Canadian Conservation Institute
Institut canadien de conservation

CCI Notes 9/8

Mechanical Removal of Rust from Machined Ferrous Surfaces

Introduction

Many museums collect industrial machines that were used for metalworking, printing, woodworking, and manufacturing. All of these machines were designed for indoor use, and all have components with bare steel or cast iron surfaces. These surfaces are found on gears, shafts, work tables, and cutting surfaces, as well as on the faces of belt-driven pulleys and flywheels. The exposed areas are highly susceptible to rusting. They were kept shiny during their working life by regular operation and maintenance. They were never painted. Rust was discouraged from forming by frictional contact of the metal with other materials (wood or metal stock, leather/canvas belting), frequent wiping with oily rags, or continual movement and lubrication (e.g. gears, journals, and guide bearings). When these machines are left inactive and are not maintained — or, worst of all, are stored outside — the bare metal surfaces quickly deteriorate. Within a short time, the once-bright metal becomes covered with rust.

Museums often seek to return idle, neglected examples of these machines to a condition resembling their last use. This requires special treatment of the machined surfaces. The challenge is to remove the surface rust without destroying the original wear marks underneath, and to avoid creating new wear patterns that could be misinterpreted as original.

This Note will discuss *mechanical* — as distinct from *chemical* — methods of removing surface rust.

Traditional Methods

The traditional industrial techniques of mechanically removing rust include sand blasting and the use of wire cup wheels, radial brushes, and emery paper.

These techniques are too aggressive to be used on artifacts, especially on machined areas that will not be painted. Sand blasting can severely pit the surface of the metal, while powered wire brushes and emery paper can leave deep scratches. Obtaining a presentable finish afterwards may require a substantial amount of polishing. Excessive polishing, in turn, may remove much of the original wear marks and surface detail from the metal. It can also result in dimensional changes to the parts and an over-restored appearance.

Current conservation techniques for removing rust include the use of fine steel wool and light oil (see CCI Notes 9/6 *Care and Cleaning of Iron*), glass bristle brushes, electric erasers, and rust erasers (fine abrasives embedded in a rubber-like material). These methods are effective for treating small, lightly corroded areas, but they are too slow and labour-intensive for use on large industrial artifacts. The results are often non-uniform and, in the case of steel wool, the debris (fine steel particles) can cause further rust staining.

Glass bead abrasive blasting is another conservation technique for removing rust. It is sometimes appropriate for use on large industrial artifacts, but the abrasives leave a fine matte or satin finish, which is undesirable for machined surfaces.

Surface Conditioning Products

Surface conditioning products have recently appeared on the market. They consist of an open three-dimensional web of flexible synthetic material (usually nylon) to which abrasive particles are bonded by an adhesive. The open web structure allows the material to conform to the contours of the metal object, while air circulation through the web keeps the metal from overheating.

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In terms of aggressiveness, these materials are *polishing* compounds. This places them midway between the operations of grinding (more aggressive) and buffing (less aggressive). Grinding rapidly removes a large amount of metal by means of abrasives bonded to a rigid backing. Buffing uses soft cloth wheels and loose or waxed abrasive compounds to level out and blend extremely fine scratches until a smooth, reflective surface is achieved.

Surface conditioning products were designed primarily to create uniform scratch patterns and satin finishes on relatively soft materials like non-ferrous metals (brass and aluminum), wood, or plastic. They are much less aggressive on rusted steel. As a result, they leave less of their own mark than any other mechanical technique for removing rust. Existing wear marks on the artifacts are enhanced rather than obscured and the artifact's history of use and wear is revealed.

Surface conditioning products are available in rectangular hand pads for light applications, or in a wide variety of cloth-backed configurations for high-speed applications with electric or pneumatic tools.

The largest selection of surface conditioning materials is available through the 3M company under the trade name *Scotch-Brite*. Most *Scotch-Brite* products are available in four degrees of hardness/aggressiveness, each with a distinct colour:

Coarse (CRS) = brown
Medium (MED) = maroon
Very Fine (VFN) = blue
Super Fine (SFN) = grey

The Super Fine grade uses an extremely fine silicon carbide abrasive. The remaining grades use various sizes of aluminum oxide abrasive particles. The Coarse grade is too aggressive to be used on artifacts. Very Fine and Super Fine will answer most needs. For heavily rusted surfaces, one can begin with the Medium coarseness to speed up the operation and save on materials.

Scotch-Brite can be obtained in a variety of different configurations, including hand pads, discs (1 1/2" [3.8 cm] to 8" [20.3 cm] diameter), belts, and star-wheels. Many of these can be adapted to treat unusual shapes and difficult-to-reach areas. Automotive hand pads, similar to *Scotch-Brite* hand pads, are available from Norton Co. (Automotive Sales) of Worcester, MA. Three grades are available, listed here in order of decreasing aggressiveness:

#58000 Scuff & Clean Pads = maroon
#58002 Micro Fine Pads = grey
#58001 Light Duty Pads = white

The white Light Duty Pads contain talc rather than an abrasive. This makes them less aggressive than any other product. They do not leave any visible scratch pattern on steel.

Power Tools

Scotch-Brite can be used with electric drills or Dremel tools. Pneumatic tools are preferable, however, because they allow for much higher speeds and cooler operation. One of the most useful tools is a hand-held mini belt sander, which can use 1/2" (1.3 cm) to 3/4" (1.9 cm) wide belts, either 18" (45.7 cm) or 24" (60.9 cm) long. A belt sander is ideal for treating flat, recessed channels and the exterior surface of cylindrical shapes, such as pipes and shafts.

A right-angle die grinder can be used for almost every other application. It can hold a variety of rotating disc pads for polishing flat areas. Two systems are available: one with a Velcro-type hook and loop design; the other with a threaded shank for screwing into a special (Roloc) holder. The Roloc discs are attached more securely than the Velcro-type discs, and are less likely to fly off the disc pad when meeting an obstruction. Star-wheels are screwed onto a threaded mandrel for polishing the interior surfaces of bearings and unthreaded holes. The flaps of the star are forced against the interior walls of the cylinder by centrifugal force. For very small diameter holes, a 3M Mini Mandrel with alligator-type jaws can be used. It can spin very small pieces of *Scotch-Brite* inside a hole as small as 1/2" (1.3 cm) in diameter.

The most versatile pneumatic tool available is the Dynafile II, made by Dynabrade Inc. It is a combination mini belt sander and right-angle die grinder in one. Changeover from one tool to the other takes less than a minute. Fourteen different interchangeable arms are available for use with belts. Like most air-powered tools, the Dynafile II requires 90 psi (620.5 kPa) operating pressure. This can be obtained with a portable compressor (minimum 5 horsepower [3.7 kW]).

Health and safety precautions to be followed during these operations are the same as those for any operations involving powered tools and dust. Goggles and a dust mask are strongly recommended.

Applications

Surface conditioning products remove rust mechanically. This means the surface is physically abraded, or finely scratched, by the very small but extremely hard abrasive particles. To achieve a smooth surface, the new scratches should be as inconspicuous to the naked eye as possible. As a rule, start with whatever grade of abrasive will do the job, then work progressively through the finer grades. Each succeeding grade should remove or blend the scratches from the preceding polishing treatment. Hand pads are less aggressive than discs or belts of the same grade because they contain less adhesive and they do not have a stiff cloth backing. Thus, an operation using a Super Fine (grey) disc can be carried further with a Super Fine hand pad.

Buffing to a mirror finish should not necessarily follow unless it was part of the artifact's original manufacturing process. In many cases, buffing was restricted to plated parts, both before and after the plating operation.

Surfaces that were originally machined will be covered with a regular pattern of tool marks, most of which will reappear when the surface rust is removed. When considering the use of surface conditioning products, try to match the direction of abrasive travel with the original tool marks and wear patterns on the metal. For example, if a surface shows concentric circles left by a milling machine, treat it with a circular, rotating disc of *Scotch-Brite*. In this way, the new scratch pattern will be almost indistinguishable from the more pronounced original marks. A cylindrical shaft, by contrast, will usually show parallel lathe marks running perpendicular to its axis; treat this type of surface with a belt on a recessed arm attachment in order to follow the lines. The arm allows the belt to conform like a strap to the cylindrical shape. For flat surfaces with parallel tool marks, use a straight arm attachment with a belt. Treat internal, cylindrical shapes with star-wheels.

The polishing material quickly becomes clogged with rust particles during use, reducing its effectiveness. It is possible to extend the life of the material by running it over a sharp metal edge; this strips off the surface debris, exposing fresh abrasive material.

Modifications

Scotch-Brite products can be modified quite easily to remove rust from almost any shape and size of steel artifact. For example, one can cut down the five flaps of a star-wheel with scissors, so that it will fit into holes with a smaller diameter. Use the leftover rectangular pieces of material in the 3M Mini Mandrel for treating even smaller holes. The cloth backing and extra adhesive on these pieces make them more durable than pieces cut from the unbacked hand pads.

The V-shaped recesses (roots) between the crests of external threads on large fasteners can be reached with the edge of a spinning star-wheel. The space between gear teeth and confined interior right angles can be treated in the same way, although the material will be worn away very quickly in the process. Two star-wheels can be threaded back to back on one mandrel; this allows polishing of two inside faces at the same time.

Used belting can be re-used for hand polishing shafts simply by cutting the belt to form a long strip.

Post-treatment Options

The newly exposed steel surfaces are once again highly vulnerable to rusting and will need to be protected from oxygen and atmospheric moisture. This can be achieved with regular coats of lubricant during operation or with the use of rust-preventive compounds for static display.

Contact a conservator for advice on selecting the most appropriate product.

Suppliers

Note: The following information is provided only to assist the reader. Inclusion of a company in this list does not in any way imply endorsement by the Canadian Conservation Institute.

Suppliers of the tools and materials discussed in this Note can be found in the Yellow Pages of most telephone directories under the following headings:

Abrasives
Industrial equipment & supplies
Automotive supplies

Otherwise, contact the manufacturers directly for the name of the nearest distributor:

3M Canada Inc.
tel.: 1-800-361-4488
or
3M (USA)
tel.: 1-800-3M-HELPS
www.mmm.com

Norton Canada Inc.
tel.: 1-800-263-6565
or
Norton Co. (USA)
tel.: 1-800-446-1119
www.nortonabrasives.com

Dynabrade Inc.
tel.: 1-800-344-1488 (Canada) or 1-800-828-7333 (USA)
www.dynabrade.com

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