product quality
- NDT
- Materials testing
- Interpret

Inspection
- Facility inspection
- Vendor inspection
- Technical staffing and inspection services
- Interpret

Certification
- Pipeline integrity
- Corrosion inspection
- Risk based inspection
- Interpret

- Cargo inspection
- Additivisation
- Technical inspection
- Interpret

- Tank inspection
- Bunker survey
- Interpret

- Building quality
- Appliance and electronic inspection
- Food inspection
- Interpret

- Equipment and component certification: industry, power generation,
- Hazardous areas certification (ETL, ATEX, IECEx)

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- Hazardous areas certification

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- Certificate of Conformity

- Management Systems certification

- Food product certification
- Social Accountability certification

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THE INTERTEK SOLUTION IS ATTRACTIVELY PLACED IN THE MARKETPLACE

Intertek Interpret – Applications cover the whole supply chain

- **Exploration Production**
  - Allocation of co-mingled crude
  - Benefit: Speed

- **Primary Logistics**
  - Online monitoring of pipeline fluids
  - Benefit: Rapid assessments

- **Refinery and Refined Products**
  - Alternative to traditional assay for optimisation of crude and refined products
  - Benefit: Speed, more data, can be taken online

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- **Retail Markets**
  - Added value for traders and refiners
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- **Derived product (chemicals, …)**
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  - Agriculture (Grains and Silage)
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**THE INTERTEK SOLUTION IS ATTRACTIVELY PLACED IN THE MARKETPLACE**
OVERVIEW

• UK Client – Going to be producing a heavy crude across existing Infrastructure

• Building on previous work on linear spectral blending

• At certain blend ratios instability is observed

• Stability is detected by spectroscopy and microscopy

• Spectral inflections indicated instability
BLEND RESULTS

**Definition of Asphaltene: Toluene Soluble / Heptane Insoluble**

- The microscopy images above show the effect of increasing saturates in a Crude blend.
- Colloidal system, it is in a delicate balance.

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OVERVIEW

- Crudes are blended and stored at the installation
- Storage time >30 days
- Experimental setup mimics storage tank
- Measurements of spectra, microscopy, and density taken at 0 and 30 days
- Samples were taken from top middle and bottom to assess stratification
The samples were first homogenized and then left to settle. It can be seen there was little deviation between top middle and bottom for both NIR and Density.

In this case the heavy crude was decanted into the light crude. It can be seen that there is much greater stratification behaviour over the 30 day period.
PROPERTY MODELLING

- Crudes are blended and stored at the installation
- TAN levels
  - Customers
  - Shippers

- Property response vs spectra – Linear
- Model can be used to monitor properties

Chart Showing TAN as a Function of Increasing Crude A

$\gamma = 4.9786x + 0.1024$

$R^2 = 0.9936$
### Upstream Application

#### 1) Live Crude (Light Ends)

- Distillation (either wt% or vol%)  
  - N2  
  - CO2  
  - C1  
  - C2  
  - C3  
  - IC4  
  - NC4  
  - IC5  
  - NC5  
  - C6  
  - C7+  
  - GOR  
  - Oil Density  
  - Dry Density

#### 2) Live Crude (Full Analysis)

- Mass%, Vol%, Molecular Weight and SG for all cuts below
  - IBP - 15  
  - 15 - 45  
  - 45 - 60  
  - 60 - 75  
  - 75 - 90  
  - 90 - 105  
  - 105 - 120  
  - 120 - 135  
  - 135 - 150  
  - 150 - 185  
  - 165 - 200  
  - 200 - 250  
  - 250 - 300  
  - 300 - 350  
  - 350 - 400  
  - 400 - 450  
  - 450 - 500  
  - 500 - 550  
  - 550+  
  - Sulphur 350+  
  - Sulphur 550+  
  - Viscosity 350+  
  - Viscosity 550+

### Refinery Application

#### 3) Stabilised Crudes

- Distillation (either wt% or vol%)  
  - IBP - 15  
  - 15 - 45  
  - 45 - 60  
  - 60 - 75  
  - 75 - 90  
  - 90 - 105  
  - 105 - 120  
  - 120 - 135  
  - 135 - 150  
  - 150 - 185  
  - 165 - 200  
  - 200 - 250  
  - 250 - 300  
  - 300 - 350  
  - 350 - 400  
  - 400 - 450  
  - 450 - 500  
  - 500 - 550  
  - 550+  
  - Sulphur 350+  
  - Sulphur 550+  
  - Viscosity 350+  
  - Viscosity 550+

#### 4) Gasoline

- IBP  
- D10  
- D50  
- D90  
- D85  
- FBP  
- E70  
- E100  
- E150  
- E180  
- RON  
- MON  
- Aromatics  
- Cetane

#### 5) Diesel

- IBP  
- D10  
- D50  
- FBP  
- Flash Point  
- Cloud Point  
- Cold Flow Properties (CFP)

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Intertek Interpret – Applications cover the whole supply chain

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- Agriculture (Grains and Silage)
- Pharma (Raw material and intermediate product assurance)

THE INTERTEK SOLUTION IS ATTRACTIVELY PLACED IN THE MARKETPLACE
THERE ARE MANY APPLICATIONS WITHIN REFINING ALONE

Intertek Interpret – Refinery Supply Chain

Storage & Blending
- Analysis of crude tanks and blends
  Benefit: More information, smart blend optimisation

Pipes and Preheat
- Online monitoring of pipeline fluids, fouling assessments
  Benefit: Rapid assessments

Distillation
- Alternative to traditional assay for optimisation of crude and refined products
  Benefit: Speed, more data, can be taken online

Refined Products
- Streamline current laboratory analysis of refined products
  Benefit: Laboratory efficiency, can be taken online

- Effective Tank Management (asphaltene deposition)
- Properly optimised crude blends can give $/bbl
  - Blend optimisation
  - Crack Spread

- Faster blend optimisation
- Time saved on reblanding
CRUDE QUALITY TRACKING

• Four samples – 6 month period
• Sample_03 different
• API higher, Sulphur Lower, 565°C+ higher
• Netback - $1/bbl lower value (Sample_03)

<table>
<thead>
<tr>
<th>SampleID</th>
<th>API</th>
<th>Sulphur</th>
<th>565°C+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample_01</td>
<td>32.8</td>
<td>0.9</td>
<td>7.6</td>
</tr>
<tr>
<td>Sample_02</td>
<td>33.8</td>
<td>0.8</td>
<td>6.0</td>
</tr>
<tr>
<td>Sample_03</td>
<td>37.9</td>
<td>0.3</td>
<td>11.6</td>
</tr>
<tr>
<td>Sample_04</td>
<td>33.0</td>
<td>0.8</td>
<td>6.22</td>
</tr>
</tbody>
</table>
The InterTek solution is attractively placed in the marketplace.

**InterTek Interpret – Applications cover the whole supply chain**

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- **primary logistics**
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- **refinery and refined products**
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- **secondary logistics**
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ONLINE FUEL BLENDER

Every 2 Minutes

Basestocks

Blender

Gasoline

RON, MON, RVP, Distillation Data, Oxygenates etc.

OR

Different Grades e.g.
Gasoline: 95/99 RON
Diesel: Summer/Winter/Marine

Diesel

Cetane, Flash Point, Cloud Point, Pour Point, CFPP

Online PC and Spectrometers with Intertek Technology in use 24/7

© Intertek Group
Intertek applies Infrared Spectroscopy and Interpret software for two main OCM areas:

1) Implementation of ASTM E2412 which is a methodology for monitoring several degradation parameters including:

   • Oxidation/Nitration/Sulphation
   • Anti-wear additives
   • Ethylene Glycol
   • Soot Content

2) Promotion of operational efficiency by utilising predictive models for commonly measured physical properties including:

   • Total Base Number (TBN),
   • Total Acid Number (TAN)
   • Viscosity
The figure to the left shows the fit of the model for high medium and low TBN lubricant oils.

The closer the points to the line, the better the model.

It can be seen that this is an excellent fit and all samples predicted within method reproducibility.

The table to the left shows measured and predicted TBN for a selection of five samples, the differences are very low.
SHIPCARE – MARINE FUEL ANALYSIS

3 sample types assessed:
High Sulphur Fuel Oil (HSFO)
Ultra Low Sulphur Fuel Oil (ULSFO)
Ultra Low Sulphur Gas Oil (ULSGO)

Property modelling focussing on ISO 8217 specification
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• The application consisted of three models:
  • 95 RON model (E5)
  • 99 RON model (SU99)
  • Blend Components Model (BC)
    • Alcoline, MethGas, MTBE, LVN
    • Reformate & BOB grade Gasoline

• 4 essential properties:
  • Research Octane Number (RON)
  • Motor Octane Number (MON)
  • Aromatics (ARO)
  • Benzene (BNZ)

• Other properties:
  • IBP, D10, D20, D50, D90, FBP, E70, E100, E150, E180, Olefins, Density, Oxygen, Methanol, Ethanol

• The number of samples in each database is as follows:
  • 95 RON model (E5): 568 samples
  • 99 RON model (SU99): 248 samples
  • Blend Components Model (BC): 199 samples

• The model also contained 600 database samples
WE CURRENTLY CONDUCT FUEL QUALITY MONITORING IN 18 COUNTRIES

- Fuel quality monitoring in at least 18 countries
- Clients include:
  - **Governments** (France, Spain, New Zealand, Ireland, South Africa, USA, Australia, Belgium, China)
  - **OEMs** (VW, Renault, Citroen, Nissan, Honda, Toyota, Isuzu, Mazda, Subaru, Hino, Suzuki, BMW)
  - **Fuel majors** (Shell, BP, Exxon, Total, Petrobras, Raizen, Ipiringa, Chevron, Repsol, Viva, Puma, Sasol, and others ...)

**Map highlights:**
- Changing fuel quality needs driven by regulators
- Push for higher quality fuels from manufacturer
- Increased need to crack down on adulteration
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NAPHTHA FEEDSTOCK

- Quality monitoring of ethylene feedstock
- Processing increased variety of feedstock
- Two applications
  - Feed ratios
  - Property predictions
- Blend ratio aggregate
- Feedstock blending very linear
• Property predictions high confidence

• Correlation between spectra and properties excellent

• Correlation on right is for D86 50% distilled

• $R^2 > 0.99$
• Monitoring Polypropylene powder

• Monitoring grade changes

• Initial feasibility study was to assess performance of NIR, Raman and NMR

• NIR showed terrific promise

• Aggregate clustered by catalyst system and ordered by TC2
• Property predictions also excellent

• Three properties modelled:
  • C2 content
  • Additive 1
  • Ratio of the Above

• Correlation on right is for Ratio v spectra
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- Opportunity to monitor adulteration of beeswax with man made contaminants

- Samples were made up with known concentrations of paraffin and stearic acid

- Blending exceptionally linear
<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Results from Discrimination</th>
<th>Basis of result</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_03</td>
<td>Beeswax Adulterated with Stearic Acid (13.4%)</td>
<td>Stearic Acid Linear Blending with Spectra, sample sits between 10% and 20% Stearic acid samples</td>
</tr>
<tr>
<td>G_04</td>
<td>Pure Beeswax Primary Sample</td>
<td>Spectral similarity to pure beeswax samples identified by Intertek Bremen</td>
</tr>
<tr>
<td>G_07</td>
<td>Beeswax Adulterated with an unknown compound</td>
<td>Sample is not within any historic clusters and is in a region of the aggregates not previously seen.</td>
</tr>
<tr>
<td>G_19</td>
<td>Beeswax Adulterated with Paraffin (23%)</td>
<td>This sample is spectrally most similar to the previous 20% paraffin sample.</td>
</tr>
<tr>
<td>G_25</td>
<td>Beeswax Adulterated with Paraffin (19%)</td>
<td>This sample is very close to two samples identified as adulterated and also to those deliberately adultered by Intertek Bremen. This sample could be either a pure sample which has been adulterated prior to being received or was adulterated with small amounts of paraffin.</td>
</tr>
<tr>
<td>R_04</td>
<td>Beeswax Adulterated with an unknown compound</td>
<td>Sample is not within any historic clusters and is in a region of the aggregates not previously seen.</td>
</tr>
<tr>
<td>R_05</td>
<td>Beeswax Adulterated with Stearic Acid (6.2%)</td>
<td>Stearic Acid Linear Blending with Spectra, sample sits between pure beeswax and 10% stearic acid samples</td>
</tr>
<tr>
<td>R_08</td>
<td>Beeswax Adulterated with Stearic Acid (20.8%)</td>
<td>Stearic Acid Linear Blending with Spectra, sample sits in the same region as the historic 20% stearic acid sample</td>
</tr>
<tr>
<td>R_14</td>
<td>Beeswax Adulterated with Stearic Acid (35.36%)</td>
<td>Stearic Acid Linear Blending with Spectra, sample sits between 30% and 40% stearic acid samples</td>
</tr>
</tbody>
</table>

- Model excellent at predicting contaminants in beeswax
- Pure sample forms a distinctive cluster
- Contaminants can be detected at very low levels
- Unknown contaminants can also be detected
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