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Design Automation for IC Engine Cooling System using Application Programming Interface

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***Abstract*—These In recent years, the intense competition in development of new products followed by their rapid prototyping has given rise to an intense competition in the market. In order to automate the design, development of Application Programming Interface (API) is most commonly followed method. The presented work showcases an attempt to develop an API for calculation of area of Heat Exchanger required for an IC Engine. The sAPI has been developed using two commonly used coding languages – HTML (Hypertext Markup Language) and Java script. The HTML along with the integration of CSS is used to develop the user interface and the mathematical formulae have been formatted into the Java script. The API is focused towards understanding the combined effect of various parameters in a heat transfer system.**

Keywords—Design Automation, API, IC Engine, Heat Transfer, HTML, Java script

I. Introduction

With a significant increase in use of programming languages, the organization's belief of mass customization is increasing proportionately. As a result, every application has distinctive user interface. An Application Programming Interface (API) can be defined as a set of rules or protocols for communication between two devices or computer programs. The API is focussed on connecting the computer programs or its pieces together. While designing new products or tools, the API provide flexibility, easy administration and a simplified design. This helps in saving time and money. The API can be used to leverage data between two software through a documented interface. Majority of the API that share the data over the internet can be known as Web-APIs which are further divided into four different types – Open APIs, Internal APIs, Partner APIs and Composite APIs. The Open APIs can be accessed by anyone through a secure internet connection i.e., with the HTTP protocol. In other words, they are also known as public APIs. Internal APIs are developed by organization such that only a few certified persons have the access to the same. It can be used for data transmission or sharing of secure information within a specified domain. The second most widely used API are the Partner APIs. They have generally been developed as a collaboration between two or more organization and anyone who wishes to access the service, has to a pay a certain amount to get valid login credentials. Composite APIs have been developed with an aim to merge multiple requests from the client into a single call for server. In the years use of API has increased significantly as stated and encapsulated by researchers [3-15]; out of which use of API has got wide scope in education sector of India which aims to enhance the abilities of fresher graduates to build a bridge between theory and practice [1]. The use of API has also been significantly increases in the process of design automation In today's world of delivering customized product to the users, design automation helps to speed up the process of designing by reducing the time consuming and iterative

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steps. Design automation is smarter way of completing the design and manufacturing of a customized product. Design automation can be defined as automatic completion of a design by using a software or other available tools with an aim to design and deliver products at increased pace by eliminating manual work. By automation of repetitive and time sensitive activities, the time can be spared to increase more value to the product by focussing on innovation aspect. The prospect of design automation has now increased not only in the field of design but also in the field of manufacturing. Manufacturing automation can be termed as replacement of human activities by computerised systems for handling of machinery in case of repetitive or labour-intensive tasks. Depending on the type of product to be delivered and the factors affecting the delivery, manufacturing automation can be classified into 4 types - Fixed automation, Programmable automation, Flexible automation and Integrated automation.

II. Development of API

Various methodologies for customization and automation of design process [1] such as API, KNOMAD and DDE have been described by the researcher but the most commonly used is API due to its easy implementation and understandability. Detailed research followed by a brain storming session to design the structure of the application, it was decided to use HTML and Java script as the two coding languages. The HTML allowed a very clean coding for creation of the GUI. As HTML supports various types of media elements, it avoids the any use of external plugins and enhancing overall user experience. The HTML is majorly used for creation of websites which can be viewed by anyone who has the access to the internet. With the help of CSS, the GUI was made interactive such as creative background textures, various font sizes, etcetera which is shown in fig. 1 . The major aim in developing of the GUI was to provide user with all the necessary information at their convenience such as a table which contains all the values of standard parameters for example dynamic viscosity of fluid, Prandtl number, etcetera as shown in fig. 2. The Java script was used as language to perform all the mathematical functions of the API. The speed and simplicity of Java script makes it a go to language. The most important part of the API was to encrypt the data within a defined space so that the text doesn't get scattered and make it difficult for user to interpret. Hence, a table is being created to hold the values and the text, that can be readable and understandable as presentation of a clean GUI in an API is necessary.

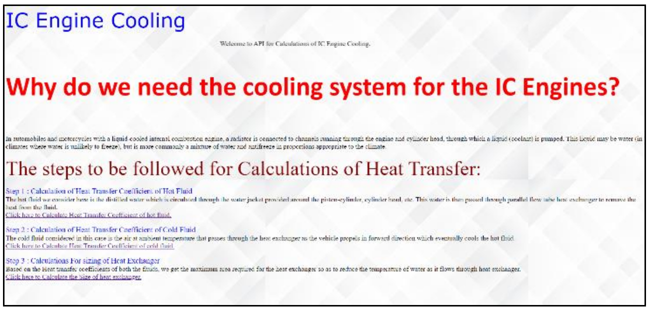

Figure 1: API Structure (1)

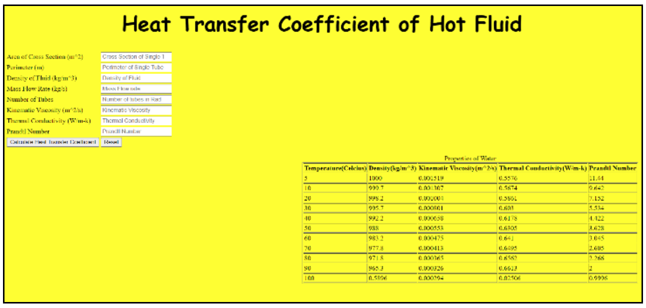

Figure 2: API Structure (2)

The development of API was based on the basic standard procedures as prescribed in the manual and the literature available [16-17]. The API was divided into a series of steps with an aim to provide an in depth understanding of the underlying calculations for the user. The first step was to give the user a brief introduction of IC engine cooling system and its need. The subsequent steps comprise of calculation of heat transfer coefficient of Hot fluid i.e. the water that is being circulated around combustion chamber, calculation of heat transfer coefficient of cold fluid i.e. the air which passes through the heat exchanger and the final step includes calculation of the area of heat exchanger required to dissipate the given amount of heat. The table I summarizes the standard equations used for scripting the API:

TABLE I
EQUATIONS USED FOR API SCRIPTING

Parameter	Symbol	Equation
Heat Transfer coeff. Of Hot Fluid	HT_w	$Ht_w = (nu*t) / dh$
Heat Transfer coeff. Of Cold Fluid	HT_c	$Ht_c = (nu*t) / dh$
Area of Heat Exchanger	A_{req}	$A_{req} = (NTU * C_{min}) / U$

The Flow chart of entire API development is shown in Fig.3.

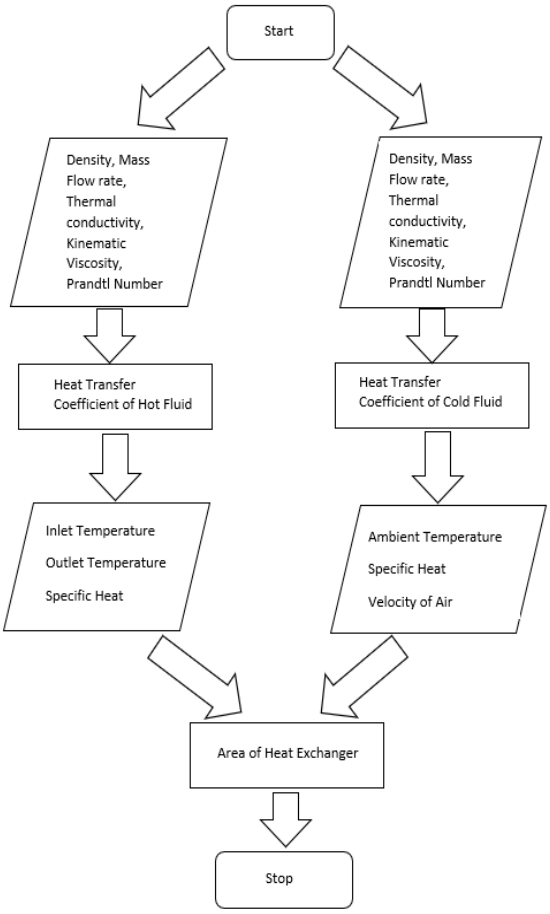

Figure 4: Flow chart of entire API development

III. Theoretical Case Studies

The theoretical relation as stated in reference book [23], 1/3rd of energy produced by an IC engine is useful or in other terms, the efficiency of an IC engine is approximately 33%. The remaining energy is dissipated in terms of heat and exhaust gases.

Following the NTU method, the required size of heat exchanger can be calculated for the dissipation of excess heat energy.

$$Ht = (nu*t) / dh \quad (1)$$

Where, Ht = Heat Transfer coefficient of fluid (W/m^2-k)

nu = Nusselt number

t= thermal conductivity (W/m-k)

dh = Hydraulic diameter (m)

The heat transfer coefficient for cold as well as hot fluid can be calculated using the same formulae as stated above.

The number of transfer units (NTU) can be calculated as,

$$NTU = \text{Log}\,[\,C \log(1 - E) + 1\,] / C \quad (2)$$

Where, NTU = Number of Transfer Units

C = Heat Capacity ratio of the fluids

E = Efficiency of Heat Exchanger

Thus, the total area of the heat exchanger can be determined by.

$$A = (NTU * C_{min}) / U \quad (3)$$

Where, A = Area of Heat Exchanger (m^2)

NTU = Number of Transfer Units

C_{min} = Minimum Heat capacity of fluid (J / K-s)

U = Overall heat transfer coefficient (W/ m^2-k)

The above relation was tested for the numerical where the results obtained through API were found to be exact. Hence, the API was validated successfully which is described in the subsequent subsections.

For the API testing, a sample problem statement was taken into consideration where the results obtained through the standard analytical method and with use of API have been compared in the table.

Sample Problem Statement: A single cylinder IC engine has a power output of 30 KW. The ideal temperature for working of the IC engine is 70°C. The temperature of the water which is to be used as coolant is 90°C near the piston cylinder. The vehicle is travelling at a constant speed of 14m/s. The water pump used has a constant mass flow rate of 0.224 kg/s and the ambient temperature is 30°C. All the other parameters can be referred for standard temperature condition of the fluids respectively.

TABLE II

COMPARISON OF THE RESULTS

Sr. no.	Comparison of Results		
	Parameter	***API result***	***Analytical result***
1	Overall Heat Transfer Coefficient	2248.49 W/m^2-K	2249.32 W/m^2-K
2	Normal transfer Units (NTU)	1.835	1.834
3	Area of Heat Exchanger	0.6186 m^2	0.6189 m^2
4	Factor of Safety	2.829	2.798

IV. Discussions

The result of sample problem that have been tabulated in the earlier section imply the successful validation of the API. The use of API not only provides accurate result but also reduce significant amount in terms of design calculation. This encourages the designer to have an iterative approach thus designing a better and efficient heat transfer system.

The time taken for number of iterations of calculation by changing a single parameter in each step have been tabulated in the table III.

Table III

Time taken for Calculation for Number of Parameters changed per iteration.

Sr. no.	Comparison of time		
	Number of Parameters Changed	***API***	***Analytical***
1	One per Iteration	25 sec	300 sec
2	Three per Iteration	40 sec	360 sec
3	Four per Iteration	53 sec	390 sec
4	Six per Iteration	80 sec	450 sec

V. CONCLUSION

Along with the reduction in time required, the use of API allows the user to operate through the GUI and understand the change in results by tweaking of each single parameter.

The API is proven to be an excellent tool used for design automation which can be further expanded to solve the live problems also.

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