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Automated Engineering Drawing Generation for Cooling Tower Support Frames Based on Parametric Design

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Abstract: Cooling towers are key components of industrial circulating-water systems, where heat and mass transfer between air and circulating water is employed to reduce the water temperature and thereby ensure the stable operation of industrial processes. As an important internal structural component of a cooling tower, the support structure is responsible for supporting structural members, transferring loads, and maintaining the stability of the overall arrangement. Cooling tower support structures are typically characterized by a large number of regularly arranged members, strong interdependence among dimensional parameters, and a substantial amount of repetitive work in engineering drawing preparation. Conventional manual drafting therefore suffers from low efficiency, labor-intensive dimensioning, and a high dependence on designers' experience for ensuring drawing standardization. Moreover, existing studies on automated dimensioning have not provided a practical solution specifically for the generation and dimensioning of cooling tower engineering drawings.

To address these issues, this study investigates the support structure of cooling towers and proposes a method for the automated generation of engineering drawings based on parametric design and SolidWorks API-based secondary development. First, the structural characteristics of the cooling tower support structure and its engineering drawing requirements are analyzed, and the relationships between structural parameters and drawing views, view scales, and dimension positions are established. Subsequently, a series of methods, including engineering drawing template invocation, bounding-box-based positioning, adaptive view scaling, coordinate transformation, automated dimensioning, and automatic completion of drawing information tables, are developed to enable rapid generation of engineering drawings. Finally, an application example section is reserved for subsequent validation of the proposed method using specific engineering models. The proposed approach can reduce repetitive operations in the preparation of engineering drawings for cooling tower support structures while improving drawing generation efficiency and the level of drawing standardization.

Keywords: Cooling Tower; Supporting Layer; Parametric Design; Automatic Generation of Engineering Drawing; Solidworks Secondary Development

1. Introduction

Cooling towers are widely used in industrial circulating-water systems in the electric-power, chemical-engineering, metallurgical, air-conditioning, and refrigeration industries. Their internal structures generally include water-distribution systems, fill systems, drift eliminators, support frames, and foundation components. Among these elements, the cooling tower support frame provides installation support for internal components and performs important functions in load transfer, spatial positioning, and structural stabilization. Its engineering drawings must clearly express member positions, bay dimensions, overall dimensions, component identifiers, and relevant technical requirements.

With the development of three-dimensional

CAD technology, cooling tower support-frame design has gradually shifted from traditional two-dimensional drafting to parametric three-dimensional modeling. Although three-dimensional models can intuitively represent structural forms and assembly relationships, two-dimensional engineering drawings remain essential documents for fabrication, construction, inspection, and technical communication. In current workflows, designers generally create drawing views, determine drawing scales, arrange dimensions, add member identifiers, and complete title-block information manually. When parameters such as the number of rows and columns, bay dimensions, or tower type change, the drawing must be readjusted, resulting in repetitive work and possible problems such as omitted dimensions, annotation overlap, inconsistent scales, and unreasonable layouts.

Considerable research has been conducted on automated engineering drawing generation and dimensioning. Huang et al. [1] developed an automatic dimensioning system for calibrator drawings based on UG NX, integrating drawing templates, feature extraction, redundant-edge removal, dimension generation, and annotation layout. Li and Yang [2] proposed a curve-chain-based method that reconstructed the topological relationships among drawing elements, distinguished absolute and relative dimensions, removed redundant dimensions, and optimized annotation positions. Gutai et al. [3] used SolidWorks API macros to automate drawing views, dimensions, annotations, formats, and file export. Jarvinen et al. [4] investigated the automatic generation of dimension and tolerance information for mating components, while Jin et al. [5] demonstrated the automatic generation of three-dimensional models and two-dimensional drawings from measured engineering parameters. SolidWorks secondary development has also been applied to parametric modeling, automated assembly, and integrated engineering analysis. Fan et al. [6] developed a network-based visual customization system that automatically generated assembly models and eDrawings files. Esanakula et al. [7] combined knowledge-based engineering, parametric modeling, VBA, and SolidWorks macros to automate universal-coupling modeling. Cinar et al. [8] integrated the SolidWorks API with a C# application to support parametric model generation, finite-element simulation, and structural optimization. These studies demonstrate that CAD APIs can effectively reduce repetitive design operations and improve model consistency.

Recent research has further extended engineering drawing automation toward intelligent recognition and semantic association. Toro and Tarkian [9] combined image processing, OCR, and vision-language models to extract dimensions, information blocks, and feature-control frames from mechanical drawings. Zong et al. [10] developed a hybrid method for recognizing dimensional tolerances, geometric tolerances, surface roughness, and other product manufacturing information. Khan et al. [11] proposed a context-aware framework for mapping two-dimensional drawing annotations to corresponding three-dimensional CAD features, supporting traceable drawing–model associations.

Existing studies have achieved progress in template invocation, view creation, automatic dimensioning, annotation layout, parametric modeling, and drawing-information processing. However, relatively little attention has been given to cooling tower support frames, which are characterized by regular grid structures, strongly correlated parameters, repeated members, and highly repetitive dimension chains. Therefore, this study develops an automated engineering drawing generation method for cooling tower support frames based on parametric design and SolidWorks secondary development. The proposed method integrates model-information extraction, drawing-template invocation, view generation, adaptive scale and position calculation, dimension generation, annotation layout, member-number generation, title-block completion, and drawing output. The objective is to reduce repetitive manual work and improve the efficiency, consistency, and completeness of cooling tower support-frame engineering drawings.

2. Structural Characteristics of Cooling Tower Support Frames and Requirements for Automated Engineering Drawing Generation

2.1 Structural Characteristics of Cooling Tower Support Frames

Cooling tower support frames are generally arranged inside the tower body or above the foundation structure, and are mainly used to support upper structures, fill systems, or related equipment components. In plan view, the support frame is generally arranged as a regular grid consisting of transverse members, longitudinal members, support points, column footings, or connecting components. Its structural dimensions are jointly determined by parameters such as the number of cooling towers, the width of a single tower, support bay dimensions, the numbers of rows and columns, edge offsets, and the overall length.

From the perspective of parametric design, a cooling tower support frame has the following characteristics. First, the structural arrangement is regular. Members are generally arranged at specified intervals in the horizontal and vertical directions, and the overall structure is rectangular or array-like, making it suitable for parameter-controlled generation. Second, the dimensional relationships are strong. The overall dimensions of the support frame are closely related to the number of towers, the horizontal and vertical bay counts, the bay dimensions, and the edge offsets. When one parameter changes, member positions and engineering drawing dimensions must be updated simultaneously. Third, engineering drawing annotations are highly repetitive. A support-frame engineering drawing must show adjacent bay dimensions, single-tower dimensions, overall dimensions, member identifiers, and directional identifiers. Although many objects must be annotated, their arrangement has an evident pattern. The position of the support frame within a cooling tower is shown in Figure 1.

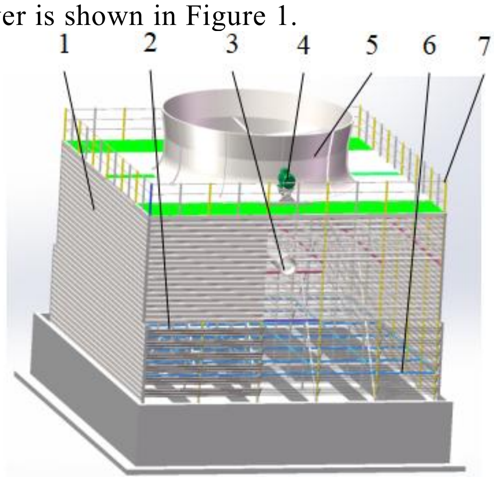

Figure 1. Three-Dimensional Structural Diagram of a Cooling Tower

In Figure 1, 1 denotes the panel, 2 the louver panel, 3 the water inlet, 4 the fan, 5 the fan stack, 6 the cooling tower support frame, and 7 the guardrail.

2.2 Requirements for Automated Engineering Drawing Generation of Cooling Tower Support Frames

An engineering drawing is an important technical document for expressing the structural dimensions, member positions, and fabrication and construction requirements of a cooling tower support frame. To satisfy design, checking, fabrication, and construction-communication requirements, automated engineering drawing generation for cooling tower support frames should meet the following requirements.

(1) Automatic invocation of the engineering drawing template. The system should select the corresponding engineering drawing template according to design requirements, automatically create the engineering drawing document, and retain standardized content such as the drawing frame, title block, and technical requirements.

(2) Automatic reading of the support-frame model. The system should read the three-dimensional support-frame model or assembly model selected by the user and determine whether the model has been opened successfully, thereby providing a data basis for subsequent view generation and dimension annotation.

(3) Automatic hiding of irrelevant components. For a complete cooling tower assembly, the system should identify components related to drawing generation, such as the support-frame assembly and column footings, and hide other irrelevant components to prevent interference in the engineering drawing view.

(4) Automatic generation of engineering drawing views. According to the structural characteristics of the support frame, the system should automatically create principal views, such as a top view or plan view, and should support view rotation, view positioning, and view-scale setting.

(5) Adaptive drawing scale. Support-frame dimensions change with tower type and design parameters. The system should automatically calculate an appropriate drawing scale according to the overall support-frame dimensions and the current sheet size, so that the engineering drawing view can be arranged reasonably within the

drawing frame.

(6) Automatic dimensioning and identification. According to parametric points, the system should automatically generate horizontal dimensions, vertical dimensions, single-tower dimensions, overall dimensions, numeric identifiers, and alphabetic identifiers, while maintaining a clear annotation hierarchy.

2.3 Overall Framework of the Automated Drawing Generation System

Considering the regular structure, strong parameter relationships, and high annotation repetition of cooling tower support frames, the automated engineering drawing generation system proposed in this study adopts the overall process of model reading, component filtering, template invocation, view generation, scale calculation, coordinate positioning, dimension annotation, and identifier generation.

First, the system uses human-computer interaction to select the three-dimensional cooling tower support-frame model file and calls the SolidWorks application interface to open the model. It then creates a model bounding box and traverses the assembly components, retaining relevant components such as the support-frame assembly and column footings while hiding other irrelevant components. After model preprocessing, the system selects an engineering drawing template, creates an engineering drawing document, and generates a drawing view in the specified direction. The system then reads the current sheet size, calculates the drawing scale according to the overall support-frame dimensions and the sheet format, and sets the view to follow the sheet scale. Finally, the system determines the reference position of the view on the sheet using bounding-box points and coordinate transformation, and automatically generates dimensions and identifier annotations. The overall process is shown in Figure 2.

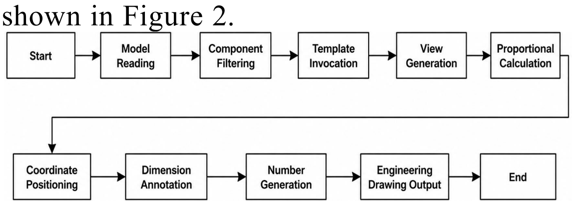

Figure 2. Overall Workflow of the Automated Engineering Drawing Generation System

3. Key Techniques for Parametric-Model-Based Automated Engineering Drawing Generation of Cooling Tower Support Frames

3.1 Parametric Support Frame Model and Component Filtering

The basis of automated engineering drawing generation for a cooling tower support frame is a parametric three-dimensional model. Parameters such as the horizontal bay count, vertical bay count, number of towers, member spacing, edge offsets, and overall dimensions directly determine the dimension annotations in the engineering drawing. Therefore, the system design must establish a correspondence between structural parameters and engineering drawing annotation objects.

In a complete cooling tower assembly model, the support frame is generally not the only component. To prevent irrelevant components from appearing in the engineering drawing, the system identifies components according to component names and assembly hierarchy. The top-level components returned by GetComponents(True) are traversed, and GetChildren() is used to descend into matching subassemblies. Objects whose names contain configured keywords corresponding to the skeleton assembly, support-frame assembly, and column footings are identified. Because the installation position of the support frame within the cooling tower must be illustrated, the column footings are retained; therefore, the support-frame subassembly cannot simply be opened in isolation. Components related to support-frame drawing generation are set to the visible state, while the remaining components are hidden. This method simplifies the engineering drawing view and reduces interference from irrelevant edges and components during dimension annotation. The detailed filtering procedure is shown in Figure 3, and the resulting support-frame structure after irrelevant components are hidden is shown in Figure 4.

The principal parameters of the cooling tower support frame and their functions in the engineering drawing are summarized in Table 1.

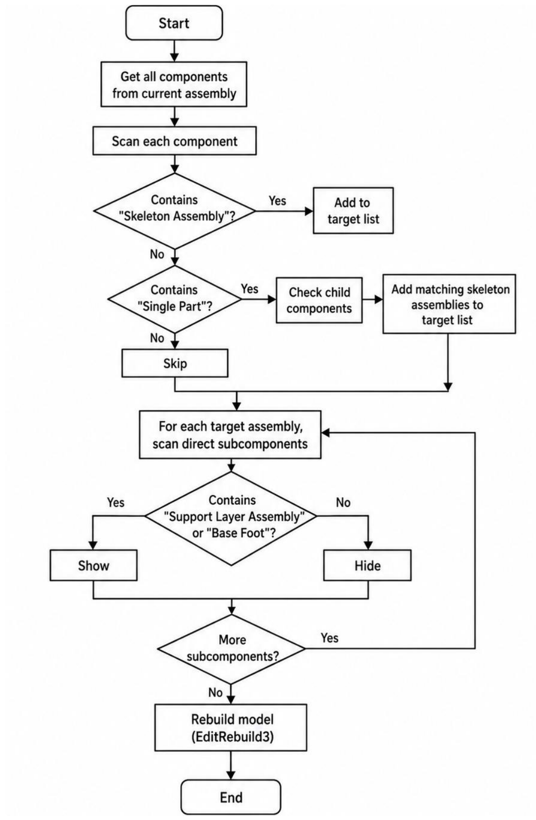

Figure 3. Workflow for Hiding Irrelevant Components in a Cooling Tower

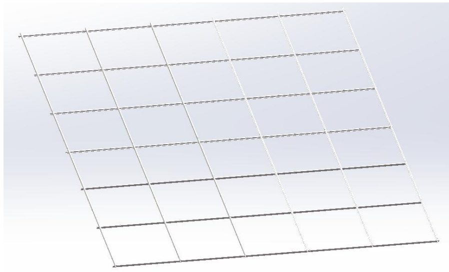

Figure 4. Three-Dimensional Support-Frame Structure After Irrelevant Components Are Hidden

3.2 Drawing Template Loading and Automated View Generation

The engineering drawing template is an important basis for ensuring drawing standardization. Engineering drawings of cooling tower support frames generally require uniform drawing frames, title blocks, scale fields, technical requirements, and drafting standards. The system creates a new engineering drawing document by selecting an engineering drawing template file, enabling different support-frame models to generate engineering drawings using a unified template.

Table 1. Principal Parameters of a Cooling Tower Support Frame

Parameter Type	Meaning	Function in the Engineering Drawing
Bay-Count Parameters	Horizontal and vertical bay counts, indicating the number of grid divisions in the two directions.	Control the number of horizontal and vertical segmented-dimension annotations.
Bay-Dimension Parameters	Horizontal and vertical bay dimensions, indicating the distance between adjacent reference points.	Generate the dimension for each bay and determine dimension-line spacing.
Single-Tower Parameters	Numbers of cooling-tower units in the longitudinal or transverse direction and the range covered by one tower.	Generate single-tower range dimensions and distinguish dimensional regions corresponding to different towers.
Edge-Offset Parameters(M/N)	Distance between the support-frame boundary and the concrete foundation boundary of the cooling tower.	Determine the view reference point, dimension origin, and annotation position.
Overall-Dimension Parameters	Overall length and width of the support frame.	Generate overall dimensions to express the external outline of the support frame.

For view generation, the system preferentially generates a top view or plan view according to the principal expression requirements of the support frame. For a support frame with evident planar arrangement characteristics, the top view can more completely express the transverse and longitudinal member arrangement, grid dimensions, and identifiers. After the view is generated, the system automatically selects and activates the engineering drawing view, providing an object for subsequent scale setting, coordinate transformation, and dimension annotation.

The process of loading the engineering drawing template and automatically generating a view is as follows: select the three-dimensional cooling tower support-frame model file; open the three-dimensional model and check the model-reading status; select the engineering drawing template file; create a new engineering drawing document from the template; create the principal support-frame view at a specified sheet position; and activate the engineering drawing view before entering the subsequent annotation process.

3.3 Bounding Box Construction and Adaptive Drawing Scale Determination

Because the dimensions of different cooling tower support frames vary considerably, using a fixed scale may cause the view to be too large and extend beyond the drawing frame, or too small to provide sufficient annotation space. Therefore, adaptive drawing-scale determination is one of the key techniques in automated engineering drawing generation.

This study creates a model bounding box to obtain the overall extent of the support frame and calculates an appropriate drawing scale in combination with the current engineering drawing sheet format. The system first reads the sheet width and height and converts them to millimetres. It then identifies the sheet format from the longer edge, such as A0, A1, A2, A3, or A4. Finally, the system calculates the drawing scale according to the overall support-frame dimensions and a scale coefficient, so that the support-frame view can be arranged reasonably within the sheet.

The theoretical external dimensions of the support frame in the planar directions can be expressed as follows:

$$Lx = A \times K1 + 2N \quad (1)$$

$$Ly = B \times K2 + 2M \quad (2)$$

where A and B are the bay counts in the two directions, K1 and K2 are the corresponding bay dimensions, and M and N are the edge-offset parameters. The engineering drawing scale can be determined according to the relationship between the maximum external support-frame dimension and the effective drawing area. Through adaptive drawing-scale determination, the system avoids repeated manual adjustment of the view scale and improves the degree of automation in engineering drawing generation.

3.4 Reference Point Positioning Based on Coordinate Transformation

For automatic dimensioning in an engineering drawing, the positions of model points in the sheet coordinate system must be determined accurately. Because the three-dimensional model coordinate system, view coordinate system, and sheet coordinate system are not completely identical, directly using model coordinates for annotation may cause dimension-position offsets. Therefore, a transformation relationship from model coordinates to sheet coordinates must be established.

As shown in Figure 5, the coordinate calculation and key-point creation process mainly consists of two stages. In the coordinate-calculation stage, the program traverses engineering drawing views 1 to 3, selects the eight characteristic points of the bounding box in each view, determines the minimum reference point in model space, and transforms it from model coordinates to sheet coordinates, thereby obtaining the minimum sheet coordinate for each view. In the key-point creation stage, the program obtains the centre coordinates of the frame of view 1 and calculates the dimension-reference position (X, Y) in combination with the minimum-point coordinates. On this basis, annotation points are created according to the spacing requirements in the horizontal and vertical directions, producing the horizontal point sequence SpPoint and the vertical point sequence SzPoint for subsequent dimension generation and position arrangement.

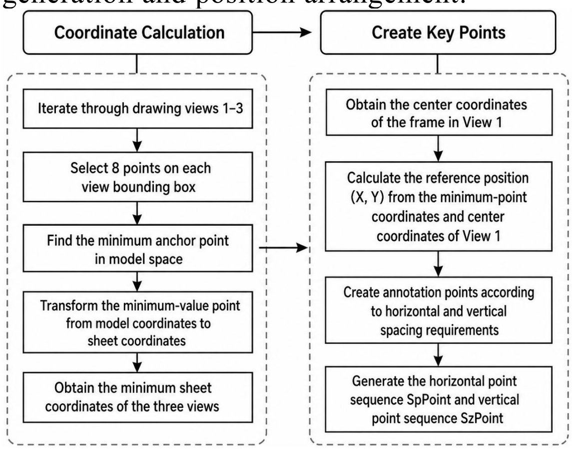

Figure 5. Reference-Point Positioning Workflow

3.5 Automatic Dimensioning

3.5.1 Dimensioning Scheme for Cooling Tower Support Frames

As shown in Figure 6, the dimensions in a cooling tower support-frame engineering drawing mainly include the dimension of each bay in the horizontal direction (X1-Xn), the dimension of each bay in the vertical direction (Y1-Yn), the single-tower dimensions (horizontal: X; vertical: Y), and the overall dimensions, which depend on the numbers of cooling towers in the horizontal and vertical directions. Because the support frame has a regular grid arrangement, the system can automatically generate annotation objects according to parametric points.

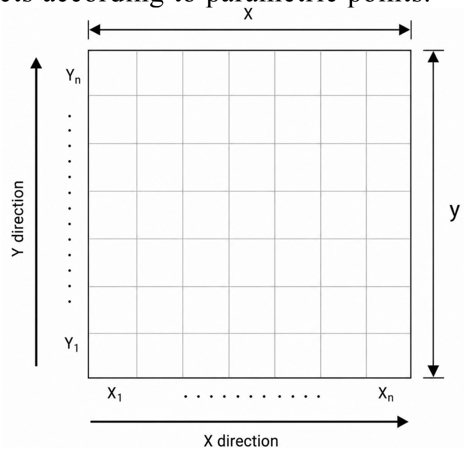

Figure 6. Dimensioning Scheme for a Cooling Tower Support Frame

3.5.2 Automatic Dimensioning Workflow

As shown in Figure 7, the dimension-generation and position-arrangement process mainly consists of two stages. In the dimension-generation stage, the program dimensions adjacent horizontal and vertical key points created previously, and generates single-tower interval dimensions according to the structural grouping of the cooling tower support frame. At the same time, the first and last key points in the corresponding direction are selected to generate the overall horizontal and vertical dimensions, thereby completely expressing the local and overall dimensional relationships of the support frame. In the position-arrangement stage, the program uses the minimum view coordinate as the reference position and determines the positions of different dimension lines and key points on the sheet by combining edge-offset parameters N and M with horizontal bay dimension K1 and vertical bay dimension K2. The dimension annotations are then arranged sequentially at the calculated positions to ensure that the results are clear, orderly, and free from overlap.

3.6 Automatic Generation of Alphanumeric Annotations

In addition to dimension annotation, engineering drawings of cooling tower support frames generally require identifiers for member positions, grid lines, or support points. After the principal dimensions have been generated, the system can automatically insert identifier annotations according to the parametric points.

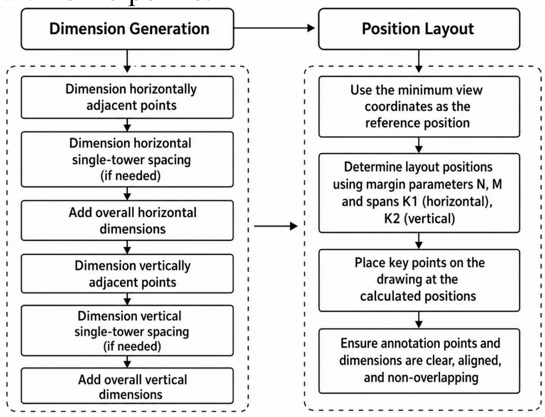

Figure 7. Automatic Dimensioning Workflow

The identifiers mainly include numeric and alphabetic forms. Numeric identifiers are generally used for grid or member positions in one direction, while alphabetic identifiers are used in the other direction. The system traverses the previously created reference points, inserts identifier annotations in sequence, and sets the leader style, arrowhead style, and annotation position. To compensate for differences in text width when the number of digits changes, the system applies different offsets, thereby making the identifier positions more orderly.

The automatic identifier-generation process is as follows: select the parametric points to be identified; generate a numeric or alphabetic identifier according to the point sequence; insert an annotation object and set its balloon style; set the leader and arrowhead form; adjust the identifier position according to the view scale and offset; and refresh the engineering drawing view after all identifiers have been completed. Automatic generation of identifier annotations reduces the repetitive operation of manually adding identifiers one by one and improves the drafting efficiency of support-frame engineering drawings.

3.7 Automatic Population of Drawing Information Tables from Excel Data

After annotation has been completed, the program reads an external Excel file and opens the required worksheet as the data source. Data from the corresponding Excel cells are then automatically written to the corresponding positions in the engineering drawing information table. Units can be appended automatically as required. If certain data must be calculated, the calculated results can be written to the engineering drawing table. This method reduces manual data-entry work and improves the accuracy and consistency of engineering drawing information.

3.8 Key SolidWorks API Methods and Functions for Automated Engineering Drawing Generation

The principal SolidWorks secondary-development methods and functions used by the system are listed in Table 2.

Table 2. Principal Methods and Functions for Automated Engineering Drawing Generation

Method or Interface Name	Function
CreateDefinition(swFmBoundingBox)	Creates the model bounding-box definition.
CreateFeature	Generates the bounding-box feature in the model.
GetComponents	Obtains the component objects in the assembly.
GetChildren	Obtains the child components of a specified assembly component.
CreateDrawViewFromModelView3	Creates an engineering drawing view from a three-dimensional model view.
GetCurrentSheet	Obtains the current engineering drawing sheet.
GetSize	Obtains the dimensions of the current sheet.
SetScale	Sets the engineering drawing sheet scale.
UseSheetScale	Makes the engineering drawing view follow the sheet scale.
ModelToViewTransform	Obtains the transformation from model coordinates to view coordinates.
CreatePoint	Creates a parametric dimension reference point.
AddDimension2	Creates an engineering drawing dimension.
InsertNote	Inserts an engineering drawing note or identifier.
SetBalloon	Sets the identifier balloon style.
SetPosition	Sets the position of the annotation on the sheet.

3.8.1 Core Functional Pseudocode

The main procedure is summarized in Algorithm 1.

Algorithm 1. Automated Engineering Drawing Generation for a Cooling Tower Support Frame

```
Input: modelPath, templatePath, A, B, K1, K2, M, N
Output: generated engineering drawing
1  Open the assembly model and create its bounding box.
2  Traverse the assembly; retain the support frame and column footings, and hide other components.
3  Create a drawing from the template and generate the required plan view.
4  Read the sheet size, calculate the scale denominator, and apply the sheet scale.
5  Transform the bounding-box reference point from model coordinates to drawing coordinates.
6  Create horizontal and vertical reference-point arrays.
7  Generate bay, single-tower, and overall dimensions from the reference points.
8  Rotate the view when required, update the coordinates, insert identifiers, and rebuild the drawing.
```

3.8.2 Representative VB.NET Implementation Fragments

Representative VB.NET fragments are given below.

Listing 1. Bounding-Box Creation and Component Filtering

```
Dim featMgr As FeatureManager = swModel.FeatureManager
Dim boxData = DirectCast(featMgr.CreateDefinition(
   swFeatureNameID_e.swFmBoundingBox), BoundingBoxFeatureData)
boxData.IncludeHiddenBodies = False : boxData.IncludeSurfaces = False
featMgr.CreateFeature(boxData)

For Each comp As Component2 In swAssy.GetComponents(True)
   Dim targets As New List(Of Component2)
   If comp.Name2.Contains(SkeletonAssemblyKey) Then targets.Add(comp)
   If comp.Name2.Contains(SingleRowTowerKey)
```

```
Then
    For Each child As Component2 In comp.GetChildren()
        If child.Name2.Contains(SkeletonAssemblyKey) Then targets.Add(child)
    Next
  End If
  For Each target As Component2 In targets
    For Each child As Component2 In target.GetChildren()
        Dim keep = child.Name2.Contains(SupportFrameAssemblyKey) OrElse

child.Name2.Contains(ColumnFootingKey)
        child.Visible = If(keep, swComponentVisible, swComponentHidden)
    Next
  Next
Next
swModel.EditRebuild3()
```

Listing 2. Drawing Creation and Adaptive Scale Setting

```
Dim drawModel = DirectCast(swApp.NewDocument(
  templatePath, 9, 0.42, 0.297), ModelDoc2)
Dim swDraw = DirectCast(drawModel, DrawingDoc)
Dim swView = swDraw.CreateDrawViewFromModelView3(
  modelPath, TopViewName, 0.30, 0.20, 0.0)
Dim sheet = swDraw.GetCurrentSheet()
Dim width As Double, height As Double
sheet.GetSize(width, height)
Dim denominator = Math.Max(1, CInt(Math.Truncate(
  (2 * M + A * K1) * 1.8 / width)))
sheet.SetScale(1, denominator, False, False)
swView.UseSheetScale = True
```

Listing 3. Coordinate Transformation and Automatic Dimensioning

```
Dim mathUtil = swApp.GetMathUtility()
Dim modelPt = mathUtil.CreatePoint(
  New Double() {minXModel, minYModel, minZModel})
Dim sheetPt = modelPt.MultiplyTransform(swView.ModelToViewTransform)
Dim xy() As Double = DirectCast(sheetPt.ArrayData, Double())

ReDim SpPoint(0 To A)
For i As Integer = 0 To A
  SpPoint(i) = swModel.SketchManager.CreatePoint(
    X + N, Y - M - i * K1, 0.0)
Next
For i As Integer = 1 To A
  SpPoint(i - 1).Select4(False, Nothing)
  SpPoint(i).Select4(True, Nothing)
  swModel.AddDimension2(xy(0) - 0.006,
    xy(1) - M / denominator -
    (2 * i - 1) * K1 / (2 * denominator), 0.0)
Next
```

4. Case Study

4.1 Case Study Model and Parameters

This study will subsequently use a cooling tower support-frame model as an example to verify the proposed automated engineering drawing generation method. The example model should include the three-dimensional support-frame model, engineering drawing template, principal structural parameters, Excel table, and drawing-generation requirements. Figure 8 shows the complete cooling tower model used in the example, while Figure 9 shows the cooling tower support frame after irrelevant components are hidden. The example parameters are listed in Table 3.

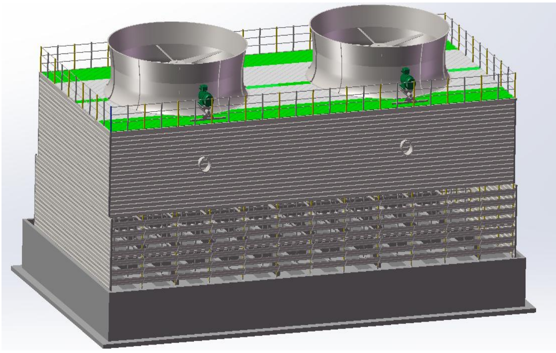

Figure 8. Three-Dimensional Model of a Cooling Tower

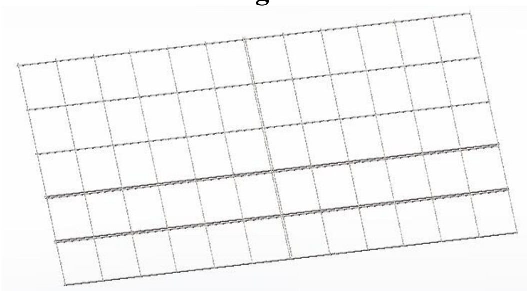

Figure 9. Three-Dimensional Cooling Tower Support-Frame Model After Irrelevant Components Are Hidden

Table 3. Example Parameters of the Cooling Tower Support Frame

Parameter	Value	Description
Horizontal Edge Offset / mm	950	Horizontal distance between the support-frame boundary and the tower body.
Vertical Edge Offset / mm	1900	Vertical distance between the support-frame boundary and the tower body.
Number of Cooling Towers	2	Number of cooling towers in the horizontal direction.
Horizontal Bay Count	6	Horizontal bay count for one cooling tower.
Vertical Bay Count	5	Vertical bay count for one cooling tower.
Horizontal Bay Dimension / mm	2100	Length of one horizontal bay.
Vertical Bay Dimension / mm	2400	Length of one vertical bay.
Overall Support-Frame Length / mm	25200	Overall horizontal length of the support frame(2 x 6 x 2100).
Overall Support-Frame Width / mm	12000	Overall vertical length of the support frame (5 x 2400).
Engineering Drawing Format	A2	Selected according to the overall support-frame length.
Drawing Scale	1:82	Selected according to the sheet and overall support-frame length.

4.2 Results of Automated Engineering Drawing Generation

As shown in Figure 10, the cooling tower support-frame engineering drawing is generated automatically. A support-frame engineering drawing template from a company is selected. The upper-right corner of the engineering drawing contains a schematic diagram of the connector installation method. The information entered in the information table is illustrative and can be read from an Excel table according to the actual content. The drawing scale and view position are appropriate, the dimension annotations are clear and do not interfere with one another, and the serial-number annotations are accurate. The result basically satisfies the company requirements for cooling tower support-frame engineering drawings.

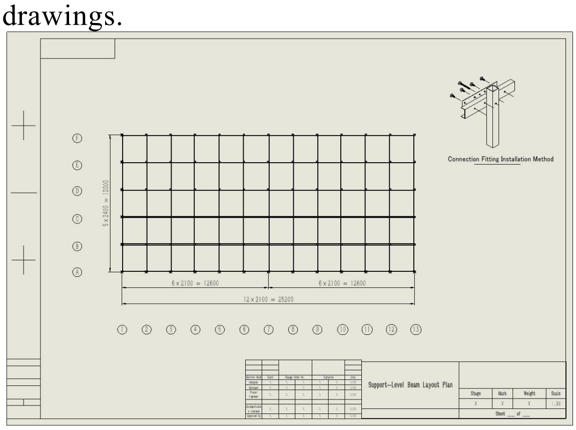

Figure 10. Automatically Generated Engineering Drawing of the Cooling Tower Support Frame

5. Conclusions and Future Work

To address the large number of repetitive operations, cumbersome dimension annotation, low drawing-scale adjustment efficiency, and dependence of drawing standardization on manual experience in the preparation of cooling tower support-frame engineering drawings, this study proposes an automated engineering drawing generation method based on parametric design. By analyzing the structural characteristics of cooling tower support frames, a correspondence between structural parameters and engineering drawing dimension annotations is established. Through SolidWorks secondary-development technology, the functions of support-frame model reading, bounding-box creation, relevant-component filtering, engineering drawing template invocation, automated view generation, adaptive drawing-scale determination, coordinate transformation, automatic dimensioning, automatic identifier generation, and automatic population of engineering drawing information tables are realized.

The method makes full use of the regular arrangement and strong dimensional-parameter relationships of cooling tower support frames. It can effectively reduce repetitive operations such as manually creating views, adjusting scales, annotating dimensions, and adding identifiers, thereby improving engineering drawing generation efficiency and drawing standardization. The use of engineering drawing templates also helps unify the drawing format, title block, and technical requirements, and provides a basis for standardizing the design process of cooling tower support frames.

However, the study still has certain limitations. First, the current method mainly applies to cooling tower support-frame models with specific naming rules and structural forms, and its general applicability to other types of support structures requires further improvement. Second, automatic dimensioning and identifier layout mainly rely on fixed offsets and rule-based arrangement. In complex structures or when sheet space is limited, local interference may still occur between dimension lines, identifiers, and model outlines. Finally, the case-study section still requires further verification using specific engineering models.

Future research can be conducted in the following areas. First, the support-frame feature-recognition method can be further improved to enhance adaptability to models with different assembly levels and naming methods. Second, dimension-annotation interference detection and automatic avoidance algorithms can be introduced to improve engineering drawing layout quality. Third, batch engineering drawing generation and automatic saving functions can be extended to realize rapid drawing generation for multiple tower types and multiple parameter schemes. Fourth, in combination with corporate drawing standards and design specifications, the title block, parts list, technical requirements, and member-identification rules can be further improved to increase the engineering application value of the system.

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