Combustion Driven Compaction Automation: A Pressing Solution for Niche Markets

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Until recently, the Combustion Driven Compaction Press (CDC) [1] has been primarily operated as a manual machine and successfully used to fabricate several high performance P/M components using variety of powder materials.[2-5] A few years ago, the manual machines had been adorned with various devices to speed up the manual process. About one year ago, an effort was launched to start designing and building a fully automated 400 ton CDC press capable of six parts per minute.

The CDC process [1] is different then the conventional flywheel, hydraulic, or magnetic press machines. Some operations can be the same, for example the powder feed shoe, but there are many other operations that are not the same and must be done differently. CDC uses a combustible gas and air to provide the press motion. This type of energy source can operate in the extreme (>1,000,000 tons) to more moderate (100 to 1,000 tons) pressures as needed for powder consolidation. Combusting gases are very efficient at producing energy as opposed to converting gas to electricity then back to mechanical energy.

The chamber [A] is filled and pressurized with a mixture of combustible gas, typically natural gas and air, the gas and air are injected separately and only mixed in the chamber. (Fig. 1) As the mixture fills the chamber it pushes down on the piston [B] which in turn applies pressure to the punch [C] and begins to compact the powder [E] located in the die [D]. The process pre-compacts the powder and once the proper amount of gas energy is loaded, the igniter [F] starts the combustion process. The fill time happens in seconds and the combustion takes place in milliseconds. The gas is then vented and the piston, along with the punch, is brought back up to the

Fig. 1 CDC Process Schematic Diagrams
top of the chamber ready for the next compaction cycle. Note: at no time is the piston allowed to accelerate and build momentum. However, it is possible to build such a device, but not for this discussion.

The CDC process described above brings a few control and operating issues:

- Precise compaction pressure:
  There are a few aspects to consider, chamber volume, type of gas being used, operating lean or rich, and the final compaction pressure.

- Repeatability:
  It is imperative that the first part and all subsequent parts receive precisely the same compaction pressure.

- Internal and external heat management:
  Unlike conventional pressing where the heat energy is produced at the electrical power plant, the CDC press produces heat energy directly from the combustion process and must managed.

To automate (several parts per minute) the CDC process and provide the controls for the process described above, various sensors were installed to provide information to a Programmed Logic Controller (PLC). Pressure sensors were placed inside the combustion chamber [A], and inside the gas feed lines while a mass flow sensor was placed in the gas feed lines. Temperature sensors were placed on the gas exhaust lines and a position sensor placed on the piston [B]. Once the information from the sensors is conditioned and digitized, the PLC can be programmed.

The press can now be operated from a wireless portable touch screen controller. (Fig. 2) The operator has full control of the compaction process. The operator can input the compaction pressure needed for the correct part density and adjust it from one part to the next as required to meet the necessary compaction pressure. Once set, the CDC press will repeat that pressure until it is changed by the operator.

Fig. 2 CDC Process Control for Automation

Load cells and strain gauges are not necessary because the pressure sensor inside the chamber provides a recorded history of the compaction pressure-time history for every part made. If anything falls out of spec, an alarm will sound.
A typical press uses electrical power to produce the compaction pressure. As such, the heat energy produced from converting natural gas to electricity is dissipated at the power plant. The CDC press derives its compaction energy directly by combusting gas and air in the chamber and creates waste heat. Seventy-five percent of that heat is vented out the exhaust line while the remaining heat is absorbed by the chamber. As a result, a cooling fluid is circulated inside the chamber wall where convection picks up the heat and moves it to a radiator where it is rejected. The waste heat energy, both from the combustion vent and the radiator, can be used to generate electricity or run a number of other cogeneration systems where heat energy is needed.

Additional automated features include a powder feed shoe from a third party and a part ejection system. The tool set shown is two level and hydraulically driven so the platens can be moved independently. Position sensors on the platens allow the PLC to place them in the exact location when needed. The PLC will monitor and maintain that position until given a command to relocate. The CDC press was designed to allow the tool set to slide in and out easily for a quick change setup and tear down.

The 400 ton press has a stroke length of 14 inches, is 80 inches tall and 50 inches square and weighs < 6000 lbs. (Fig. 3a)
The 1000 ton CDC press (Fig. 3b) has a stroke length of eight inches, is 142 inches tall and 96 inches square.[4] When completed, the 400 ton Automated Press will bring new capabilities to the powder metal market.

References:

1) UTRON Patent: 6, 767, 505.

2) www.utroninc.com


4) Karthik Nagarathnam, "CERAMIC DEFENSE: Pressing with Controlled Combustion" Published in Ceramic Industry, by BNP media, June 1, 2006 (Electronic Version of the Publication is available in the following link: http://www.ceramicindustry.com/CDA/Articles/Feature_Article/10cd85375737b010