Is It Acid or Is It Fire?

How to Train Your Dragon: The Hidden World

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ABSTRACT

The animated movie *How to Train Your Dragon: The Hidden World* introduces a new species of dragon in the franchise: the *Deathgripper*. This dragon possesses the ability to spit green acid that both dissolves and sets ablaze objects that it touches. In this talk we present the various challenges posed by this somewhat unique effect from the visual development phase to production shots.

CCS CONCEPTS

• **Computing methodologies** → Computer Graphics.

KEYWORDS

Visual effects, liquid simulation, fire simulation

ACM Reference Format:
Amaury Aubel and KC Ong. 2019. Is It Acid or Is It Fire?: How to Train Your Dragon: The Hidden World. In *Special Interest Group on Computer Graphics and Interactive Techniques Conference Talks (SIGGRAPH '20 Talks), August 17, 2020, Virtual Event, USA.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3388767.3407356

1 VISUAL DEVELOPMENT

The FX team was launched on the visual development of the acid fire in pre-production. From storyboards, it was clear that the effect was featured in fast-paced action sequences and that the sets quickly turned into burning infernos as a result. After some experimentation, we settled on a series of beats happening in rapid succession: stream of transparent liquid acid with an immediate release of steam on impact, erosion of material hit by liquid, and finally fire and smoke. We considered making the acid froth upon contact but realized there would not be enough time in shots for the viewer to notice.

While fictional, the world of *How to Train Your Dragon* is usually grounded in physical reality: effects follow the laws of physics. Consequently, the steam, fire and smoke are rendered with the hues one would expect. The green color of the acid (Fig. 1) was picked because it seemed to have an implicit association with "acidity" and reacted well to fire-lit scenarios.

SIGGRAPH '20 Talks, August 17, 2020, Virtual Event, USA

ACM ISBN 978-1-4503-7971-7/20/08.
https://doi.org/10.1145/3388767.3407356

2 SIMULATION

Early storyboards show *Deathgrippers* spitting acid at relatively distant targets. We therefore simulate the stream coming out of the dragon's mouth as high-velocity points that we emit into a regular FLIP simulation. We create artificial viscosity only in the neighborhood of collisions, so that the fluid sticks to colliders to some degree but retains an inviscid behavior elsewhere. To that effect, each point in the fluid simulation is assigned a smoothly varying *colliding* attribute based on proximity with colliders. A value of 0 indicates that the point is not in the vicinity of a collider and thus is moving freely. For any other value, a *stickiness force* is exerted onto the FLIP point to move it towards the collider. The magnitude of the *stickiness force* is proportional to the *colliding* attribute and its direction follows the gradient derived from the signed distance field (SDF) of the colliders.

The erosion process is simulated by carving holes into the colliders (Fig. 2). We first construct an erosion SDF by rasterizing the colliding points (i.e. *colliding* > 0) in the FLIP sim as spheres. We then subtract the erosion SDF from the SDF of the colliders. Note that prior to this boolean operation, the erosion SDF can be smoothed to minimize the creation of jagged edges.

We add an *acidity* attribute to the FLIP particles as a tool to control the erosion. Each colliding particle consumes a small amount of acidity at each time step. By enabling the erosion only when the acidity is within a certain range, we can delay the start of the erosion as well as decide when it stops. Although this erosion mechanism works well, it sometimes appears that matter simply disappears into thin air. To combat this, we release a subset of points originating from parts of the colliders that are eroded back into the FLIP simulation. In this way, a fraction of the eroded matter turns back into acid. This helps sell the illusion that things "liquefy" before getting dissolved.

We use the set of colliding points in the FLIP sim at each time step to emit into a secondary steam simulation. We analyze the set of colliding points and extract the border of the erosion process using heuristics such as the distance to the original, un-eroded surfaces. Steam emitted from this region will generally not get trapped inside the colliders or the acid. Similarly, we emit fuel and temperature into a fire simulation once the erosion has been occurring for a while. In practice, we paint the maximum possible coverage of the flames on the final frame of the eroded colliders. We then run a simple cellular automaton so that the emission propagates over time starting from hand-placed seeds that are activated based on time. Embellishments such as scorch marks and glowing hot burn patterns are added procedurally through noise-based shaders driven by temperature, surface curvature, and distance to the original, un-eroded surfaces.