High-Volume Cobalt Disulfide Thermal Battery Production

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Abstract

Molten salt batteries, referred to herein as thermal batteries, serve a critical role in providing on-demand electrical power for a wide array of defense applications. Although the manufacture and certification of thermal batteries remain a complex, arduous endeavor, the long storage life, and incredible power density of thermal batteries position them as the power source of choice in myriad systems. The introduction of an improved cathode material, Cobalt Disulfide (CoS_2), has extended the performance regime of thermal batteries and given rise to an even greater number of use cases. However, the structure of the improved cathode material has presented several manufacturing challenges that hindered adoption for many high-volume production applications. In the current work, several advances are outlined that have allowed the continued on-time delivery of high-volume thermal battery production employing the novel CoS_2 catholyte material. By providing a tailored particle size distribution, continuous pellet manufacturing techniques, and semi-automated assembly equipment, EnerSys Advanced Systems Inc. (EAS) has demonstrated the ability and capacity to serve high-volume production requirements using the superior CoS_2 electrochemical solution.

Keywords

Thermal batteries; high-volume production; Cobalt Disulfide; cathode; electrochemical cell

Introduction

Thermal batteries serve as a critical power source for the operation of a wide array of defense systems, including Air-to-Air/Air-to-Ground weapons systems, Gun-Launched Artillery systems, and several advanced applications within the Ballistic Missile Defense System.

Beginning in the late 1990s, implementation of cutting-edge CoS_2 cathode technology has allowed the use of thermal batteries in otherwise unsuitable applications [1]. Owing to its increased electronic conductivity and thermal stability at elevated temperatures, thermal batteries produced with CoS_2 technology have demonstrated an ability to serve mission profiles with increased discharge rates and longer mission life requirements, while minimizing the size and weight impacts of the power storage solution [2].

While CoS_2 cathode material has provided a meaningful advancement in thermal battery capabilities, the material structure itself presents unique manufacturing challenges, which have here-to-fore hindered the large-scale deployment of this advanced cathode material in high-volume thermal battery manufacturing.

Purpose:

The purpose of the current work has been to demonstrate a step change in process capability across multiple production facilities, allowing for sustained high-rate delivery of thermal batteries produced with CoS_2 cathode material.

Methods:

The success of the current work has been made possible by three technological advancements: Tailored Powder Processing, Continuous Cathode Pellet Production, and Semi-Automated Assembly.

Tailored Powder Processing: By pursuing vertical integration of CoS_2 production, EAS has developed the capability to synthesize a material with tailored particle size distribution that retains preferential activation dynamics, while improving powder flow and enabling enhanced pellet pressing techniques. Furthermore, integrated cathode powder production has positioned EAS to increase throughput in support of industry demand by evolving right-sized batch processing and deploying dedicated synthesis and characterization equipment.

Figure 1. EAS Reel-to-Reel Grafoil Feed

Continuous Cathode Pellet Production: Tailored CoS_2 processing, as described above, has allowed for the deployment of enhanced pellet production techniques, namely automated cavity fill. As a complement to automated cavity fill, EAS has developed and implemented mechanized reel-to-reel grafoil feed systems as well as automated pellet inspection techniques to allow for continuous cathode pellet production. Such a system is shown in Figure 1, above. The combined system enhancements have increased throughput two-fold, while also increasing labor efficiency by a factor of four, by removing the need for additional handling, as demonstrated in Figure 2, below.

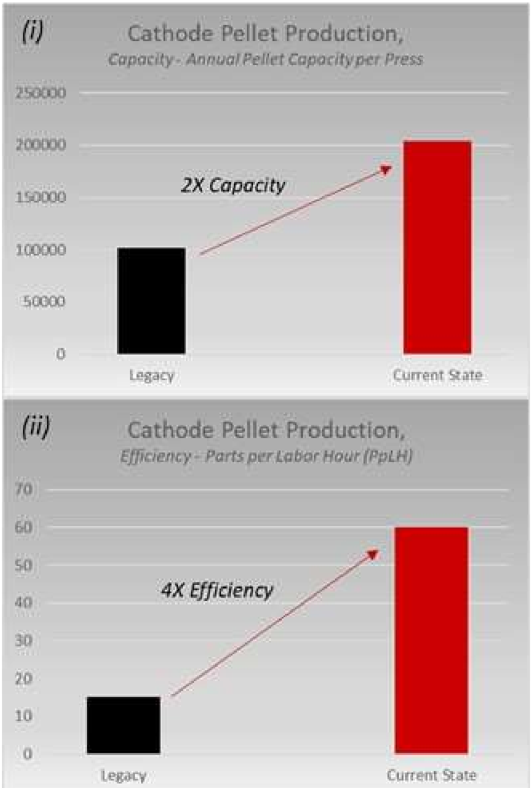

Figure 2. EAS Continuous Cathode Pellet Production, *(i)* Capacity Increase, *(ii)* Efficiency Increase

Semi-Automated Assembly: Two final key elements of the high-volume manufacturing capability established by EAS has been the development and implementation of semi-automated stack and wrap assembly equipment. These critical elements of the production process have enabled consistent production levels and reduced process variation by providing for: Recipe Controlled Stacking Order, 100% Visual Stack Inspection, and Error-Proof (Poka-Yoke) Tooling Design. Figure 3 shows the automated stacking system equipment.

Conclusions:

Thermal batteries employing advanced **CoS_2** cathode materials continue to provide enhanced performance in demanding applications. EAS has developed enhanced synthesis and manufacturing techniques to overcome inherent fabrication challenges stemming from the specific material structure. Advances related to Tailored Powder Processing, Continuous Cathode Production, and Semi-Automated Assembly have allowed EAS to meet large-scale customer demands. These advances have provided additional industrial capacity to deliver high-performing thermal batteries and allowed for consecutive years of on-time delivery of over 15,000 large format CoS_2 thermal batteries, manufactured across two production facilities.

References

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Figure 3: EAS Semi-Automated Stack Assembly Equipment