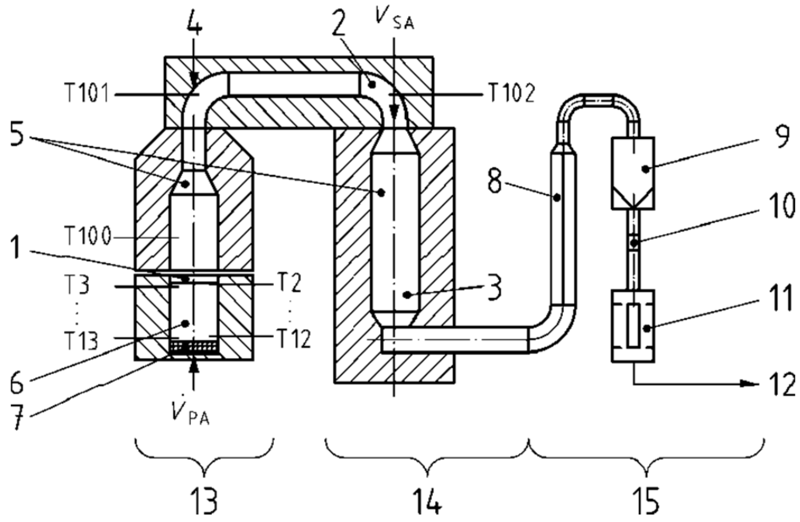
5.4 Kinetic properties

The kinetic data on a fuel provide vital information on the reaction rate and the combustion rate. Major areas of interest are:

- heating of the particle;
- drying and release of volatiles (pyrolysis, devolitilisation);
- ignition and combustion of organic components (volatile combustion);
  - ignition temperature;
  - flame stability;
- ignition and combustion of residual char (char combustion);
  - char burnout time;
  - char reactivity;
  - reactive surface area;
  - particle temperatures.

For experimental determination of kinetic fuel data, many laboratory-scale apparatus are commercially available and are used in different research centres and universities. Examples are thermo-gravimetric analysis (TGA), differential thermo-gravimetric analysis (DTG), high temperature wire mash (HTWM), and laboratory-scale reactors (drop tube furnaces, fixed bed, etc.). Major parameters to select between the different apparatus are the heating rate and required sample amount. In the following some results and schemes of apparatus are shown.

Heated wire grid (HWG) system (also called heated wire mesh): The method can reach temperatures up to 2 000 °C and heating rates up to 10^4 K/s. The used amount of sample is in a range from 2 mg to 15 mg (see[6], [29]). Such a device is shown in Figure 19.



Key
1 Gas sample 1
2 Gas sample 2
3 Gas sample 3
4 Camera
5 Electrically heated (T_{max} = 1 100 °C)
6 Fixed bed (volume 10 l)
7 Sample mass recording
8 Heat exchanger
9 Filter chamber
10 Venturimeter
11 Cole adsorber
12 Blower
13 Burning chamber
14 After burning chamber
15 Flue gas cleaning

Figure 24 — Fixed bed reactor [33]

The methods and apparatus shown above can be used to investigate single or combined relevant parameters. To get a full picture regarding combustion behaviour and emission formation the residues and intermediates, such as char and ash, need to be characterised by the standard methods (ultimate, proximate, LHV). Additional methods to determine, e.g. pore structure, are also needed.

According to such analysis results can be correlated regarding several approaches including heating value, composition of released volatiles, remaining chars, release of volatile nitrogen, etc. Such correlations give fruitful fingerprints to characterise a fuel and single fuel fraction concerning ignition, NO_X formation, and reduction potential. The use of synthetic sample with known composition may be an idea to study the influence of one component on the other. Similar approach was used to determine whether significant interactions between single components take place during thermal degradation (see [35]).

Some applications like the laboratory-scale furnaces can also give very good results regarding ash formation by characterising the intermediates and residues by SEM-EDX/WDX, CCSEM, XRD, XRF etc.

5.5 Image analysis method for particle size distribution

Another class of particle size analysis method is based an optical recognition program; here a digital photo of the SRF is used to determine the particle size distribution. There are several available commercial software using such principles to analysed size distribution (see [26]). The main advantage of this method over sieve analysis is that the sizes are determined according to the maximum projection area of the particle. Figure 25 gives a visual expression of the translation process (see [36]).