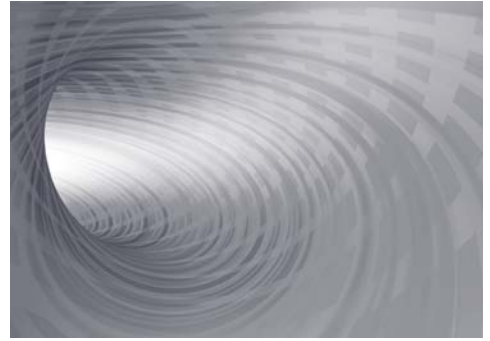


Accuracy in 3D Virtual Worlds

Interactive 3D Modeling of the Refractory Linings of Copper Smelters

By Anthony J. Rigby, Kenneth Rigby, and Mark Melaney



Some of the most popular 3D virtual world engines, such as Second Life and OpenSimulator, are very effective for socializing and meetings but fall short for serious applications that involve accurate rendering. Consider the problem of engineers designing, maintaining, and deploying the refractory linings for smelters used in copper production. The longevity of the refractory lining in these 40-foot × 15-foot anode vessels is a crucial production issue. The smelters must operate continuously for four to five years.¹ During brief shutdowns of the converting furnaces due to plant maintenance, refractory installation crews must be able to rapidly patch the anode vessels and ready them to resume production.

The optimization of these copper smelting furnaces is primarily achieved by specific zoning of the vessels' heatresistant lining. The most severe operating areas come in contact with high temperature fluid oxide slags and must be protected with a well-engineered design and relatively high-cost products. Using virtual environments can illustrate the complexity of the required configuration much more efficiently than a set of 2D prints and extracted details.

The Need for Virtual World Modeling

Using 3D modeling, designers can effectively illustrate the refractory installation, design, and lining concepts required to optimize the coppsmelter's desired performance. The use of a 3D-engineered model is highly instructive in detailing some of the more sophisticated aspects of the lining design. Refractory engineers can design these vessels with a dimensional accuracy in AutoCAD 3D, with a tolerance of +/- 0.5 mm. Using AutoCAD, they can render the model as a mesh to engineering dimension specifications and import it into a texturing software application, which can color-code and realistically apply a surface to it.

Allowing teams of engineers with different backgrounds to "walk around" inside the smelter helps them examine different elements. AutoCAD doesn't support this kind of team review, so to achieve collaborative design and monitoring, we considered 3D virtual worlds. However, we found that most popular platforms failed to provide accurate renderings. For instance, the base representation in Second Life consists of primitive graphics objects (called *prims*), so importing AutoCAD 3D graphics mesh files wasn't possible (although Second Life is reportedly integrating mesh import via the standardized Collada [*Collaborative Design Activity*] format, which provides additional rendering accuracy). In addition, we can't model certain features in these 3D worlds with AutoCAD-comparable accuracy.

To meet the need for an accurate 3D virtual world engine that could be used in engineering, manufacturing, and military applications, we chose Avaya's Web.alive (<http://avayalive.com>), which lets us import complex, high-polygon 3D models for deployment in a multiparticipant environment.

Web.alive and Unreal

Web.alive was developed primarily for virtual conferencing and collaboration engagement. It's based on a browser that embeds the Unreal gaming engine and DiamondWare 3D spatial voice over IP (VoIP). Web.alive was designed to accurately display engineering applications, enabling teams (currently up to 25 avatars) to collaborate on a design or monitor an engineering system. Web.alive offers the following features:

- Users can drag and drop documents and images to make presentations, collaboration, and training easy. Any Web content can be rendered in the world, allowing access to media (such as streaming video from YouTube), applications (for example, collaboration using Google docs), and data (such as Wikipedia entries). It supports file sharing, URL sharing, text chat, and file drop boxes.
- The VoIP works with no driver configuration. Noise suppression and echo cancellation operate with built-in laptop speakers and a microphone.
- The world has secure areas with an invitation feature that lets you vouch for other users. Users behind virtually any firewalls (including HTTP proxies) can access Web.alive. Presenters are automatically granted additional capabilities to help communicate with and manage their audience.

Web.alive uses the Unreal game engine to render accurate architectural and engineering virtual environments. Unreal (as used in the America's Army recruitment project; http://en.wikipedia.org/wiki/America's_Army) provides a powerful combination of an accurate physics application (Karma), particle system editor, and vehicle physics for any engineering or military use. It isn't yet available in virtual world platforms such as Second Life. However, Unreal version 2.5, in combination with DIRECTX 8.0 and 3D graphical acceleration video cards, enables us to render engineered objects with AutoCAD dimensional accuracy and verisimilitude, including rendering highpolygon static meshes, photo-realistic textures, and 2D graphics that aren't subject to debilitating pixelation on close inspection. The UnrealEd level editor is integrated with the rendering engine and, along with an extensible C++ core, provides an UnrealScript high-level scripting interface as well as visual editing of avatars and surface textures within the virtual world. Mellanium's bridge between CAD and Unreal lets us import CAD designs into Unreal.

UnrealEd is a real-time design tool, optimized for building 3D environments. It's integrated with Unreal's rendering engine, offering a WYSIWYG camera view and immediate display of lighting, texture placement, and geometry operations. UnrealEd also provides single-click playability; designers can launch the viewer and walk around their created environment in real time, even during the design process.

After 3D model creation, designers can apply photo-realistic textures up to 2,048x2,048 pixels to surfaces to enhance objects' perceived detail. This capability, combined with detailed texture mapping, yields photorealistic surfaces that can display intricate engineered details. Because Unreal can handle up to 60,000 polygons in one modeled item, and there is an indefinite limit to the assembled unit's size, even with a fully textured and lit surface, the engine can handle enormous spaces suitable for generating immersive engineering scenarios.

Modeling Copper Smelters

Web.alive, in conjunction with the Unreal gaming engine, provides a 3D virtual world that supports the accuracy required in engineering, manufacturing, and other complex, real-world applications. For the copper smelter model we discussed earlier, we imported computer-generated, actual-scale furnace models into the 3D virtual world application to provide accurate and realistic surface features and lighting. Figures 1 and 2 show a rendering of the copper smelter after we import the AutoCAD mesh into Web.alive.

When we import these models into the 3D engine framework, we can create content-rich environments that enable teams to interactively develop or later monitor and maintain complex equipment. In the near future, we plan to release similar environments to illustrate the more complex smelter designs required for aluminum and nickel metal primary production and the innovative incineration of domestic waste. All these applications demand a high level of engineering complexity, and real-time collaboration within these environments will result in rapid assimilation of the know-how deemed necessary for extended campaign performance.

Reference

1. A.J. Rigby, "Controlling the Process Parameter Affecting the Refractory Requirements for Peirce-Smith Converters and Anode Vessels," *TMS 2005 Converting and Fire Refining*, A.G. Ross, T. Warner, and K. Scholey, eds., Wiley, 2005, pp. 213–222.

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Figure 1. Web.alive rendering of a copper smelter. The 3D environment displays an accurate model of the anode vessel, showing the smelter and converter furnaces, including the design of the vessel's refractory lining.

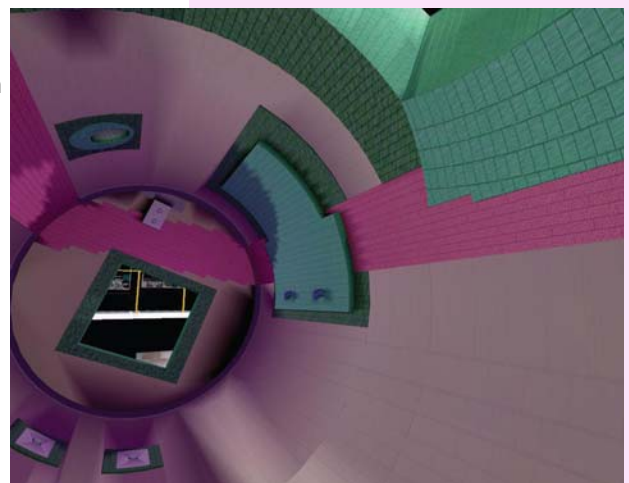


Figure 2. Interior of a copper anode vessel, rendered in Web.alive. This interior consists of thick reinforced tuyere areas, the access door, the porous plug placement, the skimming mouth, and the slag line refractory.