

From non-disposable to disposable

Thermal treatment of pyroforic or gasforming metals

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Abstract

In order to dispose of waste in either a deep geological disposal or in a shallower repository there are several demands that the waste and its package must fulfill, one is that it is not to react with oxygen or the waste package or backfill in the repository, i.e. concrete or grout.

The waste forms that do not fulfil this particular criterion must be treated in some way to render the waste non-reactive. One of these waste streams is metallic uranium. Metallic uranium is not only an issue originating from the nuclear industry as fuel, it is also present in, for example, transport flasks and as samples used in schools, which all has to be disposed of sooner or later.

Another waste that arises is magnesium doped with thorium, originating from the aviation, aerospace and missile industry. These magnesium-thorium (Mg-Th) alloys are now being replaced with others without thorium so they are in need of handling and possibly treatment before disposal. Magnesium metal is also pyrophoric, in particular in molten or powder form.

In order to evaluate thermally treating these metals in a very controlled environment, such as a pyrolysis vessel, experimental work has been performed.

Introduction

Pyrolysis equipment in muffle furnace, 2 dm³ vessel

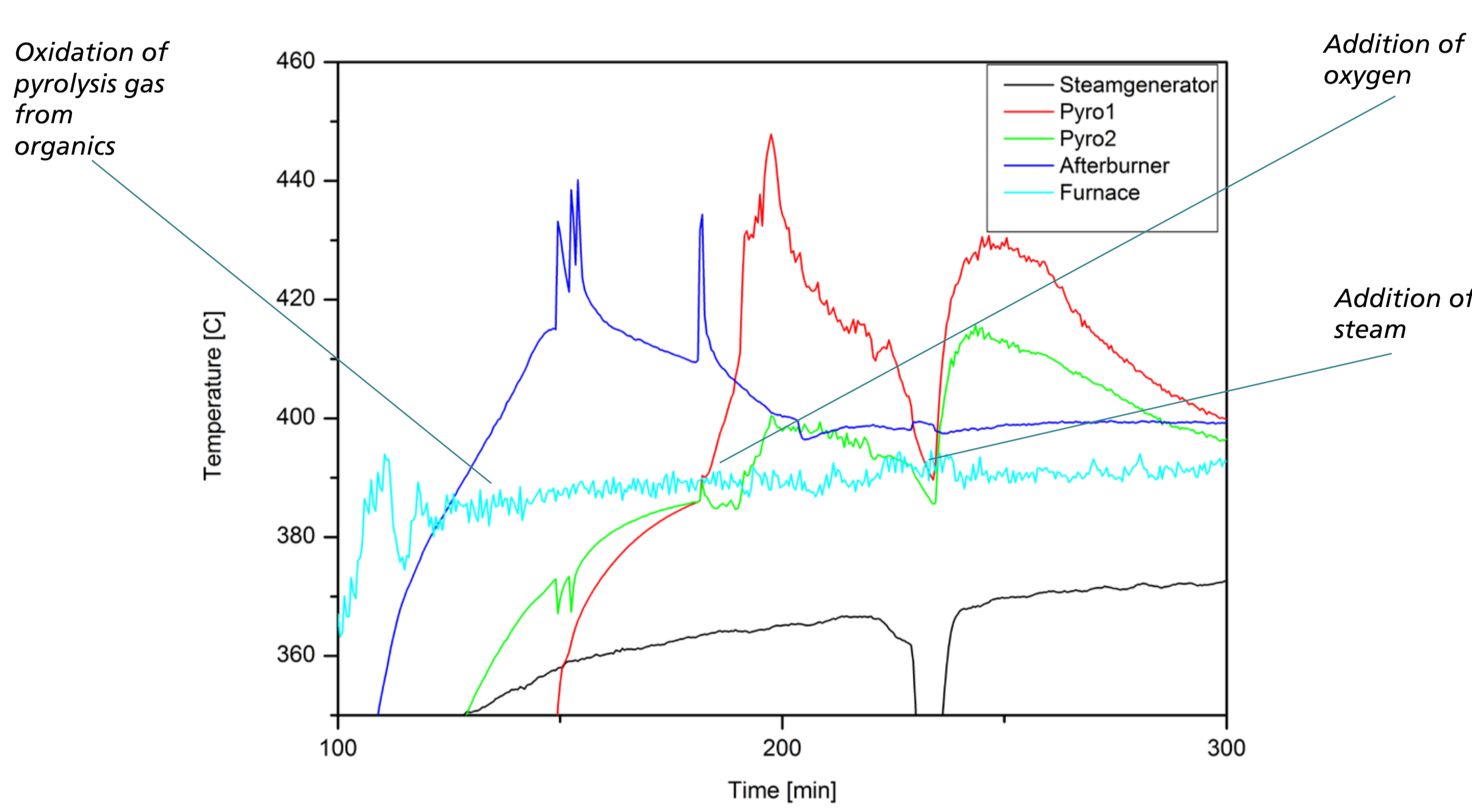
Controlled atmosphere, MFC for O₂, N₂ and H₂O

After Burner for destruction of pyrolysis gas when having organics

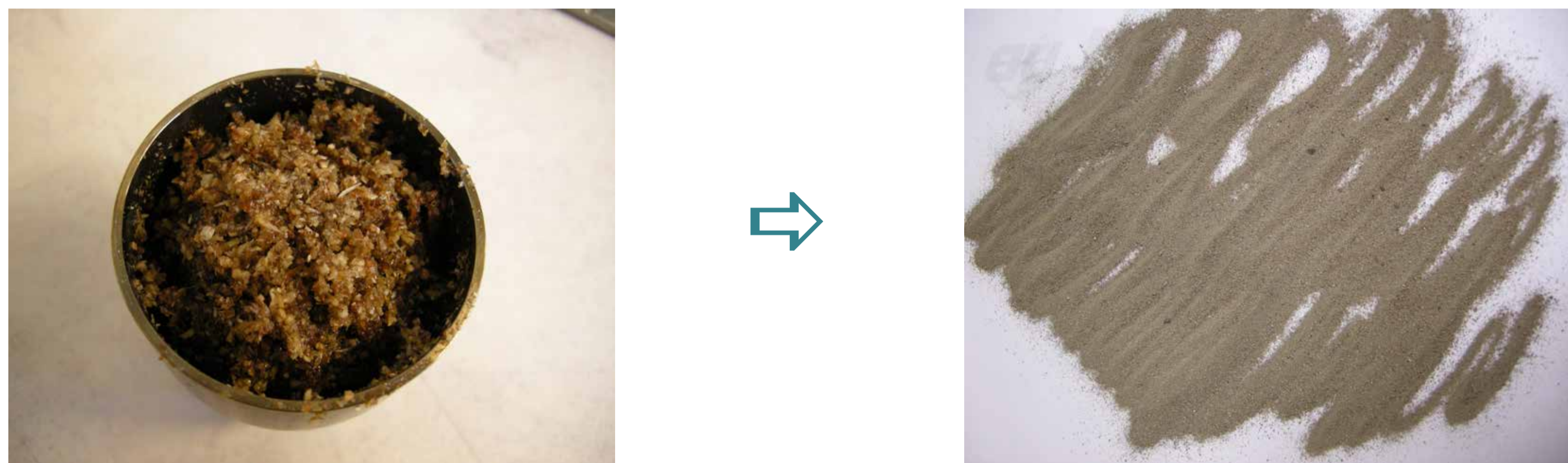
Filter and wet scrubber for acid off gases

Experimental – inactive materials

- First set of trials with Mg-shavings
 - Gave understanding for basic parameters and process control
- Cerium used as uranium surrogate, similar reactivity
 - Mixture of metal and organics (oil, sawdust)
- Goal was to show that material could be oxidised in a safe and controlled manner.
- Oxidation in several steps. Organics was gasified first, followed by a controlled oxidation of metal.



- No metallic cerium left in residues
- No or very little residues from organics

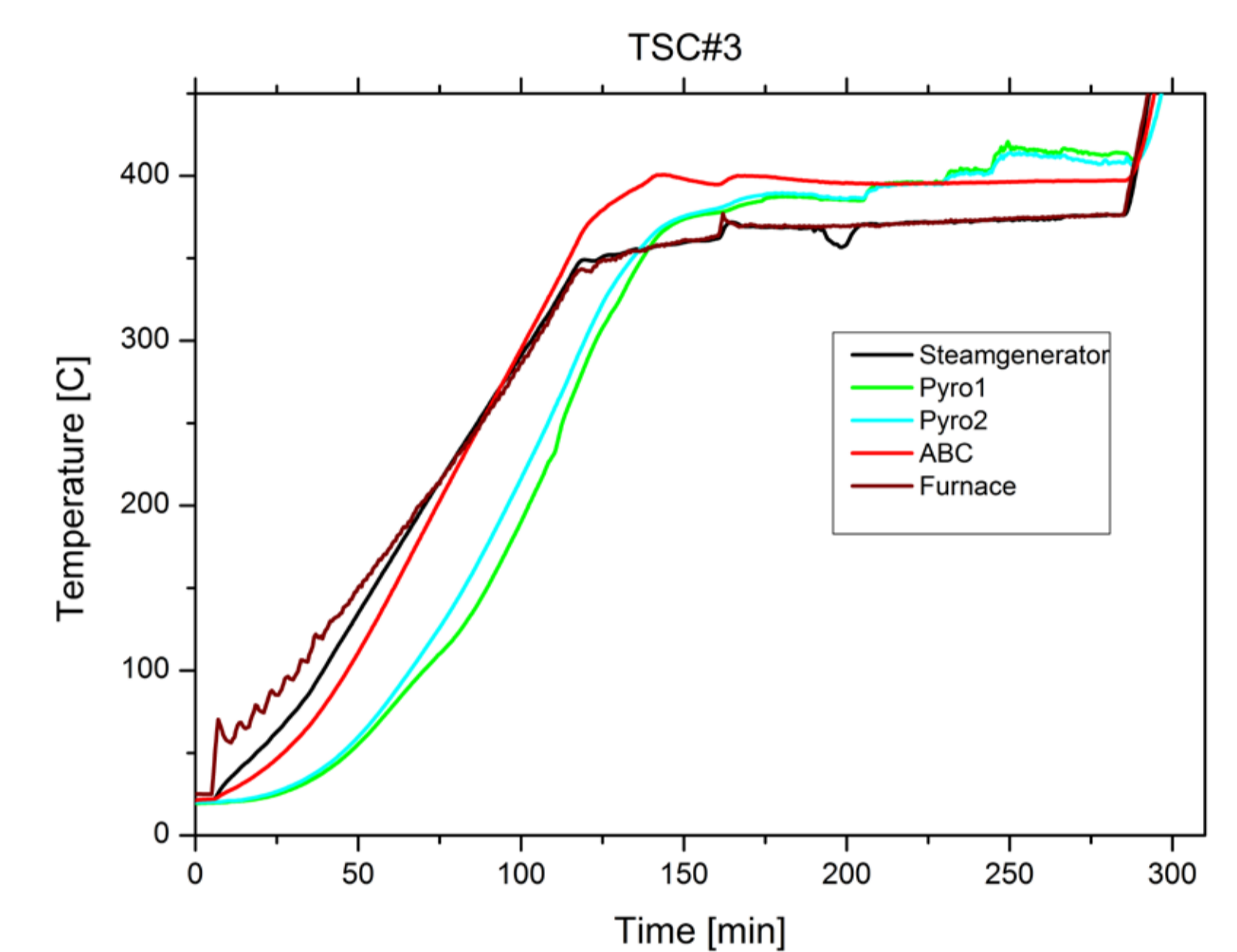


- Oxidation in several steps
- First: oxidation of organics without affecting the metal (~ 2% of metal oxidised)
- Second: oxidation of metal (also possible to do in steps)

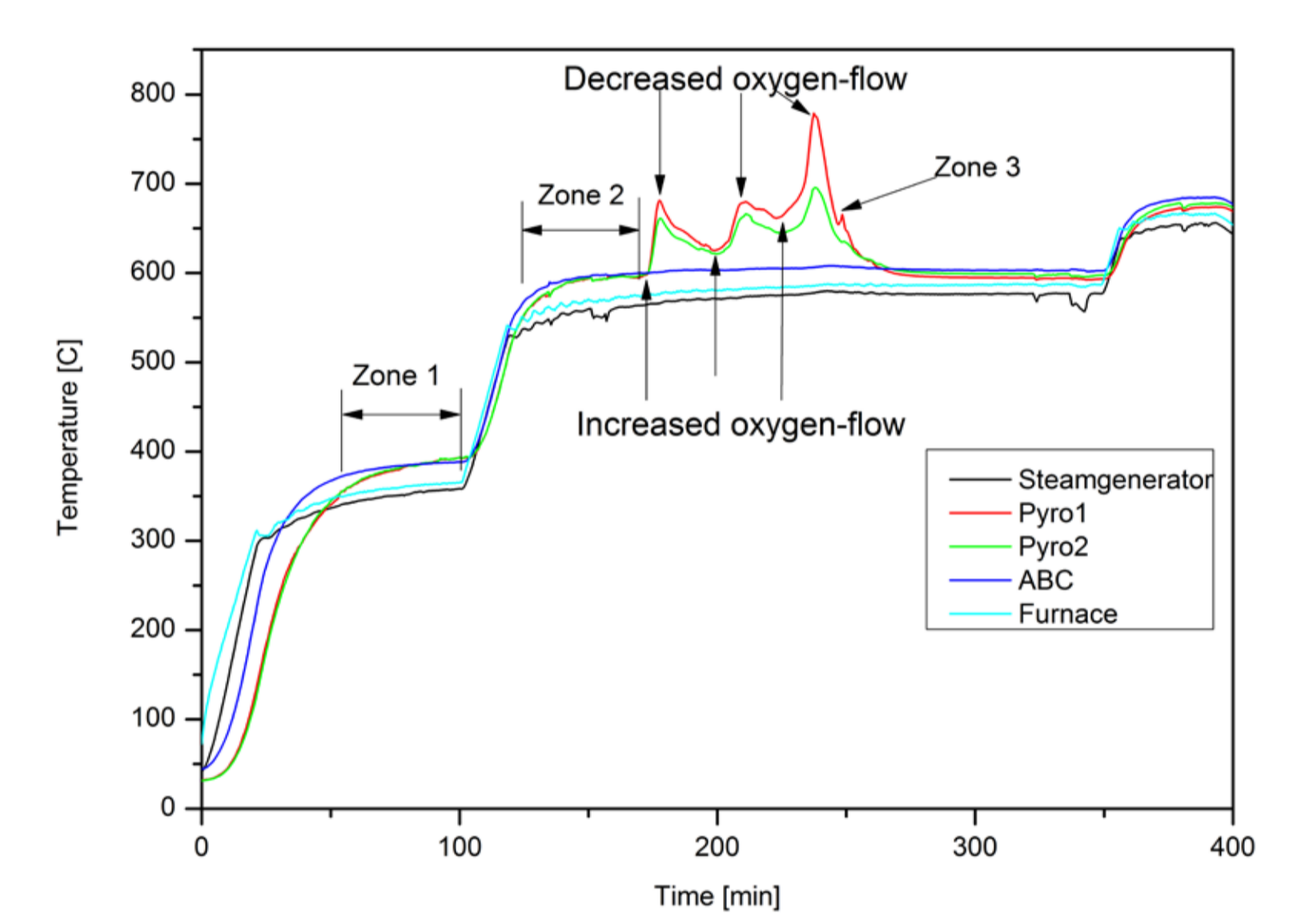


Experimental – active materials

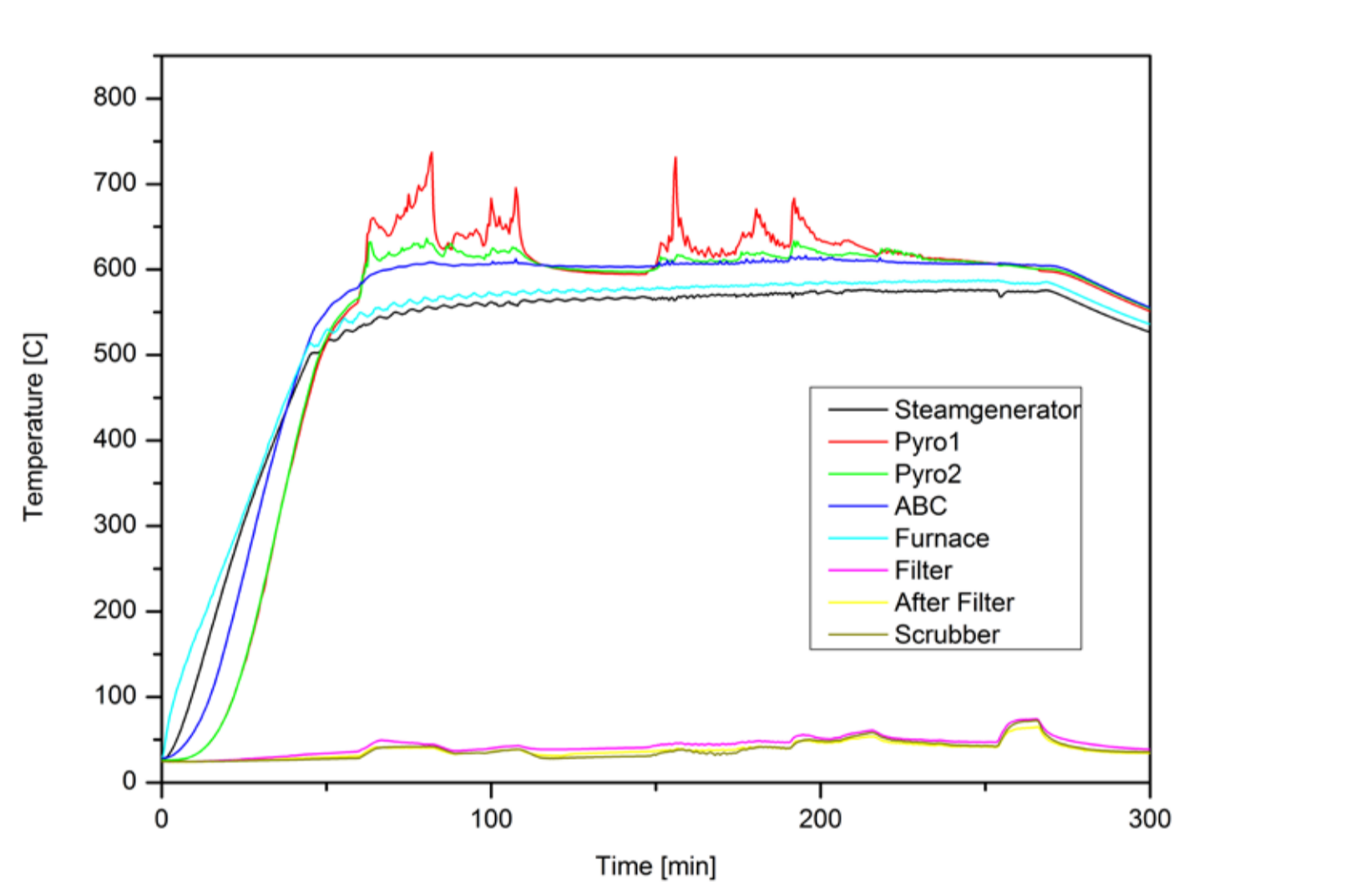
- Metallic uranium shavings mixed with organics such as oil and sawdust
- Uranium content between 5-75%
- Treatment temperature 600 °C
- Nitrogen added to remove all oxygen and also during treatment as carrier gas
- End result U₃O₈ (XRD)



- Solid blocks of metallic uranium, up to 750 grams each
- Oxidised in a controlled way



- Mg-Th alloy from example aviation and missile industry
- Oxidised in a controlled way

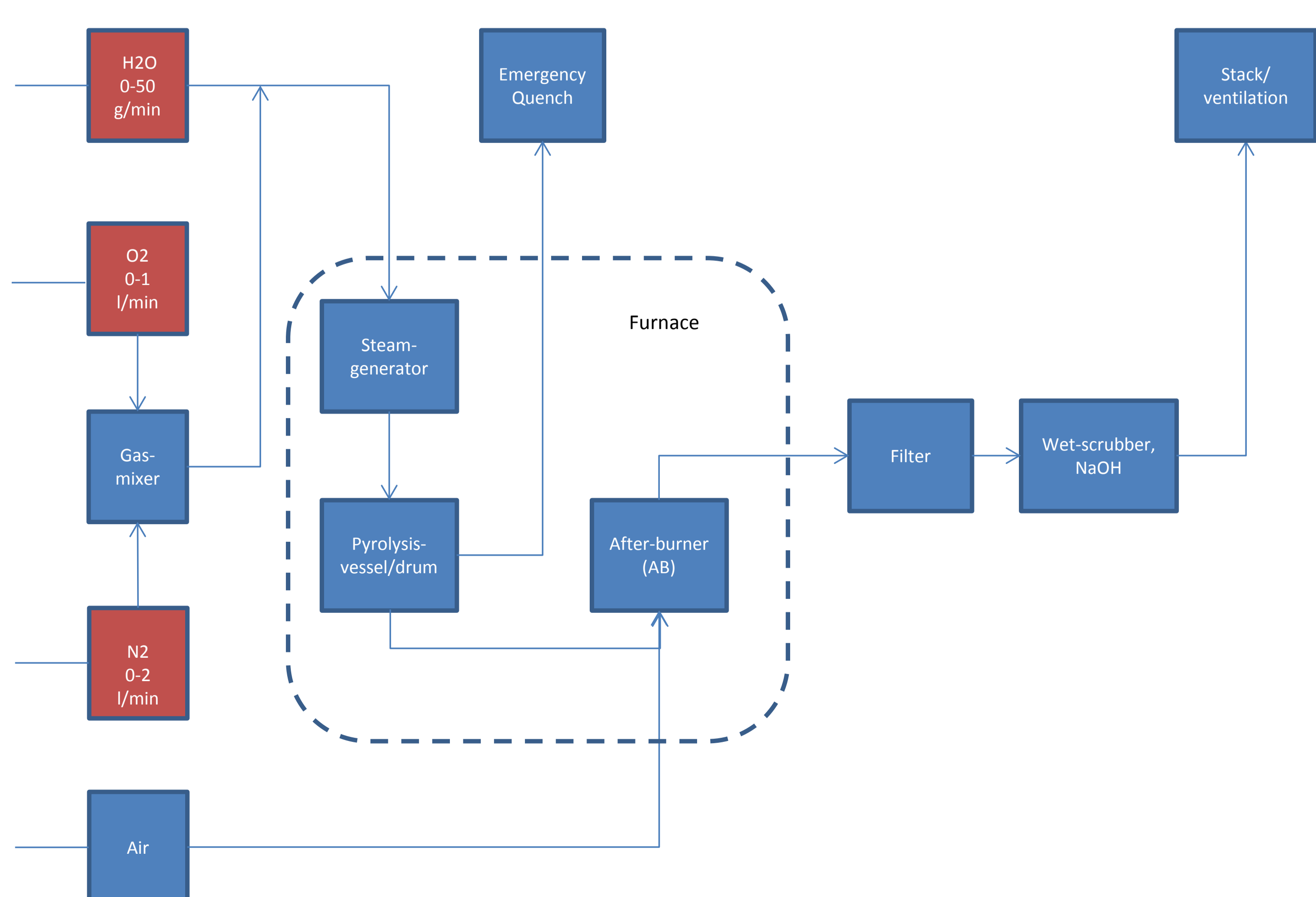


Conclusions

- Oxidation of all examined metals and metal-alloys could be performed in a safe and controlled manner
- All reactions were possible to quench by shutting off supply of oxygen either as pure oxygen or as steam

- It is possible to achieve complete oxidation of metal even if the metal is in shapes of big blocks.
- Metal powder or shavings are treated in the same manner and the process is as controllable as for solid metal blocks.

Experimental setup



Computer Interface

