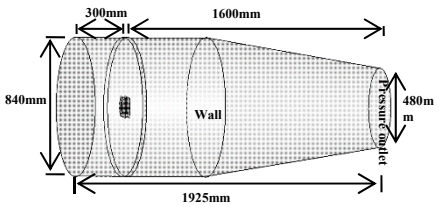
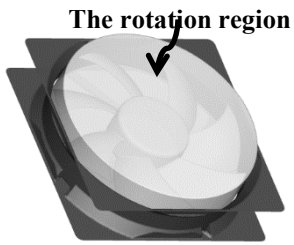
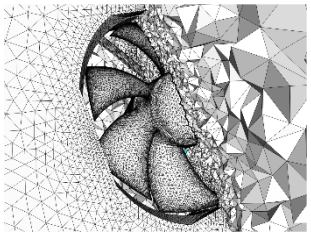
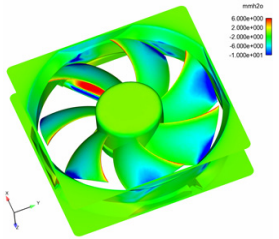
## Meshing Contest of the 25th International Meshing Roundtable

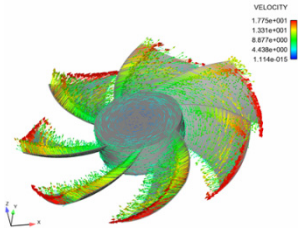
# Automatic Generation of a Hybrid Mesh for Viscous Flow Simulations of an Exhaust Fan Model







- **Meshing use:** simulating the flow structure induced by the rotation of fan blades
- Automatic workflow of the entire meshing procedure

**Compute a sizing function** ⇒ **Create the surface mesh** ⇒ **Create the BL mesh** ⇒ **Create the unstructured mesh**

## Highlight #1: Automatic sizing function for surface meshing

**Step 1.** The tessellation of the CAD model is used as the background mesh and the node values is computed by considering the combined influence of geometry factors and user parameters.

**Step 2.** A non-linear programming problem (NLP) is solved to smooth the sizing function.

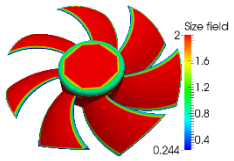
$$\min \quad \sum_{i=1}^{n} (h(p_i) - h_0(p_i))^2$$

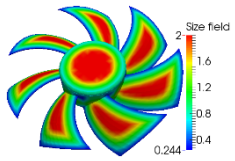
$$s.t. \quad |\nabla h(e_i)|^2 = \mathbf{H}_i^T \mathbf{K}_i \mathbf{H}_i \le \ln^2(\beta) \quad \text{for each background element}$$

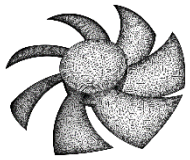
$$h_{\min} \le h(p_i) \le h_0(p_i) \quad \text{for each background node}$$

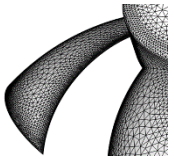
**The convexity of the NLP and the existence of the global optimal solution are rigorously proved!**

**Ref:** Chen, *et al.* IJNME, 2016. doi: 10.1002/nme.5298





**Initial Sizing function** **Smoothed Sizing function** **Surface mesh**

## Highlight #2: BL Meshing by using Vector Fields Computed by the Boundary Element Method (BEM)

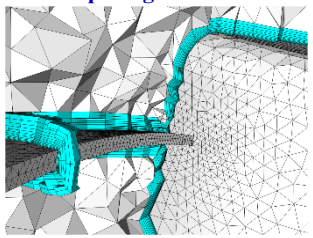
The minimization problem computed for propagating marching directions specified on domain boundaries into domain interiors smoothly could be reduced to a vector-form Laplacian equation.

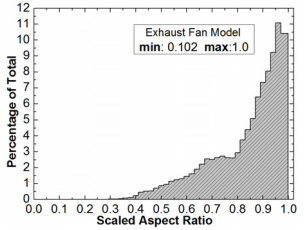
$$\begin{cases} \min \int_\Omega |\nabla \mathbf{u}(p)|^2 d\Omega \\ s.t. \quad \mathbf{u}(p) = \mathbf{u}_0(p) \quad p \in \partial\Omega_D \\ \quad\quad \partial \mathbf{u}(p)/\partial \mathbf{n} = \dot{\mathbf{u}}_0(p) \quad p \in \partial\Omega_N \end{cases} \Rightarrow \begin{cases} s.t. \quad \Delta \mathbf{u}(p) = \mathbf{0} \quad p \in \Omega \\ \quad\quad \mathbf{u}(p) = \mathbf{u}_0(p) \quad p \in \partial\Omega_D \\ \quad\quad \partial \mathbf{u}(p)/\partial \mathbf{n} = \dot{\mathbf{u}}_0(p) \quad p \in \partial\Omega_N \end{cases}$$

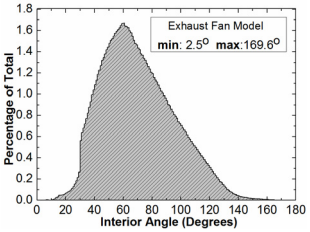
We use the BEM to numerically compute the field (in fact, the fast multipole BEM is adopted for efficiency consideration).

**Advantages:**

- No need to create a volume background mesh.
- Computing accurate marching directions by a boundary integration equation.






**Hybrid mesh and the distribution of volume element quality indices**