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Scientific Aspects of Fire and Smoke Hazards Associated with Lithium Batteries

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Abstract

Scientific aspects of fire and smoke hazards associated with batteries were introduced in this talk. Counterfeit batteries in used cars have to be watched as the consequence is more hazardous than genuine batteries. Fire protection should be enhanced.

1. Introduction

Different electrical batteries are widely used in many areas for necessity and sustainable environment. Lithium-ion batteries have high efficiency and long service life, and thus have led to many new applications including electric vehicles and buildings. Basic physics why and how it is possible to have high energy capacity in lithium-ion batteries will be briefed. Such heating might give thermal hazards. Fire or even explosion started from batteries always occurred. Scientific aspects of those hazards are pointed out in this talk for the society, particularly the authority handling fire safety, to explore in practical engineering applications.

Studies on fire hazards were focused on the starting fire of igniting a battery. Consequences of burning the combustibles inside should be watched. Smoke toxicity to human was ignored. Another key point is using too many counterfeit batteries with unknown materials and construction. Risk parameters are not available for the counterfeit batteries. Correlations for risk parameters such as time to ignition or heat release rates with battery capacity deduced for genuine batteries are not applicable.

2. Lithium-ion Battery ?

The basic physics why and how it is possible to have high energy capacity in lithium-ion batteries was explained [1]. However, heating has been a common problem. Without appropriate design, they might give fire and explosion as reported.

3. Big Starting Fire Source Easy to Ignite

As explained earlier on the basic physics, heating effect might give adverse effects. Any thermal generating effect without lost can accumulate to heat up the combustibles to ignite, particularly the electrolytes as reviewed above. A fire is resulted when heat lost is low.

Further, electrolytes as condensed matter would be transited to gas, heating up and generate pressure to give explosion.

A big ignition source with the heat release rate curve upon burning a car is recorded as in Fig. 1. Upon igniting the battery at TTI_B, the car ignited with TTI_{Car}. Must do something to delay TTI_{Car}.

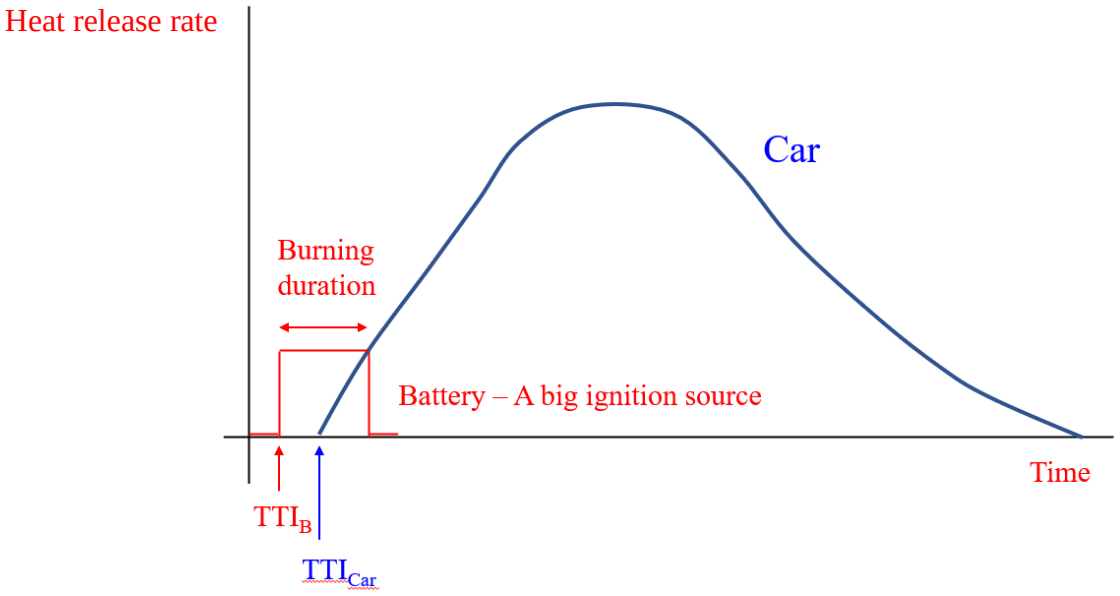

Fig. 1: Battery – A big ignition source

4. Literature Key References

There are several research papers of great interest to the topic [2-8].

However, most of the works were on genuine battery. Questions raised are:

- Counterfeit battery – Any use of the results for genuine battery ?
- Example: Any use of correlation relations on battery performed with combustibility properties ?
- The explosion scale would not be big for small rating batteries manufactured according to safety standards.
- However, it is very difficult to guarantee chemicals used and construction methods of counterfeit batteries follow safety standards.
- Fire and explosion of the battery can give larger scale disasters in igniting combustibiles.

5. Fire and Smoke Risk Factors

Three factors x, y, z are proposed [9-13]:

The first parameter is the flashover propensity x (in $kWm^{-2}s^{-1}$) given by the peak heat release rate (pkHRR) and time to ignition (TTI):

$$x = \frac{pkHRR}{TTI}$$

The second parameter is the total heat releases (THR) (in MJm^{-2}):

$$y = THR$$

Another parameter z on smoke toxicity can be calculated from LC_{50} using peak carbon monoxide concentrations to calculate FED:

$$z = LC_{50}$$

6. Discussion

Relevant fire scenarios [14-16] are essential to support fire engineering as in Fig. 2. This applies to battery fire and explosion with counterfeit battery [17-19]. The professionals concerned must have adequate practical experience. This is not just theoretical physics with new idea only. All schemes must be acceptable by the Authority. Fire sciences easily challenged to be not practical because the person might not have long experience in fire engineering !
Appropriate fire suppression system must be provided [20-22].

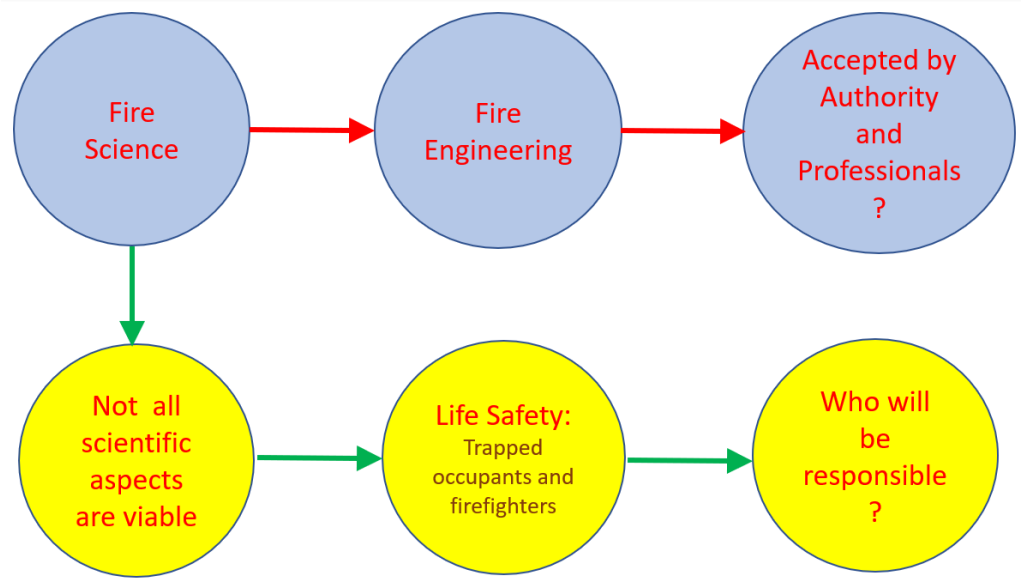

Fig. 2: Safety picture

7. Conclusion

Three key points for electrical vehicles:

- Fire hazards of battery should be taken as a starting fire, fire risk parameters should be deduced from burning combustibles of the whole car.
- Both thermal and smoke toxicity must be included. Appropriate fire risk parameters to propose.
- As too many counterfeit batteries are used, it is difficult to control their fire risk parameters.

Fire protection system must be enhanced and further explored.

Acknowledgement

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