Forging BIM Configurator for HVAC Systems

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About the speaker

Sandip Jadhav, CEO, CCTech

Sandip is a successful entrepreneur in the CAD/CAE space. He has co-founded CCTech, Zeus Numerix, Adaptive 3D Technologies, LearnCAx and recently simulationHub, a cloud-based fluid flow simulation web service. Sandip has led several product development teams in conceptualizing, designing software, and implementation of apps in CAD and simulation space. Sandip is a passionate software developer and loves to tinker with technology.
Co-Speaker

Rohit Chavan, SDM, CCTech

Rohit is Software development Manager of the simulationHub CFD cloud platform. Rohit is an agile leader who has helped to build the multiple simulations apps for the simulationHub team. He has deep expertise in building scalable, resilient, beautiful webapps using Autodesk Forge, AWS, SWS and a range of full stack technologies. He is a scrum advocate to build cross-functional and self organizing teams to create high value products. Rohit is a graduate in Computer Science from Pune University.

Praveen Kumar, PM, CCTech

Praveen is a Product Manager of simulationHub, a flagship CFD platform of CCTech. Praveen has deep expertise in converting real world problems into accurate computational problems. He has been instrumental in conceptualizing the building simulation apps for the simulationHub team. With more than 13 years of strong domain experience in CFD, he has also developed flavor for user experience. Praveen holds a Bachelor's degree in Mechanical Engineering and Postgraduate DACFD.
Outline

• Understanding the HVAC Design
  o Challenges
  o Opportunity
• Autonomous HVAC CFD App
• Building Blocks
• Implementation
• BIM Designer Studio
• Revit Design Automation
• Signup for Private Beta
HVAC system for best Thermal Comfort

Indoor Air Quality
Occupant Thermal Comfort

Thermal Comfort of occupant is that **condition of mind that expresses satisfaction with thermal environment**

**Factors affecting Human Thermal Comfort**

- **Environmental Factors**
  - Air Temperature
  - Air Velocity
  - Mean Radiant Temperature
  - Relative Humidity

- **Personal Factors**
  - Metabolic Rate
  - Clothing Insulation

**Thermal Comfort** is the condition of mind that expresses satisfaction with thermal environment.
Evaluating Occupant Thermal Comfort

Standards

ASHRAE 55
Thermal Environmental Conditions for Human Occupancy

ASHRAE 113
Method of Testing for Room Air Diffusion

ISO 7730
Ergonomics of the thermal environment

Thermal Comfort Indices

- Predicted Mean Vote (PMV)
- Percentage of People Dissatisfied (PPD)
- Draft Rating (DR) index
- Effective Draft Temperature (EDT)
- Air Diffusion Performance Index (ADPI)
- Local Discomfort
  - Draft
  - Vertical temperature difference
  - Floor temperature
  - Radiant temperature asymmetry
Democratization of Technology

Only 1 out of 100 CAD designer uses Computational Fluid Dynamics in his design workflow.
Business Case – HVAC Commercial Project
Exploring different HVAC solutions
HVAC Contractor - Roles

**HVAC Contractor**

- Collecting the space layouts
- Collaborates with HVAC designer and manufacture
- Demonstrate the proposed solution
- Close the deal

**HVAC Contractor**

- Understands the space, occupancy and scenarios
- Creates design configuration
- Performs the CFD simulations
- Provides the success scenarios to sales team

**HVAC Manufacture**

- New HVCA Systems
- Evangelize the new product
- Equipment Catalogues
- Performance Data

**HVAC Designer**

- Collecting the space layouts
- Collaborates with HVAC designer and manufacture
- Demonstrate the proposed solution
- Close the deal

**Technical Sales**

- New HVCA Systems
- Evangelize the new product
- Equipment Catalogues
- Performance Data
HVAC Manufactures

- Daikin
- Trane
- Ingersoll Rand
- Mitsubishi Electric
- Johnson Controls
- Lennox
- Nortek
- Samsung
- LG
HVAC Systems and Design Configurations

Diffuser Type
- Overhead Mixing
  - Ceiling mount
- Surface/Wall mount
- Underfloor Air Distribution

Supply-Return Positions

HVAC System
- CAV
  - Cooling/Heating Coil
- Thermostat
- Single Zone
- Blower
- Multi Zone
- VAV terminal
- VAV terminal
- VAV terminal
- VAV terminal
- VAV terminal
HVAC System Design - Multi-Objective Optimization

- Energy Efficiency
- Occupant Thermal Comfort
- Sustainability
- Resilience
- Acoustic
- Operating Expenditure
- Capital Expenditure
HVAC Contract Process

Months spend in negations and reworking the design to satisfy customers need
Limitation HVAC Contractor firm

- 2D CAD as a Reference
- Can’t afford BIM
- No CFD Experts
- No HPC
- Can’t buy expensive CFD Software
- Laptop or Tablets
How to win a client and contract with available resources?

A solution with Three innovations
WebApp based BIM Modeler

HVAC Contractor

HVAC Manufacture

HVAC Designer

Technical Sales

HVAC Equipment Catalogue

BIM Modeler

2D Sketcher
A multi-devices HVAC CFD solution
Autonomous = Automation + Intelligence

Eliminate the need of CFD expert or HPC cluster
Autonomous HVAC CFD
Autonomous HVAC CFD

BIM Design Studio  Design Configurator  Scenario Studio  Simulation  Result Visualization
Autonomous HVAC CFD - Any device Anywhere
BIM Design Studio
Design Configurations

**Diffuser Type**
- Overhead Mixing Ceiling mount
- Surface/Wall mount
- Underfloor Air Distribution

**HVAC System**
- CAV
  - Cooling/Heating Coil
  - Thermostat
- VAV
  - Single Zone
  - Multi Zone
  - Blower
  - VAV terminal
Scenario Studio

**SUMMER**

- Full 100%
- Design 70%
- Partial 30%

**WINTER**

- Full 100%
- Design 70%
- Partial 30%
Autonomous HVAC CFD
App Demo
God is in Implementation
Building Blocks

Autodesk Forge
React Planner
Revit Design Automation
SimulationHub Web Services
ReactJS
AWS
DynamoDB
Lambda
App Architecture

Autonomous HVAC CFD App

BIM Design Studio  Design Configurator  Scenario Studio  Simulation Setup  Result Visualization

Multiple users  Individual users  Enterprise

simulationHub Web Services
BIM Configurator
BIM Design Studio - Workflow

1. Sketch the BIM Model
2. Create Building Spaces
3. Place Windows and Doors
4. Place Furniture Components
5. Place HVAC Component
6. Create BIM Model
React Planner – Data Model

**Vertex Class**
- Vertex ID
- Wall IDs
- X
- Y

**Wall Class**
- Wall ID
- Name
- Wall Type
- Holes
- Vertices IDs

**Area Class**
- Area ID
- Name
- Vertices IDs

**Item Class**
- Item ID
- Name
- Rotation
- X
- Y
- Properties

**Hole Class**
- Hole ID
- Name
- Type
- Wall ID
- Offset
- Properties
BIM Component Property
Step in Revit Design Automation

- Convert Revit to Design Automation Add-In
- Upload App Bundle
- Create and Publish Activity
- Create Aliases for Activity and App Bundle
- Prepare Input Output
- Run Workitem
Wall Information

- Wall ID
- Wall Type
- Length
- Height
- Thickness
- Material Assembly
- Thermal Transmittance U-value
- Absorptivity
- Reflectivity
BIM Design Studio

Glass Window Information

- Glass ID
- Location on Wall
- Length
- Height
- Thickness
- Material Assembly
- Thermal Transmittance U-value
- Absorptivity
- Transmissivity
- Reflectivity
BIM Design Studio

Manikin Information

- Manikin ID
- Seating Layout
- Surface Area
- Position
- Metabolic Rate (MET)
- Clothing Insulation (clo)
Simulating the HVAC
Real-World Problem to a Computational Problem

Real-Life Problem

- Incident Radiation
- Reflected
- Transmitted

S.A. Duct

Computational Problem

- Solar Ray Tracing
- Convection + Radiation + Shell Conduction

Flow Profile

- 40W
- Thermal Manikin 1 MET (60 W/m²)
Autonomous HVAC CFD

- BIM Model
- Fluid Volume Extraction
- Mesh Generation
- Solve Run
- Occupant Thermal Comfort
BIM to Fluid Volume

- Consumes days for analyst
- simulationHub Propriety Algorithms
- Automatic Wet surface identification and Extraction
- Intelligence build to close the small gaps and extract the right surfaces

BIM Model

Fluid Volume Extracted
Mesh

Prism mesh cells
To resolve boundary layer

Surface mesh on thermal manikin

Surface mesh on supply diffusers

Automated mesh generation
Post processing Results

- Direct airflow over occupant
- Low temperature region
- Low PMV – Discomfort (Cold)
5.2 Weather Conditions

The external heat load on the building is applied on the external wall (walls that are in direct exposure to atmosphere) based on the outside weather conditions i.e., wind speed and air temperature. The heat transfer coefficient is calculated accordingly and applied on the external wall surfaces. The external walls are divided into summer and winter conditions considered. The values of loads are for each wall. The heat load is calculated as the product of the external wall factor and the wind speed, and the air temperature.

Wind Speed: 6 m/s
Air Temperature: 30°C

Figure 9: Outside weather conditions for summer and winter

For the current study, the supply air temperature for summer is set to 13°C, while it is set to 30°C for winter conditions.
App Validation

“Benchmark Test for a Computer Simulated Person – Manikin Heat Loss for Thermal Comfort Evaluation”
- Hakan O. Nilsson, Henrik Brohus and Peter V. Nielsen, 2007 Aalborg University
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AHC Future Plans

- Revit file support
- 3D BIM model from 2D floor plan drawing
- Building the Air diffuser manufacturers co-marketing space to add BIM components of product library
- Build the large public space templates such as Airports, Auditorium, Indoor stadium.
- Develop new Air quality indices – CO₂ concentration, Contaminant, Odor tracking, ADPI
Signup for private beta

https://www.simulationhub.com/autonomous-hvac-cfd-private-beta