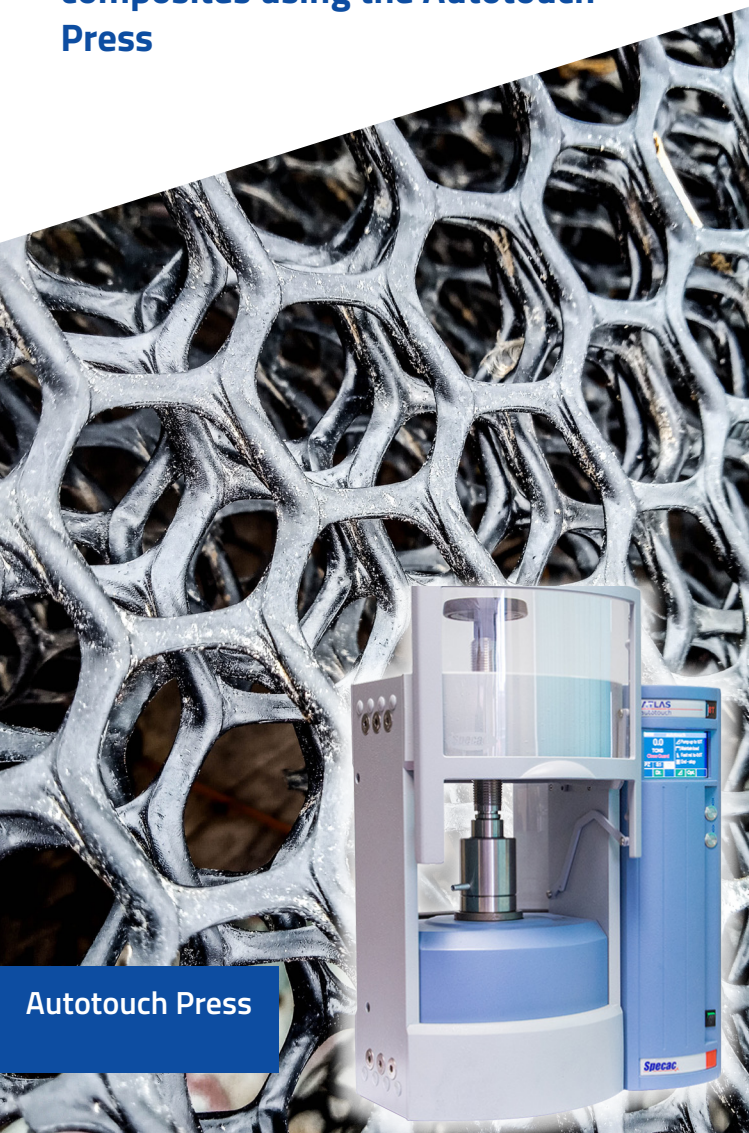
Specac

Application Note

Cold compaction of metal matrix composites using the Autotouch Press



Autotouch Press

INSIDE: Cold compaction of aluminium matrix composites using a precision programmable hydraulic press.

Introduction

Composite materials are widely used in aerospace and automotive applications for critical components such as pistons and conrods and other structural elements. In particular, the ability to deliver high strength with light weight has made composite materials highly valued.

Metals reinforced with materials such as ceramics or carbon nanostructures are known as Metal Matrix Composites (MMCs). Aluminium is one of the metals that may be reinforced in this way. Carbon (in the form of carbon nanotubes, graphene, and graphene oxide) is of current interest in metallurgy as both a reinforcing agent and also for molecular-level chemical sensing materials.

In this note we describe the preparation of sintered aluminium matrix composites via a powder compaction method.

The Autotouch press is designed for preparation of pellets and compacts for a wide range of applications, including XRF, powder compaction, and material testing.

- Programmable load cycle.
- Storage for 6 programs.
- Large working area.
- LED touchscreen.
- Safety guards & program interrupt warnings.

Acknowledgement

Prof Dermot Brabazon, Director of the Advanced Processing Technology Research Group at Dublin City University, provided the case study material for this application note.

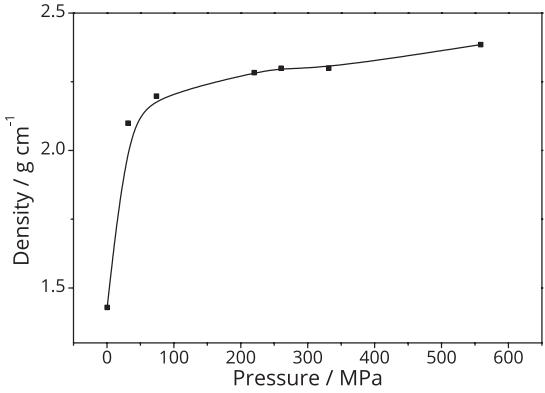


Figure 1: *Green density of pure aluminium specimens.*

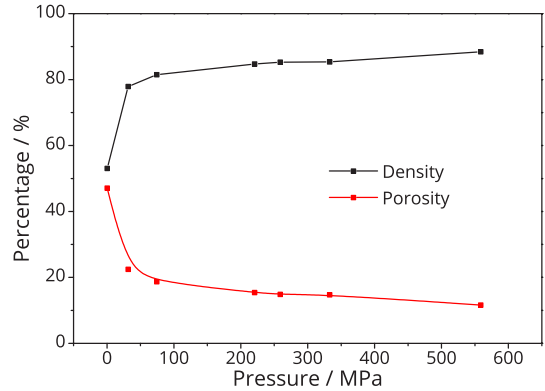


Figure 2: *Density and porosity as functions of cold compacting pressure.*

Figure 3: *Atlas Autotouch program screen*

Reinforcing carbon can be in the form of carbon nanotubes (CNT), graphene, or graphene oxide. Graphene is a two-dimensional hexagonal lattice form of carbon with extraordinary mechanical, thermal chemical, and electrical properties. These properties have made it a focus for research, as well as a useful material in industrial applications. Unoxidized graphene is hydrophobic, while graphene oxide (GO) is hydrophilic. It has remarkable mechanical strength and the potential to form the basis of new functional sensing materials. The properties of GO can be also tuned by controlling the degree of oxidation, resulting in a mix of graphene/graphene oxide.

Experimental

The main steps in the process are as follows. First, the component powders are mixed and well dispersed by various means (using solvents or directly by dry ball milling), then dried. Next the powders are transferred to a 20 mm Atlas® evacuable pellet die and compacted at pressures ranging from 30 MPa to 560 MPa using a Specac 40T Autotouch hydraulic press.

The compacted powder is known as a 'green compact'. In the final step, the compacted powders are sintered at 600 °C in an inert atmosphere to produce the final composite material. In addition to the graphene reinforced aluminium powders, specimens of pure aluminium powder were compacted and sintered as a reference.

Results and Discussion

Figures 1 and Figure 2 show the variation in density and porosity, respectively, resulting from powders compacted at various pressures. The

properties of both the green compact and the final composite are dependent upon the compaction parameters. The density of the compacts increases with compaction pressure with a corresponding decrease in porosity.

Uncontrolled compaction using a manual press results in more variation between specimens as well as wide variation in the failure load of these samples. With the 40T Autotouch press it is possible to ensure control of the pressure level, ramp rate, and dwell time. The controllability and reliability of these parameters is a major benefit in producing samples with more uniform properties. The control of these parameters also allows the compacting process parameters to be optimized via a design of experiments method. The maximum pressure levels achievable (up to 780 MPa for the 20 mm die) allow a wide range of compaction pressures and are high enough to allow for direct comparison with larger scale industrial production equipment.

Conclusion

The Autotouch press is ideal for rapidly producing metal matrix composite materials via the powder metallurgy route. Its programmable load profile results in less variation between samples and allows the process parameters to be easily optimised.

References

J Liu, U Khan, J Coleman, B Fernandez, P Rodriguez, S Naher, D Brabazon, *Materials and Design,* **94,** (2016), 87-94

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