INTRODUCTION

The InjectionObj class includes properties, methods and events needed to describe quantitatively a diluent injection point, from the process point of view, in a single well infrastructure.

The most relevant algorithms included in this class are the viscosity blending method, e.g. methods to calculate the viscosity of an oil mixture, typically one with low API gravity and viscosity, and the other with high API gravity and viscosity. Generally speaking, the density and the viscosity of a crude oil increase in the same direction, however, these two properties are unrelated.

This class includes two algorithms to calculate the viscosity of a blend:

- Cragoe's method
- ASTM D7152 (2011) method

Both methods use an exponential expression to extrapolate the viscosity of a blend, using two reference values. The methods differ on the set of calculation to calculate the adjustment parameters. For more information on these methods, it is recommended that the user reviews the following: (ASTM Standard D7152, 2011), (Cragoe, 1933), and (Sæten, 2014).

DOCUMENT OBJECTIVE

Describing the main features, algorithms and calculations perform by the InjectionObj class.

DOCUMENT SCOPE

Describe all properties, methods and events included in the InjectionObj class, in its version 01. Additional to this, provide a detailed explanation on the major algorithms applied to solve the object depending on the variable configurations.

PROPERTIES

An attribute table describes each property. This table is a simplified version of the property attributes available in MATLAB, and it purpose is for any user or programmer with no previous experience in MATLAB have a better understanding of the property functionality.

For information, the attribute descriptions are as follows:

Property attribute	Description	Values
Access	Property accessibility once a class instance is created. Public: unrestricted access Protected: access from classes and subclasses Private: access from class member only	{public | protected | private}
Dependent	Property auto-calculated by class instance, once all dependencies have been set. When true, the property does not store any value, and it is calculated in every callback.	{true | false}
Hidden	Property visibility for a class instance. When true, the property is not listed in the available class instance's properties.	{true | false}
Set access	Property ability to be written by the user in a class instance. Public: unrestricted access Protected: access from classes and subclasses Private: access from class member only Immutable: access from class constructor only	{public | protected | private | immutable}
Get access	Property ability to be read by the user in a class instance. Public: unrestricted access Protected: access from classes and subclasses Private: access from class member only	{public | protected | private}

QD

Description	*Diluent flowrate* Diluent flowrate at local conditions, given in m^3/d.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

QO

Description	*Oil flowrate* Oil flowrate at local conditions, given in m^3/d.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

QW

Description	*Water flowrate* Water flowrate at local conditions, given in m^3/d.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

TB

Description	*Blending temperature* Temperature at which the oil and the diluent flowrate will be blended, given in C.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

DRHO

Description	*Diluent density* Diluent density given in kg/m^3.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

ORHO

Description	*Oil density* Oil density given in kg/m^3.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

WRHO

Description	*Water density* Water density given in kg/m^3. Constant value of 1000 kg/m^3, at 4 C and 101,33 kPa.				
Access	Protected	**Dependent**	False	**Set access**	Public
Hidden	True	**Class**	Double	**Get access**	Public

MRT

Description	*Reference matrix, temperature* This property stores the 2x2 matrix, for the given corresponding temperature values of the reference viscosity, in C, given in property `mrmu`. The first row of the matrix includes the reference temperature value for the crude oil, while the second row includes the diluent reference.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

MRMU

Description	*Reference matrix, viscosity* This property stores the 2x2 matrix, for the given corresponding viscosity values used as reference for the blending given in cP. The first row of the matrix includes the reference viscosity value for the crude oil, while the second row includes the diluent reference. The corresponding temperature values of the viscosity values given in this matrix, must be saved in `mrT` property.				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

BMRT

Description	*Blending matrix, temperature* 5x1 matrix including the temperature value references of the corresponding viscosity blending stored in property `bmrmu`. Temperature value are given in C. The user must invoke the `BlendingReference` method to set the values for this property.				
Access	Public	**Dependent**	False	**Set access**	Protected
Hidden	False	**Class**	Double	**Get access**	Public

BMRMU

Description	*Blending matrix, temperature* 5x1 matrix including the viscosity value references of the corresponding temperature of blending stored in property `bmrT`. Viscosity is given in the same units as in the `mrmu` property. The user must invoke the `BlendingReference` method to set the values for this property.				
Access	Public	**Dependent**	False	**Set access**	Protected
Hidden	False	**Class**	Double	**Get access**	Public

BLENDINGMETHOD

Description	*Blending procedure to calculate viscosity* This property is an array of characters, indicating the procedure to be used to calculate the blend viscosity. The class supports two methods: · `'cragoe'` · `'astm_d7152'`				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	String	**Get access**	Public

CRAGOEA

Description	*Cragoe coefficient, A* Coefficient of the Cragoe viscosity fitting expression. For more information about the method, review (Cragoe, 1933). Default value = `5e-2`				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

CRAGOEB

Description	*Cragoe coefficient, B* Coefficient of the Cragoe viscosity fitting expression. For more information about the method, review (Cragoe, 1933). Default value = `1e3*log(20)`				
Access	Public	**Dependent**	False	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

BRHO

Description	*Blend density* Blend density calculated as average, on weight basis, between the crude oil and the diluent. The density is given in kg/m^3.				
Access	Public	**Dependent**	True	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

BMU

Description	*Blend viscosity* Blend viscosity calculated using one of the blending procedures available, Cragoe's method or ASTM D7152 standard. The viscosity is given in cP.				
Access	Public	**Dependent**	True	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

BSG

Description	*Blend specific gravity* Blend specific gravity calculated as average, on weight basis, between the crude oil and the diluent. The specific gravity is dimensionless.				
Access	Public	**Dependent**	True	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

WC

Description	*Water cut* Water cut calculated as average, on volume basis, between the oil phase and the water phase. The diluent is considered as oil phase, therefore, the water cut is supposed to be lower than the previous calculation step of the system. The water cut is dimensionless.				
Access	Public	**Dependent**	True	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

WT

Description	*Weight fraction, oil phase* Weight fraction of the diluent in respect to the oil phase. This variable is required to use the viscosity blending procedures.				
Access	Public	**Dependent**	True	**Set access**	Public
Hidden	False	**Class**	Double	**Get access**	Public

METHODS

An attribute table describes each method. This table is a simplified version of the method attributes available in MATLAB, and it purpose is for any user or programmer with no previous experience in MATLAB have a better understanding of the method functionality.

For information, the attribute descriptions are as follows:

Method attribute	Description	Values
Access	Method accessibility once a class instance is created. · Public: unrestricted access · Protected: access from classes and subclasses · Private: access from class member only	{public | protected | private}
Hidden	Method visibility for a class instance. When true, the property is not listed in the available class instance's methods.	{true | false}
Static	Method independency on a class object. Relative to methods inherent to the class code, such as error/exception handling. When true, the method is only available inside the class code only and does not require arguments related to the class instance.	{true | false}

BLENDINGREFERENCE

Description	*Creating blending reference values* This method allows to create two (2) 5x1 matrixes, containing viscosity and temperature reference values used by objects from the class BOObj, in order to adjust the viscosity calculation within the black oil model. The method uses the Tb property as temperature pivot, and then with a span +/-10 C, uses the selected blending method to calculate five (5) viscosity reference values. The references are stored in the `bmrT` and `bmrmu` properties.				
Access	Public	**Hidden**	False	**Static**	False

BLENDINGASTM_D7152

Description	*Blending procedure, ASTM D7152 standard (2011)* Calculation of viscosity of an oil blend, using ASTM D-7152 method (ASTM Standard D7152, 2011). It is applicable for blends based on their viscosity and weight fraction. This is an auxiliary method to the dependent property `bmu`.				
Access	Protected	**Hidden**	True	**Static**	False

BLENDINGCRAGOE

Description	*Blending procedure, Cragoe (1933)* Calculation of viscosity of an oil blend, using Cragoe method (Cragoe, 1933). It is applicable for blends based on their viscosity and weight fraction. This is an auxiliary method to the dependent property `bmu`.				
Access	Protected	**Hidden**	True	**Static**	False

STRUCTURE BRIEFING

In the following table, there is a list of all public properties included in every object created from this class.

Property	Name	Remarks
Qd	Diluent flowrate	Required.
Qo	Oil flowrate	Required.
Qw	Water flowrate	Required.
Tb	Blending temperature	Required.
drho	Diluent density	Required.
orho	Oil density	Required.
mrT	Reference matrix, temperature	Required.
mrmu	Reference matrix, viscosity	Required.
bmrT	Reference matrix, temperature	Calculated by `BlendingReference`.
bmrmu	Reference matrix, viscosity	Calculated by `BlendingReference`.
BlendingMethod	Blending procedure to calculate viscosity	Required. Default value = `'astm_d7152'`
CragoeA	Cragoe coefficient, A	Required (*). Default value = `5e-02`
CragoeB	Cragoe coefficient, B	Required (*). Default value = `1e3*log(20)`
brho	Blend density	Dependent.
bmu	Blend viscosity	Dependent.
bSG	Blend specific gravity	Dependent.
WC	Water cut	Dependent.
wt	Weight fraction, oil phase	Dependent.

(*) Required when the `BlendingMethod` property is set to `'Cragoe'`.

APPLICATION

In the next blocks of code, some applications of the class are shown

EXAMPLE 1: DEFINING AN OBJECT

```
BL = InjectionObj;
BL.Qo = 0;
```

```
BL.Qd = 500;
BL.Qw = 0;
BL.Tb = 30;
BL.mrmu = [906 329;9.8 7.5];
BL.mrT = [37.8 50.0; 38.0 54.0];
BL.drho = 872.0;
BL.orho = 969.2;
```

EXAMPLE 2: USING THE BLENDINGREFERENCE METHOD

The following code shows and application of the `BlendingReference` method using the same variable defined above.

```
BL.BlendingReference
BL.bmrmu
ans
   13.9325
   12.5575
   11.3741
   10.3496
    9.4577
BL.bmrT
ans =
    20
    25
    30
    35
    40
```

REFERENCES

ASTM Standard D7152. (2011). Standard Practice for Calculating Viscosity of a Blend of Petroleum Products. West Conshohocken, PA: ASTM International. doi:10.1520/D7152-11

Cragoe, C. (1933). Changes in the viscosity of liquids with temperature, pressure and composition. *First World Petroleum Congress*, (pp. WPC-201). London, UK.

Sæten, S. (2014). *Estimating Viscosity of a Petroleum Blend*. Specialization Project Report, Norwegian University of Science and Technology, Department of Petroleum Engineering and Applied Geophysics.