

NAWTEC17-2319

PRESSURE PULSE TECHNOLOGY FOR BOILER CLEANING

Mark A. Bunton, P.E.

Diamond Power International, Inc.
Lancaster, OH 43130, USA

1. INTRODUCTION

Steam or compressed air continue to be the typical cleaning mediums for long retractable (IK) sootblowers used to clean the convection section of the boiler. Advancements in steam/air nozzle technology have lead to improved cleaning in areas such as the secondary superheater, but due to issues with boiler tube erosion, advanced nozzles have not been routinely used in the convection section. Boiler tube erosion and the resulting forced outages due to tube leaks have consistently been an operational issue for many boilers. Sonic cleaning has offered the hope of cleaning without tube erosion, but cleaning results have been mixed. The energy created by sonic devices is more than an order of magnitude less than a sootblower jet and as a result have not been able to remove many types of deposits.

Controlled detonation combustion technology has recently received attention as an extremely efficient propulsion method for aircraft. By transitioning from typical combustion or slow pulse combustion to detonation the shock waves generated by a combustion event reach supersonic speeds. This detonation or pressure pulse energy also has the ability to be harnessed for use in boiler cleaning. Because it is a pressure wave based like sonic cleaning, boiler tube erosion is virtually eliminated, and because the wave speeds generated are supersonic like a sootblower steam jet it can provide cleaning similar to a traditional sootblower.

Harnessing detonation for boiler cleaning is not a new concept, but has been used in rare instances over the last 20 years. All applications of this technology to date have been with devices mounted to the boiler wall and directing a detonation across the boiler. This approach requires a large amount of energy to provide cleaning which may have a long term impact for parts of the boiler. Diamond Power has recently taken a novel approach to adapting pressure pulse (detonation) technology for use in convection section cleaning of the boiler. By utilizing traditional, retractable sootblowers as the delivery

system, detonation or pressure pulse cleaning can safely provide convection section cleaning while eliminating boiler tube erosion caused by conventional cleaning devices.

2. THEORY

Detonation combustion technology has been utilized in other applications. Detonation combustion differs from more typical combustion (deflagration) in that during a detonation event, a fuel/oxidizer mixture is detonated rather than burned. Detonation combustion leads to a much greater release of energy than deflagration, thereby creating greater pressures, and much greater reaction velocities. For example, while the reaction velocity due to a deflagration process is typically less than 200 meters per second and develops a relatively low pressure, the reaction velocity associated with the detonation combustion typically approaches 2,000 meters per second and offers pressure differentials of approximately 300 pounds per square inch.

Diamond Power's Pressure Pulse sootblower cleaning is based on detonation combustion technology. Unlike a conventional sootblower, this device produces high amplitude supersonic pressure waves which expand in all directions throughout the area to be cleaned. This non-line-of-sight cleaning captures the features of non-directional sonic cleaners but with much greater cleaning energy.

The supersonic pressure waves are generated by simply filling a conventional lance tube with an air-fuel mixture and igniting it, refer to Figures 1 and 2. Pressure pulses from the initial combustion run ahead of the flame and gradually preheat unburned gases inside the lance tube thus increasing the speed of sound. As pressure pulses start traveling at sonic speed, they coalesce and further heat up the unburned gases.

A pocket of unburned gas reaches the auto-ignition temperature and produces a local detonation. Rapidly expanding gases produce a sharp shock wave which exits the lance tube at