

Casting Impregnation: Modern Processes

Dr. Mark Cross, Sales Director
Ultraseal International
Coventry, United Kingdom

Vacuum impregnation is a reliable and permanent solution to the eternal problem of porosity in casting, a phenomenon that can ultimately lead to the failure of a finished component if porosity leads to a leak path forming.

Many companies around the world that embrace sealant impregnation of die cast components as routine quality enhancement now favor modern methods of vacuum impregnation. These methods employ high quality sealants to maximize quality in low cost, fast cycle time, environmentally friendly processes, which dispense with the need (in the majority of instances) for added pressure, thus increasing efficiency with shorter cycle times.

Cutting Edge Sealants

Two sealant technologies now dominate vacuum impregnation - anaerobic and thermocure. Both of these technologies use similar base chemicals, but with different curing systems; the performance and ease of use of each are significantly different:

Anaerobic

These sealants are formulated so that curing of the resin occurs at room temperature. As such curing times are typically very long, up to 24 hours, rendering the process unsuitable for modern JIT (Just In Time) production facilities, with pressure testing not possible until curing is complete. Additionally, the sealants are unstable and require significant maintenance to ensure unwanted bulk polymerization in the autoclave does not occur (constant refrigeration, aeration and reactivity checks). Typically, this technology is limited to sections of North America and Mexico.

Thermocure

Thermocure sealants now dominate the global impregnation market. Introduced in the 1970s, they were rapidly adopted due to their fast curing times. These products are based on methacrylate monomers that cure in the presence of heat. Development of this technology since its introduction means this class of product can be subdivided into two groups:

- non recycling sealant
- recycling sealant

Non-recycling sealants were the first thermocure products to be introduced to the impregnation market. They are now a relatively old technology, having been used for the past 40 years. However, they still offer reasonable sealing performance, and are widely used in particular markets. Thermal resistance of these products tend to be limited and some formulations can also lack the correct adhesion and flexibility characteristics required to give optimum performance in the harsh environments that they operate in.

The Myth of Recoverable Sealants: A Crucial Distinction

Confusingly, some describe these thermocure non-recycling sealants as “recoverable sealants” – referring to the part of the process where some sealant can be “recovered” after the impregnation stage and before the washing stage (drain or centrifuge). However this is a false distinction: all sealants can be (and are) recovered, via a drain or centrifuge, after impregnation and before the cold wash stage. The term “recoverable” is not a differentiator. There is no such term as a unique “recoverable sealant” category. Even anaerobic sealants can be (and are) recovered. The crucial distinction that exists in the thermocure sector is between recycling and non-recycling sealants.

With *non-recycling sealants*, resin removed from the surfaces of components during the wash stages of the impregnation cycle cannot be reclaimed. As a result, a very high volume of effluent is produced that is both difficult and expensive to treat. After a relatively small number of cycles the wash water must be replaced to prevent unwanted sealant contamination of components.

This leads to a very high effluent output and a wastefully high consumption of sealant. For example, a typical moderate user of non-recyclable sealant may consume 3,000 gallons of sealant a year, of which 2,900 gallons is simply washed away in the waste water.

Cutting Edge Modern Sealants are Recyclable

The cutting edge of sealant design is represented by *recycling thermocure sealants*. These give high sealing rates, last

longer in service through increased thermal stability and reduce the costs and environmental impact of the impregnation process because far less effluent is produced when compared to non-recycling thermocure sealants.

Recycling sealants combine high performance with marked environmental benefits: the majority of the sealant which is removed from the surface of treated components in the cold wash stage is recovered and returned to the autoclave for immediate re-use in the first stage of the impregnation process.

This drastically reduces the consumption of sealant – by up to 95% – and eliminates up to 95% of the effluent stream.

Full Closed Loop Impregnation System

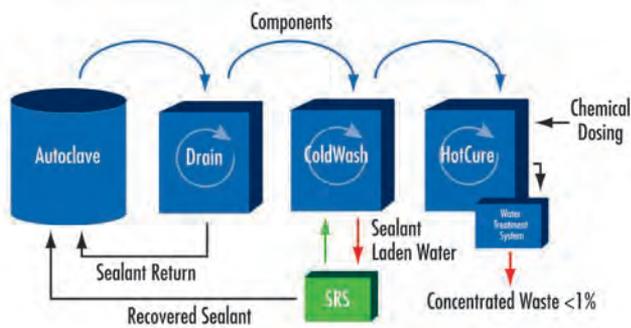


Figure 1 – Ultraseal Fully Closed Impregnation System.

There need be no compromise in performance with recycling sealants – indeed some, such as Rexeal 100™, offer exceptional efficiency, being effective at temperatures of up to 220°C (428°F) and being independently verified as achieving US military specification MIL-I-17563C (Class 1 and 3), an internationally recognized quality standard.

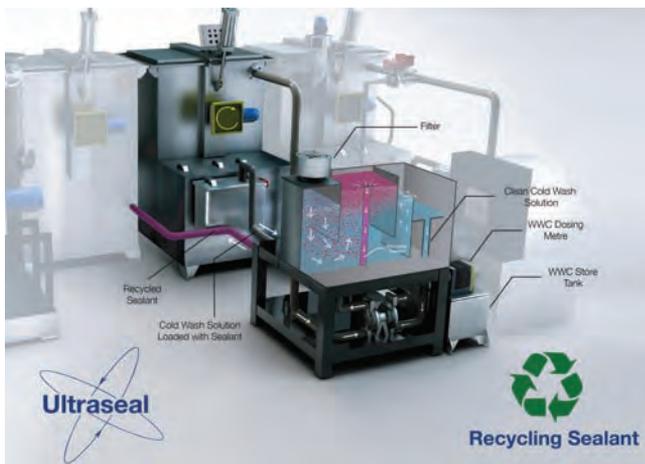


Figure 2 – Ultraseal Sealant Recycling System (SRS).

Figure 2 shows the Ultraseal’s Sealant Recovery System (SRS) where the sealant which has been collected from the wash tank is passed through the system for retrieval and reuse.

Contrary to some perceptions, recycling sealants have an unlimited pot life as with non-recycling sealants. The process control requirements of these products are also no different to conventional non-recycling sealants.

Another misconception is that additional refrigeration is required, when in fact the only cooling required is to keep the impregnation vessel at a sensible ambient temperature of below 25°C (77°F) – the same requirement exists for all thermocure sealants. Nor do recycling sealants incur higher operating costs: in fact the opposite is true, recycling sealants are designed to have lower operating costs than non-recycling sealants through reduced chemical consumption and effluent; reduced handling and greater machine up-time.

Pressure vs. Non-pressure

The process used to apply the sealant is also important. Today modern impregnation methods are achieving excellent results without recourse to applying pressure after the initial application of sealant.

In the first stage of impregnation, the parts are loaded into an autoclave and a vacuum applied to draw air out of any porosity before the sealant is applied.

The practice of applying pressures of up to 6 Bar after initial application of sealant is known as Dry Vacuum and Pressure Impregnation and dates back decades to the 1960s before modern impregnation sealants, which are less viscous than previous sealants, were invented.

Still used in some countries and in a few specific applications, adding pressure to the impregnation process is believed to drive sealant more effectively into any porosity. However research carried out by the University of Plymouth¹ showed that this effect was minimal at the lower viscosities which modern recyclable sealants have. The university developed a software mathematical model which allowed researchers to investigate the outcomes for varying pore size, specific gravity, viscosity, initial vacuum and the application of extra pressure.

As shown in Figure 3, the model demonstrates that, for porosities of 5mm length, of varying diameters between 250 microns to a few nanometers, the pore would fill very quickly at ambient pressure, in less than one second, for liquids with the low viscosity of modern recycling sealants (typically 6, 7 or 8 centipoise). While adding additional pressure of 5 Bar would speed this up further, it was unnecessary as the time for impregnation was already so fast.

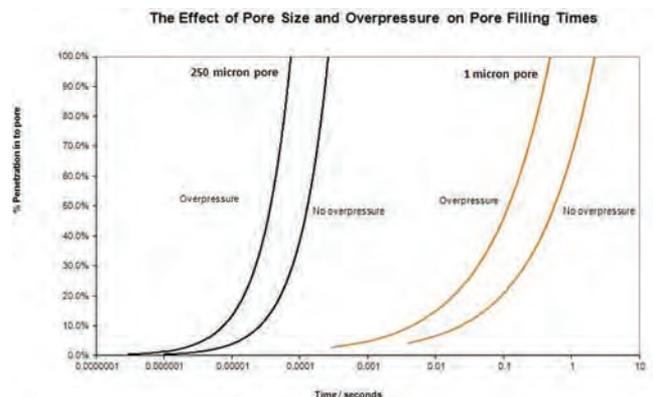


Figure 3 – Effect of Pressure on Pore Penetration.



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While modern recyclable sealants can fill porosity in less than one second, the results were different for more viscous liquids such as the older-fashioned sealants. The model showed these took a significantly longer time to impregnate completely.

Simple table top tests² on both aluminum and iron test rings have borne out these predictions. Test rings with 20% porosity were effectively 100% impregnated with a simple vacuum impregnation without the application of any additional pressure.

Globally, dry vacuum impregnation is the most widely accepted form of impregnation especially for gearboxes and engine blocks. Pressure impregnation originated from a time when it was a necessary step to compensate for the weaker characteristics of an older sealant technology; new sealant technology has replaced the need for additional pressure in many areas of the World. However, some special applications may still require the extra step.

Overall, to increase the efficiency of the impregnation process and realize the benefits of shorter process times, without any impact on the process effectiveness, additional pressure generally need not be applied.

References

¹ "Modeling of casting impregnation using a single open pore model"; Dr G. Peter Matthews, 2003

² Tests carried out at Ultraseal International

Ultraseal USA and Canada

Ultraseal America Inc
4343 Concourse Drive
Suite 340
Ann Arbor, MI 48108
T: 001.734.222.9478
F: 001.734.222.9479
E: us@ultraseal-impregnation.com
www.ultraseal-impregnation.com

Ultraseal India

Ultraseal (India) Pvt Limited
43/1 D-2 Block, Telco Road
MIDC Chinchwad
Pune, India 411019
T: +91.20.27477390.27470045
F: 0091.20.2747.2432
E: useal@vsnl.com
www.ultrasealindia.com

Ultraseal International (Europe)

Ultraseal International
Lyons Park
Coventry
England, UK CV5 9PF
T: +44.024.7625.8444
F: +44.024.7655.1402
E: sales@ultraseal-impregnation.com
www.ultraseal-impregnation.com

Ultraseal Japan

Ultraseal Japan
Surface Technology plc
Twin 21 MID Tower 23F
2-1-61 Shiromi
Chuo-ku, Osaka City
Japan 540-6123
T: 0081.06.6944.3433
F: 0081.06.6944.3434
E: kashiwa@ultraseal.co.jp
www.ultraseal-impregnation.com/jp

Ultraseal Shanghai (China)

Ultraseal Shanghai Limited 1999
Jia An Gong Lu
Jiading District
Shanghai, China 201821
T: 0086 (0) 21.6916.0313
F: 0086 (0) 2.6916.0380
E: china@ultraseal-impregnation.com
www.ultraseal-impregnation.com/cn