dp seals

The unseen advantage

Rubber-to-metal bonding guide

Welcome

This guide has been produced to help engineers using rubber-to-metal bonding in their products. It includes an introduction to rubber-to-metal bonding, typical applications, the importance of early and effective communication, the process itself and some top tips for your consideration.

We hope you find the guide useful and welcome your feedback.

Andrew Piper

Managing Director

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Introduction

Rubber-to-metal bonding is a means by which rubber is mechanically bonded to a metal component during the moulding process. Each step is dependent on the success of those that preceded it and the stages are numerous and complex.

The process was first introduced about 140 years ago when it was used on rollers for wringers, carriage wheels and fire hose nozzles. Various ingenious mixtures of rubber, turpentine and resins were used with a wide variety of inorganic pigments. These were then dissolved in benzene to form cement. Ebonite was a commonly used rubber of the time but unfortunately due to its low softening point, many bonds were sensitive to heat!

Initially the introduction of the motor car and then the first and second world wars saw great leaps in rubber-to-metal bonding innovation. This included:

- Bonding to brass plating, patented by Charles Sanderson in 1862
- Cyclised rubber in the late 1920s
- Trials with phenolic resins
- Goodyear's patent of latex-protein mixtures
- The patent for the use of brominated rubber and the recognition of the value of carbon black to the process in 1936
- German experiments with di-isocyanates to cross link Buna rubber

Today, it is possible to bond almost any elastomer to any substrate, which is testimony to the ingenuity and innovation of chemists and those in the industry throughout the years. DP Seals is at the forefront of this.

Which metals can be used in the rubber-to-metal bonding process?

Provided that it can withstand the heat and pressures of the rubber moulding process almost any metal can be bonded to rubber. However, each metal has a different chemical composition that can react to the type of rubber being used.

An important step is to determine the best metal type and grade for the application, as well as the optimal type of rubber to specify for the application. DP Seals can advise on the best rubber material and specify custom compounds with additives to aid metal bonding.

One problematic material is brass, which contains lead that chemically counteracts rubber bonding. The softer, free-cutting brass materials have higher lead content and can be difficult to bond. Better bond strength can be achieved with the lowest possible level of lead content. Substrate preparation is absolutely key along with timely application of two coat bonding agent systems.

Why use rubber-to-metal bonding?

Manufacturers in many industries rely on rubber-to-metal bonding for their components. It can turn up in innumerable applications, from exotic F1 Grand Prix engines to humble electric kettles.

Some key reasons why you might choose to use rubber-to-metal bonding include the following:

- Any part which requires a combination of the flexibility of rubber and the stability of metal
- Combining several parts into a single assembly
- Ensuring that critical functions will not fail due to a weak bond where they may if using a traditional adhesive.
- Enhancing sound proofing and vibration control
- Sealing against organic solvents, sea water and boiling water

DP Seals is an acknowledged expert in rubber-to-metal bonding, utilising innovative solutions and moulding techniques to provide high-performance, high-specification products.

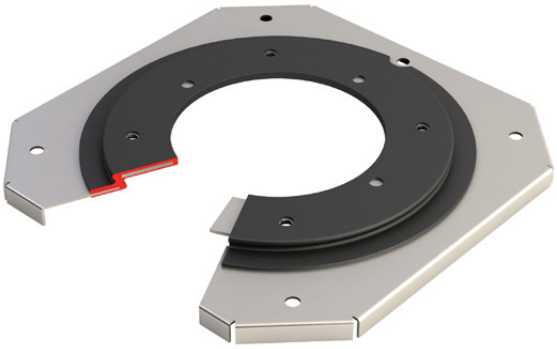
Typical industry applications can include:

- Rubber-to-metal plates
- Engine mounts and other automotive applications
- Hydraulics and pneumatics
- Medical devices such as instrument handles
- Oil/gas - support rings, location elements and compliant flanges
- Electrical appliances and other industries – bulk head seals, rollers, connectors, hoses, valves and insulators

This 3mm rubber-to-metal bonded plunger seal is used to sample ocean water and analyse it in an ocean-going drone mini-submarine.

The steel ring enclosed in this moulding provides vital structural integrity in operation.

This rubber-to-metal bonded seal plays a critical role within the mechanism of an in-flight refuelling system.



Cutaway, showing the details of this rubber-to-metal bonded gasket for the motoring industry.

These rubber-to-metal bonded seals manufactured for Hope Technology are pivotal components in its high performance braking systems for sports bikes.

This rubber-to-metal bonded seal finished in anodised aluminium, is used in a fuel line system within the aerospace industry.

The importance of early communication

Because of the complexity of the rubber-to-metal bonding process, successful bonding requires active participation between engineers and material and mould technologists. Many problems in production stem from ineffective communication during these earlier stages, so we can't emphasise its importance enough!

Some of the factors we will want to discuss include the following:

- What is the geometry of the metal part?
- What is the grade and type of metal?
- How the metal part is made, turned, stamped, punched, cast including tolerance and repeatability?
- Where and what is it used for – i.e. is it a static or dynamic application?

What will the rubber be exposed to?

- What fluids will the rubber be exposed to in both its primary use but also when being cleaned or lubricated, for example?
- What temperature extremes will the rubber need to work under, both hot and cold?
- Will there be a presence of ozone which can attack rubber?
- Will the rubber be exposed to processes such as sterilisation by gas, autoclaving or radiation?
- Will the rubber be exposed to ultra-violet or direct sunlight?
- Will the rubber be exposed to the potential for outgassing?
- What pressures will the rubber work under, both low and high?
- What level of friction will the rubber be exposed to?
- Peel strength. Will the rubber be mechanically exposed at the edges of the bond?

The rubber-to-metal bonding process

Every manufacturer is focused on reducing cost and improving quality wherever possible. Through the combination of the following value-adding services, applied throughout the rubber to metal bonding process, we are committed to helping you achieve these aims:

- Product advice
- Prototype and 3-D printing
- CAD/CAM links
- Unrivalled materials expertise
- Patented moulding system
- Fluorination
- Cryogenic cleaning services
- A first class approach to quality control

With respect to the process itself we follow five steps, including product shape & geometry, preparation of the part, application of the bonding agent, moulding and finally testing.

Let's take a look at each of these in turn.

1 Product shape and geometry

The choice of metal depends on the strength and durability requirements for the part being produced. Steel is commonly used, but due to weight factors, aluminium is increasingly common. As mentioned earlier, almost any metal can be bonded – so please speak with us early in the process for advice.

Once you have specified the geometry of the metal component, along with the grade and type of metal, DP Seals' engineers will evaluate your product and advise on any necessary modifications and the best production method to produce the parts.

It is at this point that we will also make recommendations on the rubber compound to be used. Considerations will include the cure characteristic of the rubber to ensure it satisfies application dynamics like fatigue, creep and maintenance and also the bonding environment within the cure cycle.

As the rubber filling the mould has very low viscosity, the geometry of the part can present challenges. The moulding tool must enable a positive shut-off or clamp-off on the metal component to reduce the amount of flash.

Stamped or punched metal components may also present problems, as the process does not always hold tight tolerances reliably. Once all parties have discussed and agreed the optimum material, the component can be procured.

2 Preparing the part

Preparing the part for maximum bond strength is a key consideration. It is here that the complex chemistry of metal and rubber interaction and the effects of the moulding process itself must be addressed. Metals may be treated by mechanical or chemical means and preparation includes a combination of the following steps appropriate to the finished product:

- Cleaning the component with a solvent to eliminate any remnants of machine oil or grease
- Aqueous degreasing to meet stringent environmental standards
- Treating the surface through grit blasting and other physical abrasion to allow more bonding surface area
- Treating the surface with chemical agents such as zinc phosphate or ammonium persulphate.
- Drying

3 Application of the primer and bonding agent

Oxidation of metal means there may only be a small window to apply the primer. Most bonding agents are diluted with a reagent grade of solvent which makes it easier to spray or dip.

It is critical that the correct mixing ratio of bonding agent to solvent is specifed to ensure that bonding agent thickness and percent solids are sufficient to provide a strong bond. If the blend is too viscous, it can result in the bonding agent not properly setting up correctly. Too low viscosity and it can be swept off the component due to the high-pressure rubber flowing into the cavity.

Application of the bonding agent includes a combination of the following steps appropriate to the finished product:

- Masking a section of the component to cover everything except the specific area where rubber is to bond
- Applying heat-activated primer and bonding systems through dipping, spraying or by brush
- Baking the primed component to ensure it is dry and set up for moulding
- Depending on the rubber material being used we will either apply one or two coats of primer/bonding agent

4 The moulding process

This is the most important part in the process and there are various moulding techniques available. At DP Seals, we believe that in most cases there is no need to go to full injection mould tooling and its attendant high process control costs. We find the combination of specialised compression and transfer moulding that we offer allows us to cater for both high and low volume custom solutions, achieving the excellent levels of precision and quality for which we are known. We have also been granted a UK patent for our unique tooling and moulding system.

Originally created by the company's founder, David Piper, almost 40 years ago, the basic concept was for a moulding tool incorporating locating plates that allowed free and easy movement during assembly and disassembly and could also be locked into position to ensure the closed cavities remained closed. This results in drastically reducing and even removing any potential for flashing.

The combination of practicality and ingenuity immediately gave DP Seals an advantage over competitors and enables us to produce small, close tolerance, flashless mouldings that no-one else can match.

Intellectual Property Office

Certificate of Grant of Patent

Patent Number: GB2513012
Proprietor(s): DP Seals Limited
Inventor(s): David J Piper

This is to Certify that, in accordance with the Patents Act 1977,

a Patent has been granted to the proprietor(s) for an invention entitled "**Mould tooling**" disclosed in an application filed **26 March 2014**.

Dated 11 March 2015

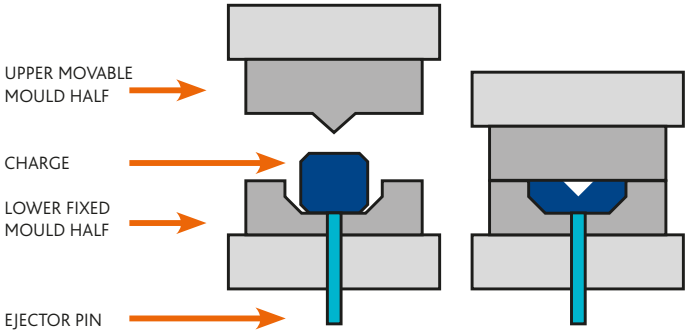
John Alty
Comptroller-General of Patents, Designs and Trade Marks
Intellectual Property Office

The attention of the Proprietor(s) is drawn to the important notes overleaf.

Intellectual Property Office is an operating name of the Patent Office

Compression moulding

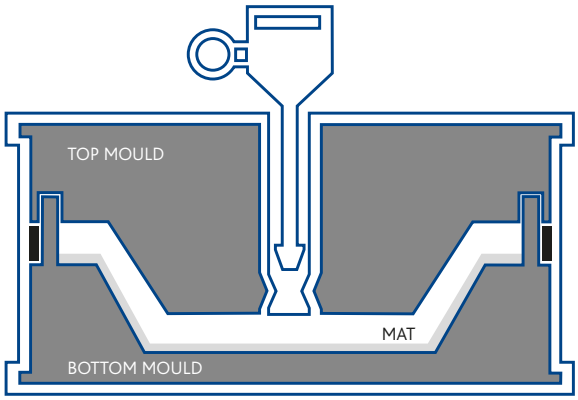
The rubber material is placed in an open, heated mould cavity. The mould is closed and pressure applied to force the material into contact with the mould area. Heat and pressure are maintained until the moulding material has cured. This is shown in the diagram below.



This technique is useful for small to medium volume, straightforward and precision components, particularly where metal parts are required. Highly suitable for expensive materials like FFKM/perfluoroelastomers, as there is very little wastage and it is the lowest cost tooling option.

Transfer moulding

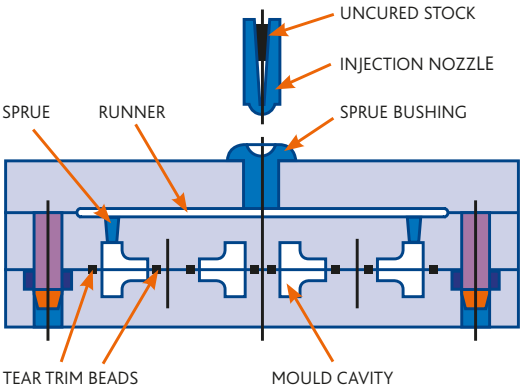
The amount of moulding material is measured and inserted into the moulding in a transfer chamber. Once the raw material is in the chamber, it is forced through runners and into the mould cavity or cavities. The mould remains closed until curing has taken place.



This is an excellent technique for high quality, precision and intricate product features in larger volumes. It is also particularly useful where less flash is required.

Injection Moulding

Components are produced by injecting raw material into a mould. Material for the part is fed into a heated barrel, mixed and forced into a mould cavity.



This extremely versatile process is useful for varied sizes of components. However there are higher set-up and tooling costs compared to transfer or compression moulding so it is more suited to high volume production of the same part where the per-unit cost can be reduced. As outlined previously, this is not a process we offer but we'll happily recommend a supplier should this be the best process for your particular requirements.

5 Test with prototypes or finished parts

Testing is typically conducted to see how the part reacts when stressed through compression, tension, shear or torsion.

The only testing methods for determining bond strength involve destroying the part and tests such as hand peeling or stripping are common for visual performance results. Machines such as tensile testers are more scientific and will measure the amount of force required to break the bond.

Summary

To achieve a bonded component that is stronger than the sum of its parts, every step of the rubber-to-metal bonding process must be expertly conducted. With over 40 years' experience, and as a specialist in the field, DP Seals is ideally placed to help you. From in-flight refuelling systems to a 3mm Rubber-to-metal bonded plunger seal used to sample ocean water, we have the adaptability and innovative approach to help achieve your goals.

Top tips

Now we're coming to the end of the guide we thought it would be useful to provide you with some top tips to help in your planning and production phases.

At initial product creation stage

- Use our chemical compatibility database app to consider your initial material specifications. Then get in touch so we can help you with our expert advice
- Think about the quality of finish you require. What do you mean by quality? Less flash, split line, integrity, surface finish, appearance. Prioritising your requirements will really help in discussions about material selection and product features
- When sizing a seal, specify it to work in the worst case scenario
- Build speed and flexibility into the manufacturing process with our expertise in CAD support and toolmaking
- Avoid defaulting to tolerances that are biased to metallic, machined or turned parts. Rubber is a very different material!
- Don't unduly discount FFKM or other high cost materials without talking to us first. At DP Seals we can often utilise these rubbers and create a much more effective solution offering significant savings

Communicating with your manufacturer

- Communicate as early as possible with us.
- Use the handy checklist we shared earlier in the guide to think about things you'll need to talk through
- Sharing what you don't need can be as important as what you do need. Do you need certain quality, tolerances etc for the whole product or just for parts of it?
- Provide detailed seal installation and assembly instructions, especially if the unit could be serviced by the end-user of the product. When appropriate or required, specify the use of OEM sealing parts

Production

- 3-D printing and prototyping facilities ensure you can quickly test and refine the quality of your products features.
- We retain details of the component materials and manufacturing process for easy retrieval and future production of the parts you require.

About DP Seals

At DP Seals, we provide customised rubber-to-metal bonding solutions for customers seeking extreme performance without an extreme price tag.

We've mastered demanding production parameters associated with high-cost materials, putting us firmly at the forefront of rubber-to-metal bonding.

And we have 40 years experience supporting customers in the aerospace, subsea, oil & gas, specialist automotive, motorsport, food & dairy, medical equipment and instrumentation & electronic industries.

Choosing the best partner for your project can be a key factor in its success. So when you decide we're the people for the job, what can you expect from us?

On time, every time

- In-house project management to keep things on track
- On-line data exchange and CAD/CAM links to speed up communication
- In-house tool room for faster production
- 3-D printing of prototypes to speed up testing and quickly iron out problems

Quality without compromise

- One of the UK's first custom rubber moulding manufacturers to achieve ISO9001
- Accredited to ISO 14001, OHSAS 18001, AS 9100 and BAE systems approval.
- Unique closed cavity moulding process
- Automated cryogenic cleaning systems for flashless mouldings

Specialist expertise

- In-house tool making and product advice to solve your most difficult issues
- Unrivalled materials expertise in advanced rubber technology for extreme environments
- Pioneers in precision moulding extremely soft rubbers down to 10 Shore
- In-tool rubber-to-metal bonding

Added value, extra support

- Chemical Compatibility app to help you research rubber material suitability any time, anywhere
- Unique Guide to custom rubber seals to broaden your knowledge still further
- No obligation, expert advice from our materials technologists

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