Examples of data set

The user finds here some examples illustrating different configurations related to the namelist "Fluid_Properties".
The data initialized by default, and not explicitly required, are generally not present for a sake of clarity.
Data values are showed for equations used in a dimensional form.

Usual incompressible Flows

One fluid is considered.
In these examples, the physical properties are constant but the viscosity or the thermal conductivity can depend on temperature (Sutherland's law).
The heat capacity of the fluid is considered constant(no temperature dependence).
The gravity or buoyancy effects are related to the temperature variation only.

Isothermal flows

```
&Fluid_Properties  Reference_Dynamic_Viscosity = 1.84D-05 ,
                   Reference_Density           = 1.2058789  /
```

Example of axisymmetrical flows

```
&Fluid_Properties  Axisymmetric_Case_3D_Enabled= .true. ,
                   Reference_Dynamic_Viscosity = 1.84D-05 ,
                   Reference_Density           = 1.20    /
```

In this case, do not forget to define the domain in cylindrical geometry (see the Namelist "Domain_Features" .

Flows with Boussinesq's hypothesis

Here Heat transfer are considered.
The physical properties are constant.
The buoyancy effect are related to the temperature variation.

```
&Fluid_Properties  Heat_Transfer_Flow          = .true. ,
                   Reference_Dynamic_Viscosity = 1.84D-05 ,
                   Prandtl                     = 0.71 ,
                   Reference_Temperature       = 300.0    ,
                   Reference_Density           = 1.20    ,
                   Thermal_Expansion_Coefficient= 0.033
                   Reference_Heat_Capacity = 1004.50  /
```

For incompressible flows with buoyancy effects, do not forget to define the “Thermal_Expansion_Coefficient” because the buoyancy force is defined from the temperature variation in place of the density.
Don not forget also to define the gravity constant in the namelist "Gravity".
Thermal_Expansion_Coefficient= 0.0 involves that it is automatically calculated as the inverse of the “Reference_Temperature”.
The “Reference_Heat_Capacity” is only useful when the simulation must explicitly take into account the heat flux (i.e. a heat flux boundary condition or heat exchange between the fluid and a thermal conductive material). In these cases, the equation of enthalpy is globally considered and not its simplified version that leads to the equation of temperature.

Incompressible two phase flows

No heat transfer is considered at present.
The physical properties of each fluid are constant.
Two-phase flow simulations are performed with a level approach.
The simulations are restricted to enclosed domains at present.

```
&Fluid_Properties  Incomp_MultiFluids= .true. ,
                   Reference_Dynamic_Viscosity   = 1.84D-05 ,
                   Reference_Dynamic_Viscosity_2 = 1.00D-03 ,
                   Reference_Density             = 1.2      ,
                   Reference_Density_2           = 1000.    ,
                   Interface_Thickness_Scale     = 1.e-2    /
```

“Interface_Thickness_Scale” is a parameter of the level set model and it is strongly dependent of the simulation (nature of the problem, meshsize, ...). If the variable is set to zero, the interface thickness is automatically estimated. Used with caution.

Low Mach-number Flows

The fluid is a perfect gas.
Heat transfer and multi-component gas can be considered.
Physical properties can be considered constant or dependent of gas mixture and temperature.
The dependence of the heat capacity is considered only in the case of multi-component gas flows. Otherwise it is constant.

Example of flow with heat transfer

One species only (or homogenous species gas).
The viscosity and the thermal conductivity depend on the Sutherland's law.
When the buoyancy/gravity force is considered, it is directly related to the density variation.

```
&Fluid_Properties  Variable_Density            = .true.   ,
                   Heat_Transfer_Flow          = .true. ,
                   Reference_Dynamic_Viscosity = 1.84D-05 ,
                   Reference_Temperature       = 300.0    ,
                   Reference_Density           = 1.20     ,
                   Prandtl                     = 0.71     ,
                   Heat_Capacity_Ratio         = 1.4      ,
                   Molecular_Mass              = 2.9D-02  ,
                   Reference_Heat_Capacity     = 1004.50  ,
                   Sutherland_Law_Enabled      = .true.   /
```

The heat capacity is calculated from the constant of perfect gas ($R=8.3144598 J.mol^{-1}.K^{-1}$), the “Heat_Capacity_Ratio” and the “Molecular_Mass ” of the gas.
In the dimensionless form, the specific gas constant is generally equal to unity and the heat capacity is $C_p= \frac{\gamma}{\gamma -1}$. The reference value of the molecular mass must be set to the constant of perfect gas R.
If gravity/buoyancy effects must be considered, they are directly connected to the density variation. The variable “Thermal_Heat_Expansion” can be omitted and the gravity source term can be defined in the namelist "Gravity".

Multi-species flows

Heat transfer is activated.
Multi-species component gas .
Physical properties depend on the gas components.
When the buoyancy/gravity force is considered, it is directly related to the density variation.

```
 &Fluid_Properties Variable_Density             = .true.   ,
                   Heat_Transfer_Flow           = .true. ,
                   MultiSpecies_Flow            = .true.   ,
                   Reference_Dynamic_Viscosity  = 1.84D-05 ,
                   Reference_Temperature        = 300.0    ,
                   Reference_Density            = 1.20     ,
                   Prandtl                      = 0.71     ,
                   Heat_Capacity_Ratio          = 1.4      ,
                   Molecular_Mass               = 2.9D-02  ,
                   Reference_Heat_Capacity      = 1004.50  ,
                   Sutherland_Law_Enabled       = .true.
                   Multi_Species_Mixture_Law_for_Viscosity_Enabled
= .true. ,
Multi_Species_Mixture_Law_for_Thermal_Conductivity_Enabled= .true. ,
                   Multi_Species_Mixture_Law_for_Mass_Diffusion_Enabled
= .true.  ,
                   Soret_Effect_Enabled = .false. //
```

The reference values must be compatible each others (by means of law of perfect gas).
In this example, the physical properties are not constant depend on the gas mixture and the temperature. They are calculated in each cell for each time step by means of formulations coming from the kinetic theory of gas.
The gas properties associated to each species are provided by the namelist "Species_Properties".