FEATURES OF HYDROGEN EVOLUTION AT HYDROLYSIS OF SODIUM SUSPENSION IN TOLUENE

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A research was conducted into the reaction of hydrides with water accompanied by explosion, hydrolysis of sodium suspend-sion in toluene was chosen as an example.

A possibility of fire extinguishing of suspension substances including sodium suspension in toluene (SST) by water- foam means was studied. The fact that an explosive reaction with hydrogen evolution at direct contact of sodium with water is possible was taken into account. At the same time it was necessary to determine the influence of toluene on the character of the reaction and the scale allowable from the standpoint of explosion and fire hazard connected with the use of water- foam fire extinguishing means being the most accessible ones. Besides it was planned to determine the conditions of spontaneous combustion of SST at water discharge.

During the research SST of 3-5% was tested, it is used as an intermediate product in industrial production. Sodium particles were oval in shape with sides of 3 and 5 mm.

A special laboratory test apparatus was created to investigate the features of reaction of SST with water. It included a vessel with SST where water was supplied by drops. It should be emphasized that so called SST in this case was 2-layer mixture consisting of sodium particles layer at the bottom and toluene layer above.

It is found experimentally that the rate of hydrogen evolution directly depends on the rate of water discharge (ml/min). Presence of toluene influences the rate of hydrolysis. According to our estimation in order to accomplish the complete hydrolysis an excess of water is necessary going beyond the design value (stochiometric) by a magnitude.

The behavior of sodium particles in contact with water under toluene layer was studied in an effort to determine the conditions of SST ignition.

Sodium particle sank through the toluene layer to the boundary owing to the difference of densities of toluene, sodium and water, it reached the surface of water, reacted with it and hydrogen evolved. Meanwhile hydrogen bubbles having stuck round the particle of sodium promoted its movement upward to toluene layer surface. Here the particle got free from the part of the bubbles and again sank to the boundary. And the same cycle recurred again. The cycle time depends on toluene layer height. In our research it was equal to 10 mm and the particle accompli shed 2 cycles for 10 s.

It should be stressed that sodium particle being heated on the boundary looses certain part of heat when moving upward in toluene layer. According to calculation the particle can be heated to the temperature of 670 K at the contact with water, this value is somewhat higher than the spontaneous ignition temperature of sodium (570-600K [1] according to literary data) and substantially higher than boiling point of toluene.

Consequently, toluene layer thick-ness governs the value of heat loss of the particle. The higher the layer of toluene above water the greater amount of heat the particle looses during its transfer. Test date testify that the ignition of toluene does not take place if the height of its thickness exceeds the maximal dimensions of the particle in 5 times and more. We have considered the case when SST was spilled onto the damp surface.

During the extinguishing of spilled SST by water the particle of sodium reacts with water

twice: on the surface of the non-settled particle and under the layer of toluene if it has settled. In this case the probability of SST ignition grows due to additional heating.

The features of SST hydrolysis described give ground to reach a conclusion about the limited use of water – foam extinguishing means (at spillage of 5 – 10 l of SST). If hydrolysis proceeds during SST combustion, the hydrogen evolved burns out in the flame intensifying the process of combustion. If hydrolysis proceeds without flame the hydrogen releases in the room, this situation requires to take necessary measures to reduce explosion and fire hazard.

Real amount of SST spillage in the room which can attain hundreds of liters should be extinguished by special pow der compositions following special proce dure developed by VNIIPO [2]. VNIIPO in cooperation with ZAO "Ecokhimmash" (town of Buy, Kostroma region) developed special powder composition Vexon-D2, which is manufactured in industrial series at "Ecokhimmash" plant. Powder fire extinguishers with charge of special powders for extinguishing of fires of sodium and other metals in the form of powders and chips (aluminum, magnesium, calcium, titanium, uranium, zirconium, hydrides of metals, organometallic substances) are produced at pilot plant of FGU VNIIPO EMERCOM of Russia.

The test results obtained in the research devoted to the hydrolysis of sodium particles in the system of toluene – water can be used in nuclear-power engineering for fast reactors (FR).

References

1. Fire And Explosion Hazard of Substances And Materials And Means of Their Extinguishment: Guide: volumes 1,1: Khimiya, 1990.
2. Recommendations On Extinguishing Means of Liquid Sodium And Pyrophorus Alumoorganic Catalyst : VNIIPO-GUGPS EMERCOM RF:M.:2000.19 p.