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Chairman’s Corner
Sam Black, PEMD Chair

Welcome to the Winter 2014 Issue of the PEMD Newsletter! In this issue you will find a couple of articles that present good information on gasket and aging plant equipment. These are some very relevant topics that cross industry boundaries and apply to pretty much all types of plants whether they be discrete manufacturing, power plants, the continuous processing industries, facilities management, etc. You will also find within these articles some good links to further your knowledge on the subjects or possibly help you resolve a current challenge you may be facing. If you do benefit from reading them we would love to hear back from you with the specifics of your challenge and subsequent solution(s).

As a reminder, next year will present leadership volunteer opportunities within the Plant Engineering and Maintenance Division of ASME. If you would like to volunteer please contact anyone on the executive committee. You can find our contact information at https://community.asme.org/pemd_executive/groupleadership.aspx.

As we traditionally point out in our newsletter, this division exists for the purpose of serving our professional community and our membership. Once again, we thank you and remind you to: Get Active and Get Involved by Volunteering!

On behalf of the Executive Committee of PEMD we wish a very happy and successful new year!

Gaskets – Their Types, Uses, and Maintenance Issues
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Introduction
Gaskets rank as one of the most ubiquitous components found in the modern factory, home or car. In quantity, it is ranked only behind screws, nails, nuts and washers. Its function in the world is generally understood: sealing, mating irregular surfaces, insulating and vibration damping; but with the steady introduction of new materials and manufacturing processes the plant worker of today has new choices to consider as they perform their daily tasks. This article will attempt to clarify those new choices, and review some old ones, and relate them in a way that will make your job more successful.
**Background on Gaskets and Gasket Manufacturing**

Gaskets are categorized by their material and function. There are metal gaskets and elastomer gaskets. Elastomer gaskets are further broken down by solid, foam and organic. Metal gaskets are categorized by material and form, flat or ring.

![Figures 1 & 2: Metal (left) and elastomer gaskets (right).](image)

Gasket production is part of a larger industry known as the converting industry. Sheet metal, signage, washers and shims are all part of this industry so designated because the primary material dimension remains relatively unchanged throughout the production process. I am referring to the material thickness. There are also many similarities between how gaskets are made and sheet metal even though the materials, in some cases, cannot be more different.

The primary production method for elastomer gaskets is die-cutting. Die-cutting is not dissimilar to cookie cutting in that a bent and formed steel rule (the knife edge) is brought down against a flat and usually featureless cutting board. This process is great for modest tolerances in medium to high volume production. For low volume and one-offs, CNC Die-cutting, Laser cutting and water-jet cutting offer tool-less methods. These processes are lower cost and quicker turnaround because no tooling is required and they can be setup quicker. Each method has its own cost/benefit; laser cutting will leave a heat-effected zone which could introduce contamination, water-jet cutting will also create contamination issues especially with foam gaskets; CNC Die-cutting has issues with small features sizes (smaller than 3mm typically).

**Gasket Issues as related to Maintenance**

Scheduled or emergency, maintenance’s task is to return the equipment to a condition of safe and efficient production. Disassembly, followed by repair or replace (the broken components), and finally assembly and test are the basic tasks. Gaskets are especially vulnerable to breakage during the disassembly step. Often time personnel are hopeful to reuse the old gasket, so this vulnerability is unfortunate.

The good news is the age-old choice of reuse or replace should be revisited from time to time. With new and better materials available (better performance and lower price), and quicker turnaround times available (rapid prototyping processes), I propose that reusing should be the very last choice. The advent of rapid prototyping can remove availability issues within the time frame of the maintenance organization.

**Gasket Replacement Process**

Primary source of replacement gaskets should always be the OEM (not a very earth shattering announcement). And, when it comes to the high-performance gaskets found in your equipment (high pressure or hard vacuum, high temperature or cryogenic and chemically aggressive gas and fluid systems), it is very important to source the gasket from the OEM or its subsidiaries. Reuse of gaskets in these applications is extremely hazardous. Don’t do it; according to ASME “only a new gasket will reliably provide the necessary plastic deformation and elastic recovery characteristics essential to achieve an effective seal.” However, what about custom equipment or the inability to find the OEM’s replacement part, or the OEM for that matter? And, of course, you need it now. You could make it yourself; buy the material (usually much more than you need) and using one of the components make a pattern for the gasket and then cut the gasket by hand. This is a time consuming process...
and not your best choice as the quality will be extremely variable, not to mention cost and time. Make use of the new rapid prototyping methods and you will save your company time and money and have a more reliable gasket.

You need to replace a gasket now and there are no off-the-shelf items available in the time frame. If there are no spec sheets on the gasket then the tools you will need are measuring devices and a 2D CAD computer application. The task is to create a scaled drawing of the gasket and send it to the rapid-prototyping manufacturers, in a DXF file format at best. DXF files are the drawing format of choice for gasket manufacturers. It is accurate, universal and a 3D file is not needed- the material thickness is specified with the material. Otherwise, send a picture (jpeg) with dimensions and the gasket manufacturer will create the file for you, though this will take time. Lastly, include material specifications and/or detailed description of the gasket's environment: temperature range, pressure range, type of application, fluids in contact with gasket and any installation issues. See below for resources to specify materials and acquire 2D CAD applications.

Figure 3: Gasket CAD drawing.

Rapid-prototyping companies are flexible and will work with you to obtain the best solution. Since there are no tools developed, you will get faster turnarounds and no-guilt revisions should something not work correctly the first time. Some rapid-prototyping manufacturers have on-line ordering websites and will ship the next day after receipt of the order when stocked materials are specified. This is a perfect solution for those low performance gaskets found in your plant such as enclosures and cover plates, for instance.

New Resources for Maintenance
Finding rapid-prototyping companies offering new materials and processes is the key to successfully second sourcing your gaskets. Google, ThomasNet and GlobalSpec are great, general purpose search engines that can bring you thousands of hits. Using the search terms: 'rapid prototyping gaskets' and 'prototyping gaskets' will bring the appropriate companies onto the first and second page of your search engine.

For General Information on Gaskets:
The Fluid Sealing Association (http://www.fluidsealing.com/index.html) and the Gasket Fabricators Association (www.gasketfab.com) websites are an excellent resources. General and specific information about gasket materials and processes can be found at both sites. The hand book at http://www.gasketfab.com/downloads/TechnicalHandbook.pdf is a very good overview of materials and process and you can drill down a little deeper if you are interested and have the time.

To Obtain or Purchase 2D CAD:
If your company has a CAD program in-house then it can be used to generate a DXF file. All commercial 3D and 2D CAD programs have this export ability: for 3D CAD systems it is usually accessible from "Drawing" mode. There are also low-cost and free 2D CAD systems. A very good free program that only requires registration for use is DraftSight from Dassault Systems who also produce SolidWorks.
About the author:
Glenn Edwards has a BS Mechanical Engineering and an MS in Systems Engineering, is a registered Professional Engineer in the state of CA, and a member of ASME since 1982. He has no affiliation, monetary or otherwise, with Google, GlobalSpec, ThomasNet, IADD, GFA, FSA and Dassault Systems. He is President and Founder of Rapid Converting LLC which provides rapid prototyping of elastomer gaskets using a proprietary CNC Die-cutting method through the www.rapidgasket.com website.

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Assessing Plant Components’ Degradation
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The aging assets...
The median age of fossil-fueled electric power generating units in many countries, excluding the gas/combustion turbine prime movers, is in the range of 30-35 years, with most at least 25 years old. These aging fossil power generating units were not planned for the extended service being seen today.

Owner-operators are increasingly looking at assessing the condition and possibility of extending the existing power plants’ operation lifetime including improvement of efficiency and environmental conditions. The aging components in these plants force operators to make run/repair/replace decisions on equipment more often than ever before.

Keep it running...
The material properties of an in-service component that determines its mechanical response, damage accumulation rate and remaining lifetime are seldom measured while in service. Generally, assumptions are made about properties based on original construction specifications and, as relevant, by conservative estimates of aging effects. This is often the least-accurate representation of real material property in service.

For most equipment, where damage accumulation and lifetime are controlled by the component’s mechanical response to service conditions, the input to run/repair/replace decisions involves three key sets of variables:

a) Service loads/stresses, including environmental effects
b) Flaws (cracks) in the component and section thickness, as determined from nondestructive evaluation (NDE)
c) Current and projected material properties of components

In the case of loads/stresses, advanced computing capability now available allows plant engineers to perform fairly complex stress analyses of system configurations and component geometries. With regard to the flaw condition, NDE of in-service equipment is an intensive component-specific activity undertaken by plant operators.

When considering the assessment of component condition, it may be useful to take a step-wise, rigorous approach. The assessment is generally performed for components, which are operating at or above 400°C since they undergo such changes in properties, which can be co-related with time. Non-destructive tests, such as microstructure assessment by replica, ultrasonic testing etc., enable assessment of accumulated damage and consequently the remaining life. The creep and fatigue damage can be calculated to estimate total life from which relevant fractions of exhausted life are deducted to arrive at remaining life.

The methods followed for plant component assessment can be put broadly under two categories:

a) Methods based on the operational history in which the expended life of a component has been assessed on the basis of operational history and standard material properties.
b) Methods based on post service examinations or post-exposure tests (PET) [Non Destructive Examination] on the actual components.

While the operational history review method is made to identify the critical locations and stage at which post exposure testing in called for, non-destructive approach is used to assess the present condition and the structural integrity allowing the equipment for continued, safe and economical operation or else take decision to refurbish / replace.

The basic data required for damage computations are:

- **Plant Operational Data:** This typically includes number of hours of steady operations and number of hot start, warm start and cold starts. If the load changes are known from the past history, it is also noted down with amplitudes and time duration.
- **Geometrical Data of the components:** Relevant geometrical parameters such as thickness and diameter of the headers / pipes, branch pipes, tubes and their connection ligament details etc. are obtained from the production /fabrication drawings which are essential for the stress/ strain computations.
- **Material Property Data of the Components:** Using parametric relations (for example, Larsen-Miller Parameter for creep rupture time) most suitable for the material under investigation, properties at desired operating parameters (stress-temperature) are derived from the data collected and using standard parameters such as modulus of elasticity, Poisson’s ratio, yield strength, ultimate strength, critical stress, intensity factors.

Non-Destructive Techniques, which are taken up during a planned shutdown of the plant, include Time of Flight Defraction Ultrasonic testing (TOFD), Phased array ultrasonic testing, Magnetic particle inspection, Dye penetrant inspection, In-situ Metallography (Replication), Hardness measurement, Remote Video Imagerycopy, Dimensional measurement and Visual Examination methods to assess the present health condition of every component. When several activities/testing are to be carried out on the same component, which is usually the case, the logistics are followed for testing sequence to optimize time and resources. Findings requiring immediate attention of plant authorities to facilitate taking action are given then and there to plant authorities. Observations are further augmented with laboratory investigations and a logical analysis of the results.

**Figures 1 and 2:** Taking a hardness measurement (left), replication for microstructure examination (right).

Thick walled components such as steam pipes are subjected to thermal and stress gradient due to thermal expansion and contraction during operation leading to cyclic strain in the material. In such cases damage due to both creep and fatigue takes place. The high temperature components in utilities when subjected to high stresses for a long time undergo steady changes in structural carbide phases. Initially fine carbide grows with time and temperature. As a result, the carbide particle size and inter-particle spacing increases, thereby material gets softened. This is the beginning of the creep of slow plastic deformation leading to gradual deformation of highly stressed parts. This can be correlated to the remaining life of the component based on the creep curve.

Replication is a non-destructive technique adopted to obtain the microstructure ‘in-situ’ which is analyzed to provide health status of components, and expected future behavior in broad time frame.
Critical components including Critical piping etc are visually examined after being de-insulated wherever necessary. An extensive NDE of components is made at vulnerable locations such as butt welds, fillet welds, stub welds, ligaments etc. Buffing or grinding is done for adequate width near butt welds to permit ultrasonic flaw detection and penetrant Examination.

![Figure 3: Microstructure from spot on rotor at 100X magnification.](image)

In summary, condition assessment of components for an aging plant is an important and specific study which helps in giving recommendatory decisions like run/repairs/replace for further safe usage of the unit and also for continuous monitoring of critical parts at regular intervals based on which preventive maintenance interventions can be planned. With advances in computational, NDE and materials sampling and testing capabilities, such an assessment can be planned and performed at a reasonable cost.

**About the Author**

Hemant Gajjar is an engineer with 27 years’ experience working with power plants. Mrinal Mohan is an engineer with 6 years’ experience. Both work for Steag Energy Services (India) Pvt Ltd, a power plant consulting firm whose service areas include energy systems, water systems, project, operations and maintenance, efficiency, training, and system technology.

*Editor’s Note:* The article originally stated 4,000°C. This typo has been corrected to 400°C.