AC 2009-2297: EXCEL IN ME: PACKAGING ADD-INS AND PROVIDING ON-LINE HELP

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Excel in ME: Packaging Add-ins and Providing Online Help

Abstract

Microsoft Excel is a ubiquitous software tool that provides an excellent electronic format for engineering computation and organization of information. This paper reports on the second year of an NSF CCLI Phase I project to implement a sequence of Excel modules for use in the Thermal Mechanical Engineering Curriculum.

Several modules were developed in the first year of the program including several for Heat Transfer. These modules have been integrated and significant online help modules developed to assist the user. Additional integration occurred in the second year of the NSF project with module development assisting in Energy Systems Design engineering calculations. The method for developing these modules mimicked the approach used in development of the Heat Transfer modules. Similar online help was developed for the Energy Systems Design modules. Details of the help compiler process, which are not widely documented, are described. Example problems illustrating sound engineering workbook solution techniques and access to the help files are given.

Introduction

In the mechanical engineering curriculum, consistent organization remains a key to successful teaching and learning. The mission of presenting students with the most straightforward and accommodating software learning environment requires great organization and tedious planning. These organization and support methods must also be readily available to offer optimal "user-friendliness." Although several Microsoft Excel-based modules for use in the mechanical engineering curriculum had been developed and made readily-available via download over the internet, a re-evaluation of the project status determined that a more consistent organization format was needed. Also, the ability to offer more assistance to the user beyond the user-defined function descriptions was clearly desired. Through discovery of many of the seemingly unlimited features in Microsoft Excel, it was determined that the developed macros could be easily rearranged. Also, internet research proved that a compiled help file could be created and applied to the Excel-based modules in order to offer more "user-help." In the interests of providing maximum classroom time for applying the learned material of the course, the previously developed Excel-based modules were rearranged and paired with compiled "user-help" files in turn allowing students to solve more complex problems in the thermal mechanical engineering curriculum.

Prior status of Modules

The prior organization of the developed modules resulted from the order in which they were created and subsequently tested in their "beta" phase. Since module development mostly occurred in conjunction with the teaching of a course, modules were created as separate entities for each specific topic in the course. As these modules developed individually, they were then made available to users enrolled in the courses where they could be evaluated for further development.

Prior Add-In Status

All developed modules were converted to Microsoft Excel Add-Ins[1]. The conversion of these developed modules into Add-Ins from within the Visual Basic (VB) editor requires the editor to save the Visual Basic code as a .xla (Office 2003) or .xlam (Office 2007) file extension[1]. With these files in the Add-In format, they could now be posted on-line and made available for download by students. A central location for accessing these Add-In files was needed. As a result, a project website[1] was created where each topic specific Add-In was posted on a page for the corresponding course along with a description of the Add-In's contents[1]. Figure 1 demonstrates the original website organization and Add-In tool distribution for the two courses, Heat Transfer and Energy Systems Design.
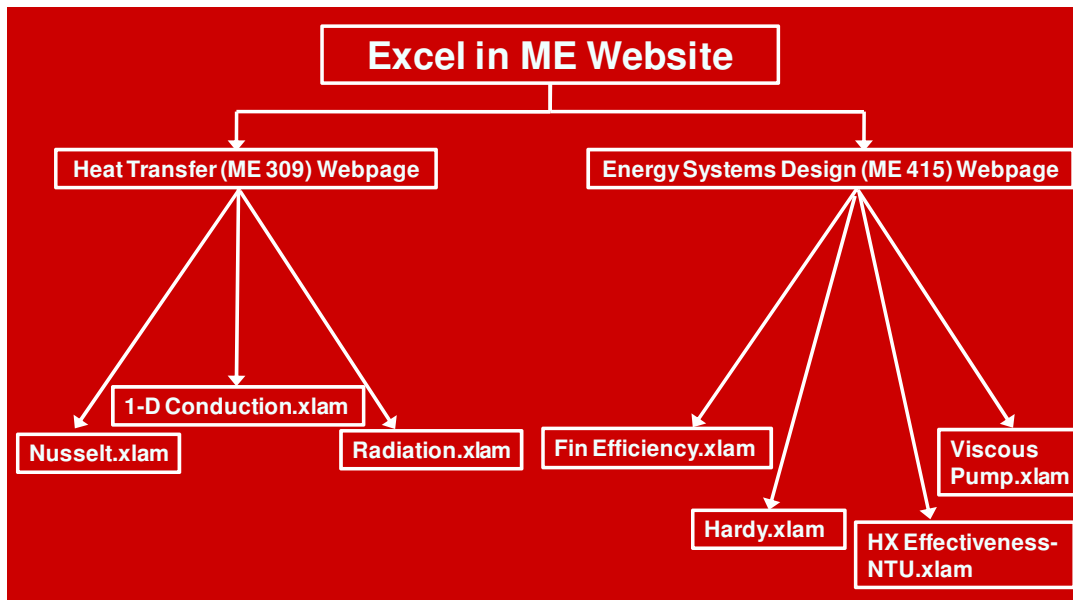
Figure 1 Original Excel in ME website organization

The Heat Transfer webpage offered the three individual Add-Ins shown above Nusselt.xlam, 1-D Conduction.xlam, and Radiation.xlam. The Nusselt Add-In contained nine functions for calculating Nusselt numbers according to the correlations given in the heat transfer text[5]. The 1-D Conduction Add-In contained six functions for transient heat conduction solutions, and the Radiation Add-In included five functions important for solving radiation heat transfer problems. The correlations used for the 1-D Conduction and Radiation Add-Ins were also taken from the heat transfer text mentioned above.

The Energy Systems Design webpage offered the four individual Add-Ins Fin Efficiency.xlam, Hardy.xlam, HX Effectivness-NTU.xlam, and Viscous Pump.xlam all seen above in Figure 1. The Fin Efficiency Add-In, containing efficiency calculators for six different types of fins, was developed from a spreadsheet and equations given in the heat transfer[5] and energy systems design[7] text. The HX Effectiveness-NTU Add-In included effectiveness-NTU relations for eight different heat exchanger types and was also developed from both the heat transfer and energy systems design course books. The Hardy Add-In supplied functions for calculating values of flow and head loss in piping systems using Hardy-Cross and Darcy-Weisbach relationships given

in the energy systems design course manual referenced above. Finally, the Viscous Pump Add-In provided two different functions for calculating corrected pump curved data for high viscosity fluids. This Add-In utilized a relationship provided in the energy systems design text.

With this website structure, each new topic covered in the course required users to visit the on-line site and download the matching Add-In for that problem type. For example, a student needing to solve a radiation heat transfer problem would have to visit the website in order to download and install the appropriate Radiation Add In or *Radiation.xlam* file. This organization is perhaps beneficial to the casual user not needing help with all topics in a particular course. However, students in particular can be burdened by managing multiple Add-Ins for each course. Therefore, it is reasoned that a re-packaging of the modules was needed to promote consistent use throughout the length of a course.

Prior Help Status

As part of development of the modules for Heat Transfer and Energy Systems Design, several forms of user help were created. Microsoft Excel offers several ways to incorporate help for the user of an Add-In. Also, help was created in PowerPoint files to assist the user in Excel navigation and operation of specific user-defined functions.

Perhaps the simplest way to integrate help into Excel user-defined functions is to type a function description directly into the *Macro Options* window. This *Macro Options* window can be found on the *View* tab in Microsoft Excel 2007 and is seen below in Figure 2.
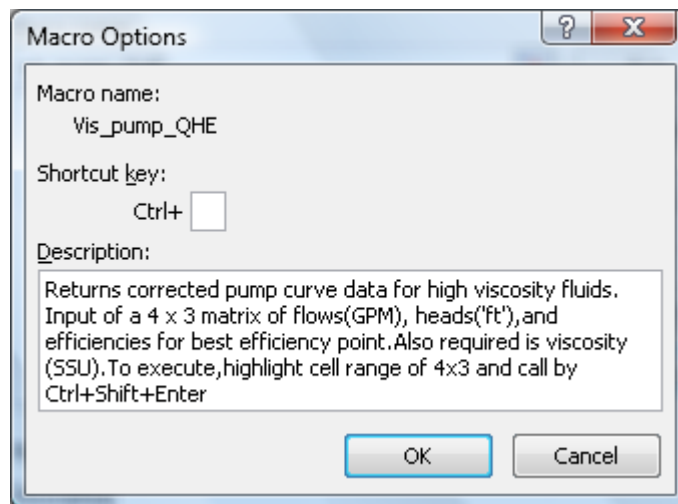

Figure 2 Macro options function description input window

The function descriptions can then be seen the next time the function is used. When a user employs the *Insert Function* button in Excel, a window appears showing the function arguments and supplied description.

The user-defined function descriptions can also be entered or typed into the VB code. This method allows the developer more freedom to categorize the functions for a specific group. For

example, the group of functions dealing with calculations of Nusselt numbers can have their own "Category" as seen below in Figure 3.
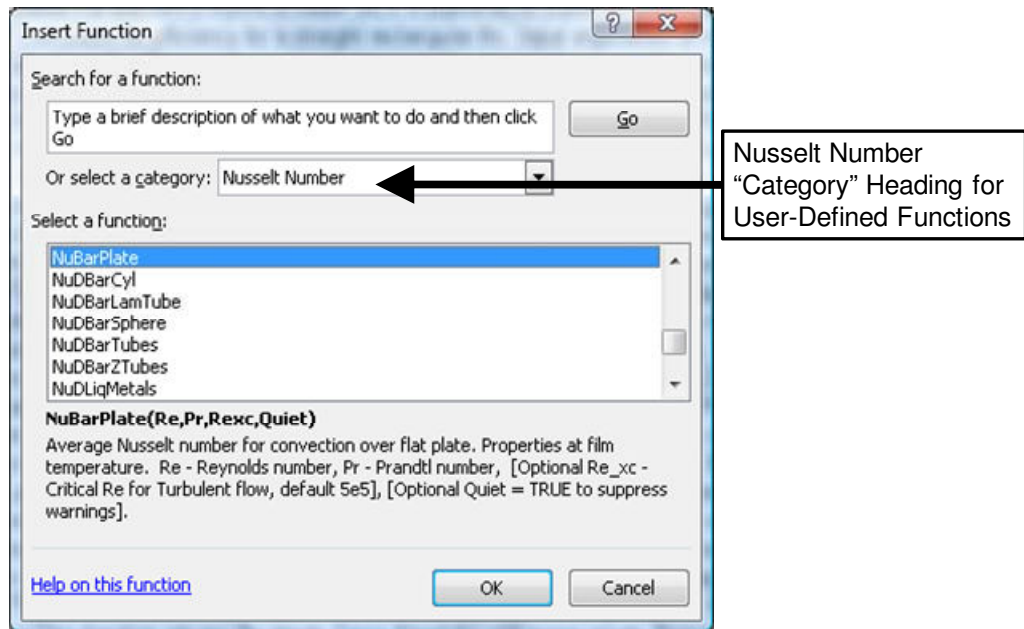
Figure 3 Insert function window with category designation

By utilizing the *Macro Options* command and inserting the following example character string in VB, a category will be created according to whatever is placed in the last argument of the MacroOptions Application.

> **Application.MacroOptions Macro:="NuBarPlate", Description:="Average Nusselt number for convection over flat plate. Properties at film temperature. Re - Reynolds number, Pr - Prandtl number, [Optional Re_xc - Critical Re for Turbulent flow, default 5e5], [Optional Quiet = TRUE to suppress warnings]", Category:="Nusselt Number"**

Although this particular mode of help is useful, the extensiveness of the help is limited by several factors. These limitations exist due to the inability to supply schematics, figures, or equations. Also, each function description is restricted by the letters, numbers, and symbols on the keyboard as well as a 255 character count.

The help files created in Microsoft PowerPoint were designed to assist the user not only with specific user-defined functions but also general Excel tips. The PowerPoint tutorials available for download from the project website include topics in the use of Add-Ins, general Excel tips, and Energy Systems Design-Heat Transfer functions. Each tutorial includes a description of its contents below the download link.

Once all of the descriptions for the user-defined functions were finished, a reevaluation of the project progress determined that the provided modes of help were still lacking in the extensive detail and availability that was desired by the research team. A more extensive help would

provide the ability for more informative wording, figures, schematics, and equations. The discovery of the "Help on this function" link, seen below in Figure 4, served as an impetus for
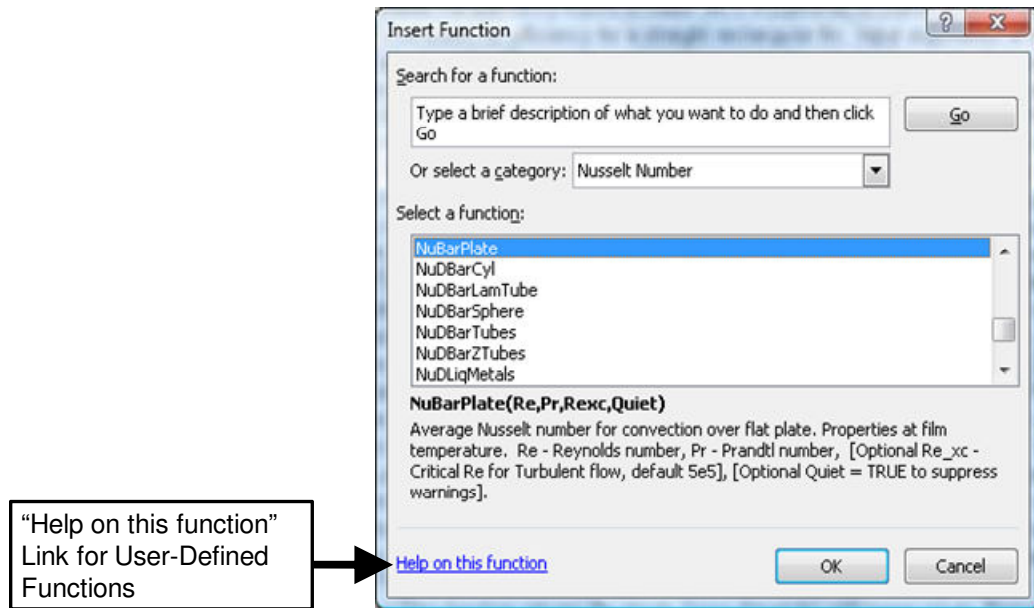
Figure 4 Function help link

the next step in the research project. More extensive user help was desired. Consequently, a new level of integration presented itself for study and implementation.

Repackaging Heat Transfer and Energy Systems Design Modules

While a casual user of the Excel in Mechanical Engineering website may find the prior module organization sufficient, a more frequent visitor might find the organization cumbersome and possibly discouraging. The aforementioned design is unique in that it allows a user the option to 'pick and choose' which Add-Ins he or she desires to have. However, several significant advantages are realized by combining several modules into one larger Add-In according to their course designation. The main motivation for repackaging is to maintain one Add-In per course. So, the Heat Transfer course will have one Add-In. Accordingly, the Energy Systems Design course will have one Add-In. Therefore, a more user-friendly design becomes available from within the Excel environment.

As was mentioned earlier, students in a particular course can become easily burdened by managing multiple Add-Ins for each course. A more advantageous re-packaging of the modules would include the combining of all topic material (separate Add-Ins) into one new and bigger module for each course. This is a more practical layout as opposed to asking the user to download and install multiple times over the length of the course. While maintaining one Add-In per course was the primary motivation for the repackaging project, several other advantages are realized from this new organization. First, one single Add-In is not that much bigger in size compared to having numerous Add-Ins for the same information. One combined Add-In for the Heat Transfer or Energy Systems Design courses could be somewhere between 60-100 KB. Second, the *Category* application mentioned earlier provides a way to group all applicable

functions into one sub-heading such as "Heat Transfer". Third, only a single download and install for each computer the user chooses to supply with the Add-In is required. This allows for and encourages consistent spreadsheet solutions necessary for well-documented electronic engineering calculations[2].

The process for combining several smaller modules into one larger module is fairly simple. This new organization scheme becomes a matter of creating a new Visual Basic for Application (VBA) project and combining the VB code from all separate modules. For example, the module for the Heat Transfer course can be seen below in Figure 5.
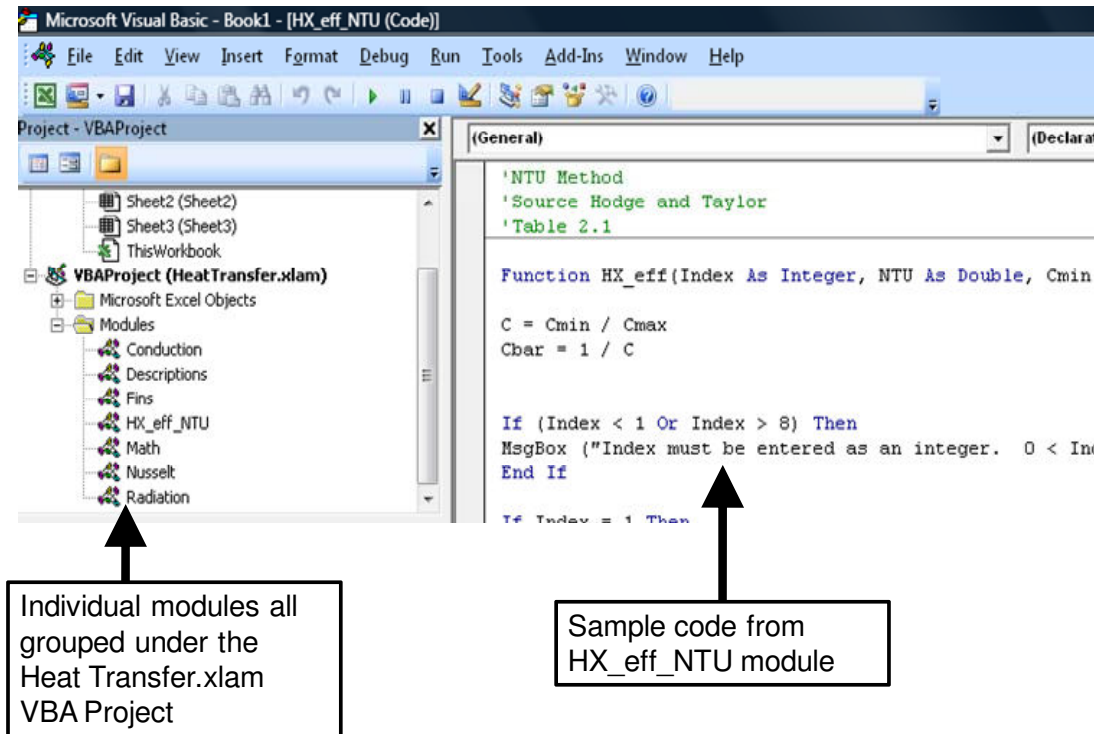
Figure 5 Visual Basic Editor for combining into one Add-In

In the Heat Transfer Add-In, the VB code is split into its several different modules as seen on the left of the screenshot. There are separate modules for the function descriptions, conduction functions, fin calculators, heat exchanger-effectiveness relationships, Nusselt numbers, and radiation functions. However, they are all part of the same VBA project and remain as one single Add-In. On the right of the screenshot is a view of the sample code from the heat exchanger-effectiveness relationships module. The same method was used for creating the Energy Systems Design course Add-In. Figure 6 below demonstrates the grouping of the new course Add-Ins.
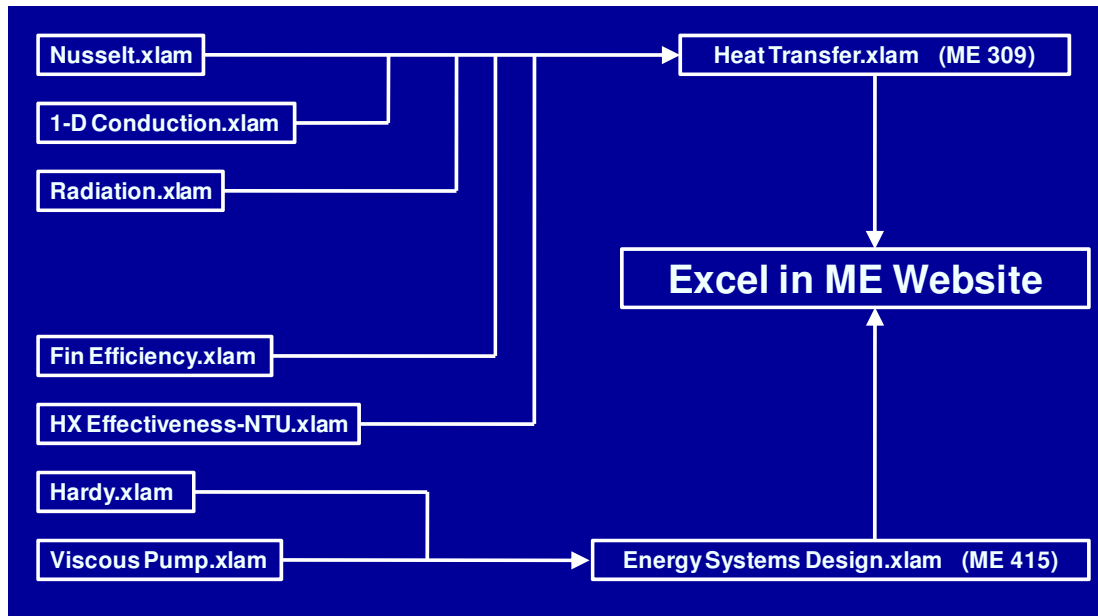
Figure 6 New organization of Add-Ins for each course

Previously, the Heat Transfer webpage offered the three individual Add-Ins shown above Nusselt.xlam, 1-D Conduction.xlam, and Radiation.xlam. During repackaging, a logical decision was reached that prompted the developers to assign all course material pertinent to heat transfer in the heat transfer Add-In. Therefore, the contents of the Fin Efficiency.xlam as well as the HX Effectiveness-NTU.xlam were grouped with the rest of the previously designated Heat Transfer Add-In. The material that was left over would be assigned to the Energy Systems Design Add-In. This included only the Hardy.xlam and the Viscous Pump.xlam.

The new Add-Ins are posted on-line and have been made available at the same location for the project website(www.me.ua.edu/ExcelinME). A view of the Heat Transfer web page can be seen below in Figure 7.
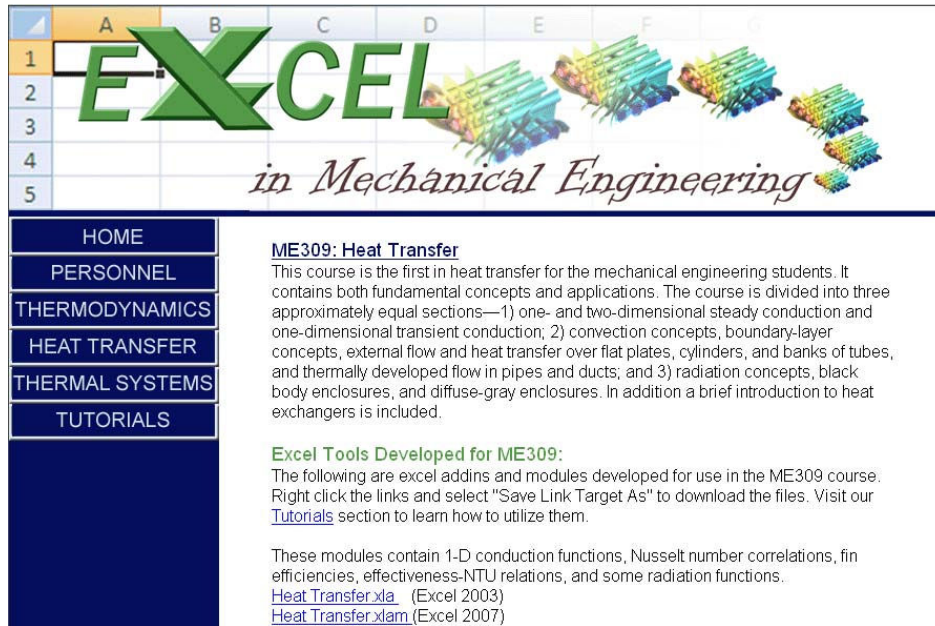
Figure 7 Sample screenshot of heat transfer web page

A short course description as well as an explanation of the capabilities of the Heat Transfer Add-In is provided. Also, links to tutorials on the website are provided for assistance in using Microsoft Excel and in particular using Add-Ins. The combined format of the modules offers a cleaner and more user-ready environment for Excel-based mechanical engineering calculations.

Microsoft HTML Workshop

After a thorough internet research, a connection was discovered between the "Help on this function" link in Microsoft Excel and its ability to support Microsoft Compiled HTML Help. Microsoft HTML Help Workshop is a help authoring toolbox for developing a set of web pages in subsets of HTML along with hyper-linking capabilities for a table of contents, index, and keywords[4]. Microsoft Compiled HTML Help was first released with Windows 98 and is still supported up through Windows Vista. Most Windows packages come with the HTML Help Workshop pre-loaded. The most recent version, the HTML Help Workshop 4.74.8702.0 can also be found on the internet at the Microsoft Developer Network (MSDN) web site[4].

One unique characteristic of the HTML help compiler is its ability to compress HTML and graphics into relatively small compiled help (.chm file extension). These files can then be distributed with software or downloaded from the internet. Instruction for creating help projects is hard to locate on the internet and little guidance is offered by Microsoft. To provide assistance in methods for developing help projects, several screenshots with explanations will help to solidify the background information needed to create a compiled help file (.chm) from the developer's standpoint. Upon running the HTML Help Workshop, the user first has to create a new project. The home screen appears and can be seen in Figure 8.
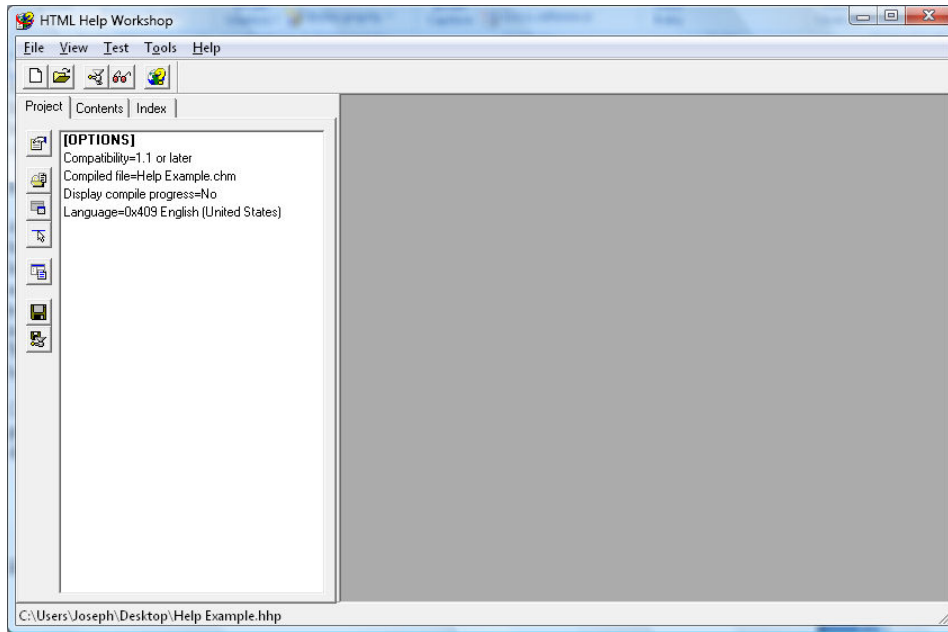
Figure 8 HTML Help Workshop home screen

To begin creating the pieces of a project, the developer first creates a new HTML Help file under the *File* tab. The developer is then asked to provide a Title for the HTML file as seen in Figure 9.
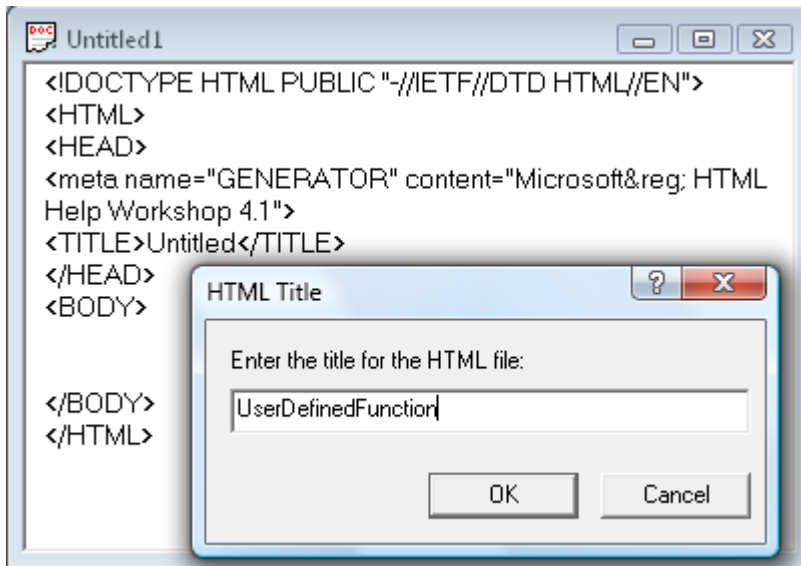
**Figure 9 Create and name the help file windows**

Once the help file has been created, there are really no limitations as to the extent of detail that can be supplied. Any HTML code can be supported as well as several options for the developer to change background colors and the help pop-up window size. Therefore, figures and graphics can be provided through the use of the HTML Help Image Editor which is installed in conjunction with the HTML Help Workshop. Any kind of figures can be pasted into the HTML

Help Image Editor. For example, the scanned image in Figure 10 below was opened and saved as a bitmap (.bmp) so that it can be inserted into the HTML code for a particular help file.
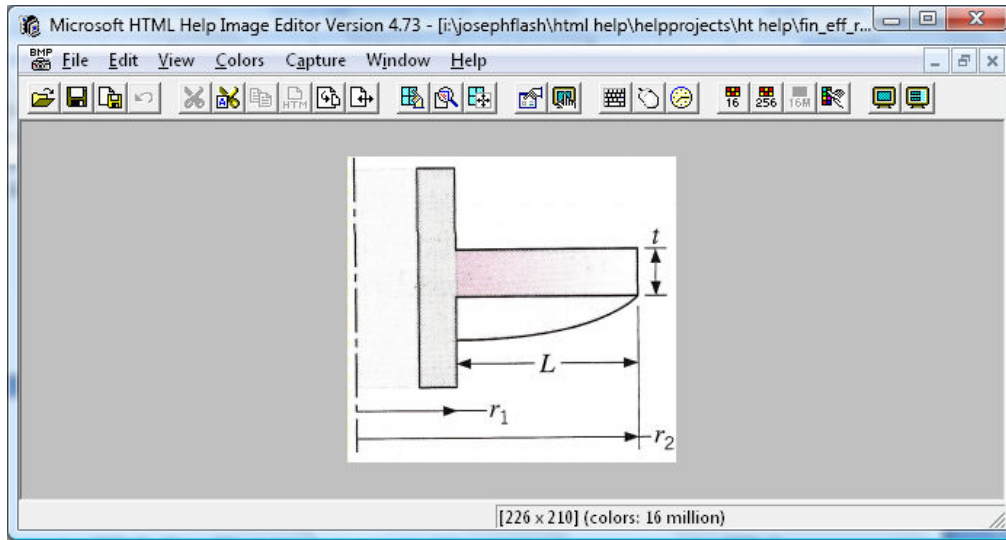
Figure 10 HTML Help Image Editor sample screenshot

Once all the desired information is entered into the HTML help file(.htm extension), it should be saved. A table of contents (.hhc extension) can be created from the *Contents* tab in the HTML Help Workshop. By inserting a page in the Table of Contents entry, the dialog box in Figure 11 will appear.
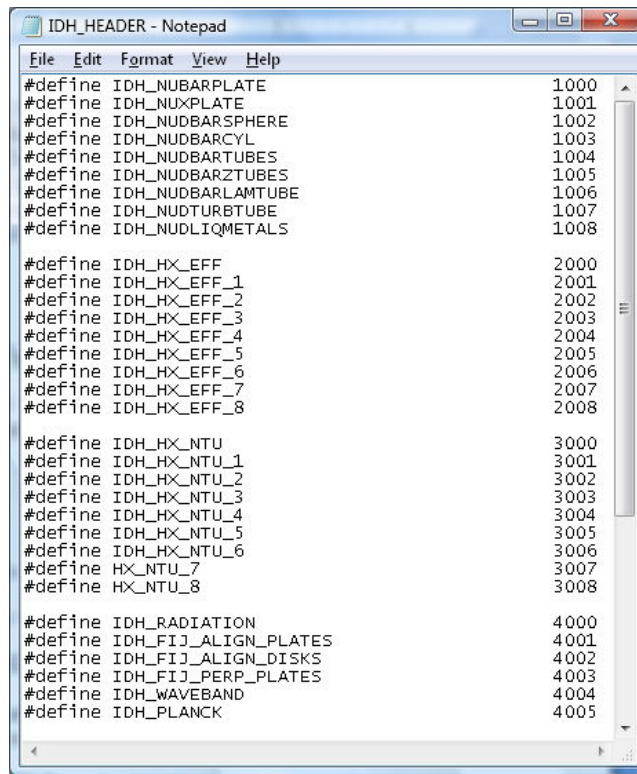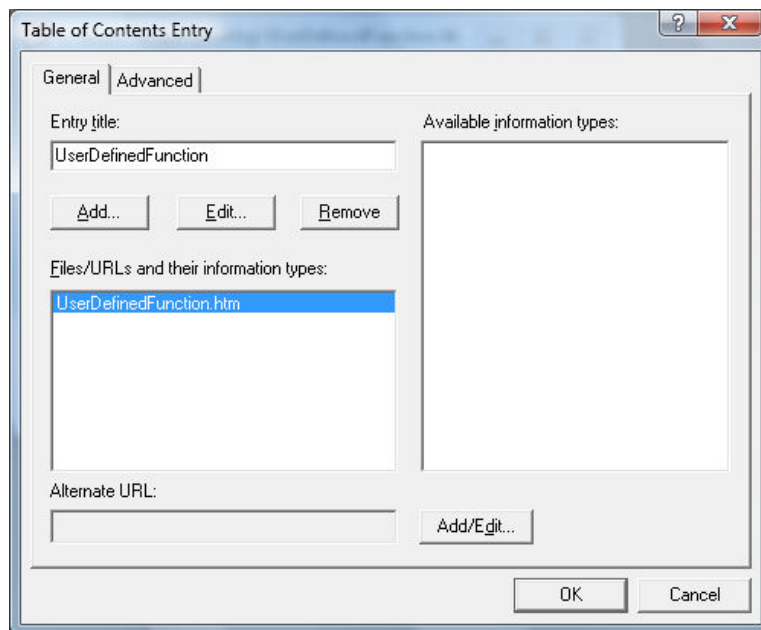

Figure 11 Table of Contents entry window in HTML Help Workshop

The *Entry title* slot provides the option for naming the particular Table of Contents heading that has been added and therefore linked to the specific user-defined function help file(.htm). This

name will appear again when the compiled help file (.chm) is running in an open window. The Table of Contents allows for instituting a function hierarchy or organization system with Folders concerning broad topics, for example Nusselt numbers, and a subset html page for a specific user-defined function, such as NuBarPlate for calculating averaged Nusselt number over a flat plate.

The last important piece of the HTML Help Workshop involves creating an Index header file(.h extension) in order to provide capabilities for linking a particular help file with its corresponding user-defined function in Excel. Figure 12 shows a simple Index file created in *Notepad* that assigns a number value to each particular Excel user-defined function.


```
IDH_HEADER - Notepad

File   Edit   Format   View   Help

#define IDH_NUBARPLATE              1000
#define IDH_NUXPLATE                1001
#define IDH_NUDBARSPHERE            1002
#define IDH_NUDBARCYL               1003
#define IDH_NUDBARTUBES             1004
#define IDH_NUDBARZTUBES            1005
#define IDH_NUDBARLAMTUBE           1006
#define IDH_NUDTURBTUBE             1007
#define IDH_NUDLIQMETALS            1008

#define IDH_HX_EFF                  2000
#define IDH_HX_EFF_1                2001
#define IDH_HX_EFF_2                2002
#define IDH_HX_EFF_3                2003
#define IDH_HX_EFF_4                2004
#define IDH_HX_EFF_5                2005
#define IDH_HX_EFF_6                2006
#define IDH_HX_EFF_7                2007
#define IDH_HX_EFF_8                2008

#define IDH_HX_NTU                  3000
#define IDH_HX_NTU_1                3001
#define IDH_HX_NTU_2                3002
#define IDH_HX_NTU_3                3003
#define IDH_HX_NTU_4                3004
#define IDH_HX_NTU_5                3005
#define IDH_HX_NTU_6                3006
#define HX_NTU_7                    3007
#define HX_NTU_8                    3008

#define IDH_RADIATION               4000
#define IDH_FIJ_ALIGN_PLATES        4001
#define IDH_FIJ_ALIGN_DISKS         4002
#define IDH_FIJ_PERP_PLATES         4003
#define IDH_WAVEBAND                4004
#define IDH_PLANCK                  4005
```

Figure 12 Sample index file

The developer ultimately will have to re-visit the VB code in order to assign these number values to each function as another *Macro Option* application. Once the steps of creating and saving all of the help files (.htm), the table of contents file (.hhc), and the index file (.h) are complete, the developer should then go to the *Save all files and compile* button on the Project tab within the HTML workshop. Performing this step will create the compiled help file (.chm) that will be used to link to the "Help on this function" in Microsoft Excel. These basic screenshots are only a brief introduction of the many capabilities of the Microsoft HTML Help Workshop.

Writing Help Files for Heat Transfer

The task of writing help files for each course Add-In can become a considerable undertaking depending on the depth and detail desired in a help file and the number of user-defined functions

that need additional help beyond the function description. In order to develop the Heat Transfer compiled help file, a system was devised to help complete the development of nineteen individual help files (.htm) into one compiled help file (.chm).

Help files for each individual function were written to compliment the function descriptions that already existed. Care was taken to explain to the best capacity, the details of each function argument and expected output. This was done by providing supplemental figures and equations, all saved as bitmap images (.bmp), and linking them into the help file (.htm). These figures and equations for the help file were edited in the HTML Help Image Editor. Sample HTML code for the function that calculates averaged Nusselt number for flow over a flat plate is provided below in Figure 13.

```
<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML//EN">
<HTML>
<HEAD>
<meta name="GENERATOR" content="Microsoft&reg; HTML Help Workshop 4.1">
<Title>NuBarPlate</Title>
</HEAD>
<BODY>
<B>NuBarPlate(Re, Pr, Rexc, QUIET) </B></br>
This function returns the <I>averaged</I> value of the Nusselt number for flow over a flat
plate using Equation 7.31 of Incropera, et al [1].
<p>The user must supply the Reynolds number(<B>Re</B>) for the length of the plate
and the Prandtl number(<B>Pr</B>). The film temperature should be used to evaluate
all properties.
</p>
<img src=Laminartoturbulent.bmp> </br>

<p>
The last two arguments are optional:  <B>Re<sub>x,c</sub></B> is the transition
Reynolds number and will be taken as <B>500,000</B> if left unspecified. QUIET is a
boolean variable which defaults to FALSE, but when specified as TRUE causes
suppression of any MsgBox error output from the function.
</p>

<p>
[1] Incropera, DeWitt, Bergman, Levine, <em>Introduction to Heat Transfer</em>, 5th
Edition
```

Figure 13 Sample HTML code for a help file

The major components of each file include the title and the body. The body contains the function call and arguments, detailed descriptions with unlimited character space, links to images, and a citation for the supplemental text that a user should refer to for additional information. The highlighted line is the link to the bitmap image named Laminartoturbulent.bmp. The corresponding HTML code for linking that image to the help file is

**<img src=Laminartoturbulent.bmp>.**

In order for the image to properly link to the appropriate help file, the image must be saved in the same folder as the corresponding help file. Proper care was taken to give credit to all scanned images and figures as well as equations for the Heat Transfer help files[5]. The Table of Contents and Index files allowed for organization and clustering of the whole help module. The compiled help file view can be seen in Figure 14.
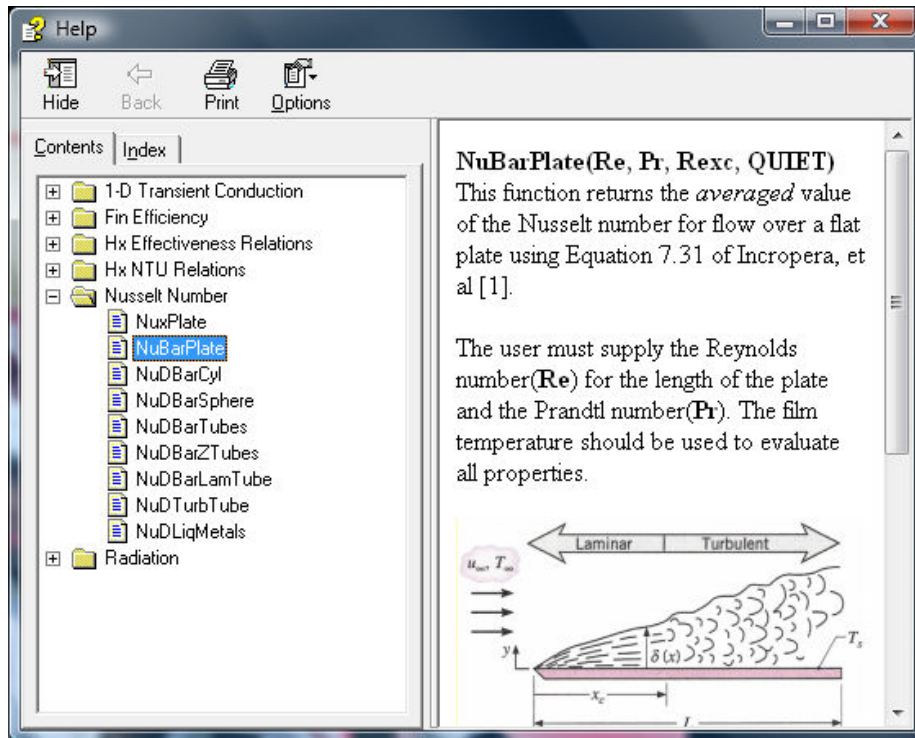
Figure 14 Compiled help file view

Several internet sites provide assistance on HTML code for beginners. In particular, Alan Wood's website provides lots of pertinent information on HTML code for symbol font of Greek and special characters[6]. These are especially useful for writing help for equations in the Help Workshop.

The compiled help files (.chm) files can be downloaded off the internet also at the project website and placed in the same folder with the add-in. Once downloaded, the user needs to visit the *Properties* of the file to "Unblock" the Security prevention mechanism as seen at the bottom of Figure 15. Then the user will be able to view the help file via "Help on this function" as long as the Add-In(.xlam) and the help file(.chm) are in the same folder.
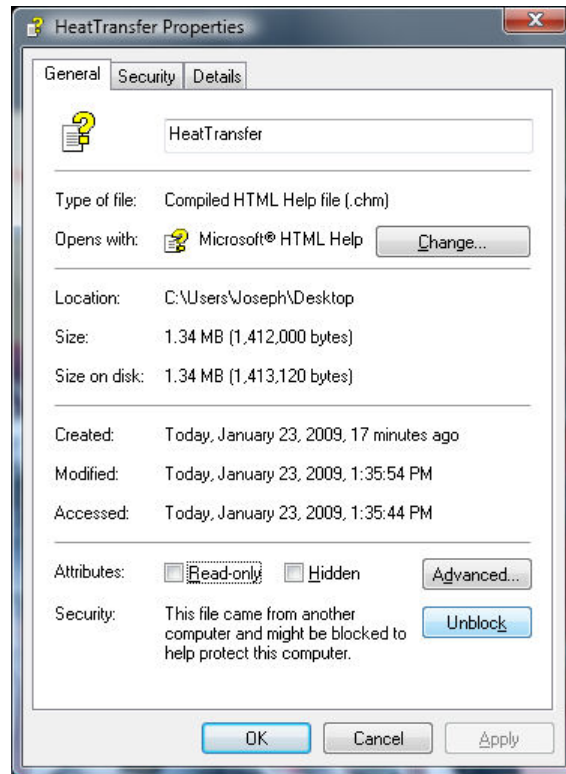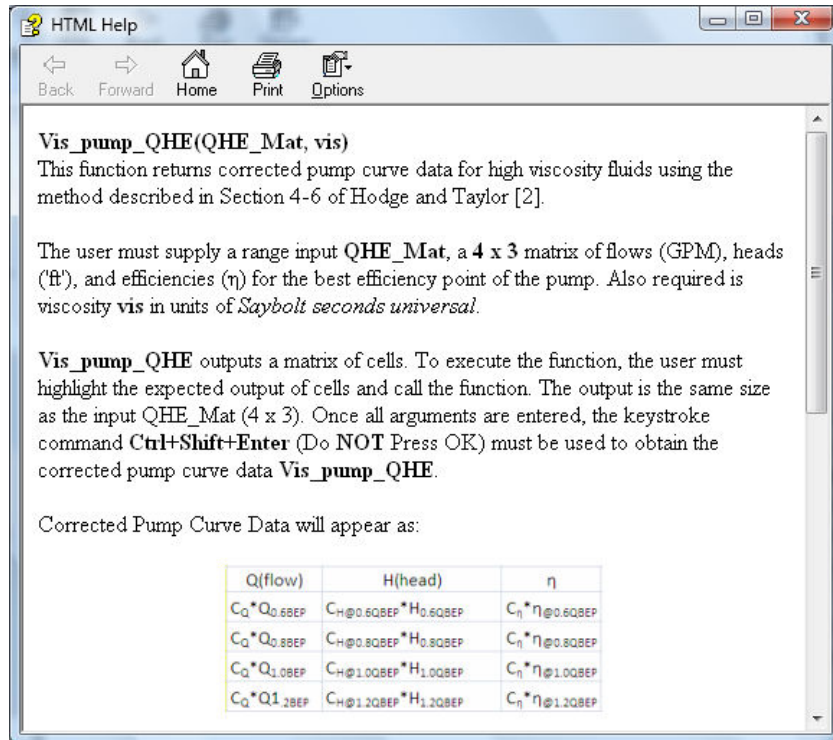
Figure 15 Compiled help file security block/unblock

Writing Help Files for Energy Systems Design

The method for writing the Energy Systems Design help file followed the exam same pattern mentioned above for the Heat Transfer help file. Though there were only eight help files to write, as opposed to nineteen for Heat Transfer, some of the help files involved very thorough explanation. The details of the operation of these functions were described to the best capacity and should supplement students looking for explanation to go along with the text.

Several of the user-defined functions for Energy Systems Design involve array outputs. Supplemental figures and equations were once again provided to assist in explanation of these functions. The HTML Help Image Editor supported the considerable number of figures that became part of the help files. A sample help file for the, Vis_pump_QHE, viscous pump flow, head, and efficiency matrix describes a function that outputs an array and is presented below in Figure 16.

HTML Help

Back　Forward　Home　Print　Options

Vis_pump_QHE(QHE_Mat, vis)
This function returns corrected pump curve data for high viscosity fluids using the method described in Section 4-6 of Hodge and Taylor [2].

The user must supply a range input **QHE_Mat**, a **4 x 3** matrix of flows (GPM), heads ('ft'), and efficiencies (η) for the best efficiency point of the pump. Also required is viscosity **vis** in units of *Saybolt seconds universal*.

Vis_pump_QHE outputs a matrix of cells. To execute the function, the user must highlight the expected output of cells and call the function. The output is the same size as the input QHE_Mat (4 x 3). Once all arguments are entered, the keystroke command **Ctrl+Shift+Enter** (Do **NOT** Press OK) must be used to obtain the corrected pump curve data **Vis_pump_QHE**.

Corrected Pump Curve Data will appear as:

Q(flow)	H(head)	η
$C_Q * Q_{0.6BEP}$	$C_{H@0.6QBEP} * H_{0.6QBEP}$	$C_\eta * \eta_{@0.6QBEP}$
$C_Q * Q_{0.8BEP}$	$C_{H@0.8QBEP} * H_{0.8QBEP}$	$C_\eta * \eta_{@0.8QBEP}$
$C_Q * Q_{1.0BEP}$	$C_{H@1.0QBEP} * H_{1.0QBEP}$	$C_\eta * \eta_{@1.0QBEP}$
$C_Q * Q1_{.2BEP}$	$C_{H@1.2QBEP} * H_{1.2QBEP}$	$C_\eta * \eta_{@1.2QBEP}$

Figure 16 Sample help file for Vis_pump_QHE

The help file pictured shows some of the body. The table presented is a bitmap image used to describe how corrected pump curve data will appear. Once again, in order for the image to properly link to the appropriate help file, the image must be saved in the same folder as the corresponding help file. Proper care was taken to give credit to all scanned images and figures as well as equations for the Energy Systems Design help files[7]. The Table of Contents and Index files allowed for organization and clustering of the whole help module. The compiled help file view can be seen in Figure 17.
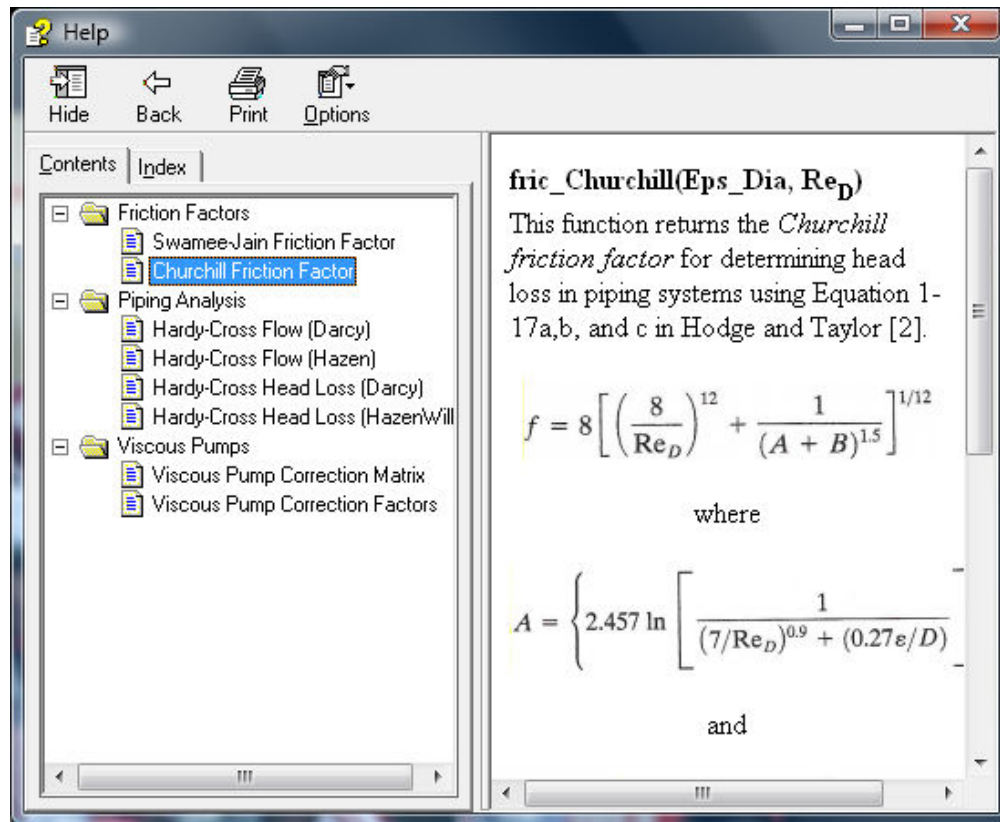
Figure 17 Compiled help file view

This compiled help file(.chm) can also be downloaded off the internet at the project website and placed in the same folder with the add-in. Once downloaded, the user needs to visit the *Properties* of the file to "Unblock" the Security prevention mechanism. The user will be able to view the help file via "Help on this function" as long as the Add-In(.xlam) and the help file(.chm) are in the same folder.

Example

Problem
An aluminum pin fin 15 mm in length and 5 mm in diameter is integrally attached to a wall which is maintained at 100 C. Air at 20C flows past the pin at 5 m/s. What is the heat transfer coefficient and the heat loss from the fin?

Solution
The problem requires use of a correlation to estimate the heat transfer coefficient. The "Heat Transfer" module function help presents a list of available functions, as seen in Figure 18. The NuDBarCyl help description indicates this is the proper function for flow over a cylinder. By clicking on "Help on this function", the HTML help file for the function is presented as seen in Figure 19. This help screen confirms that the properties are needed at the film temperature for the flow, so this is the temperature needed to compute the fluid properties.

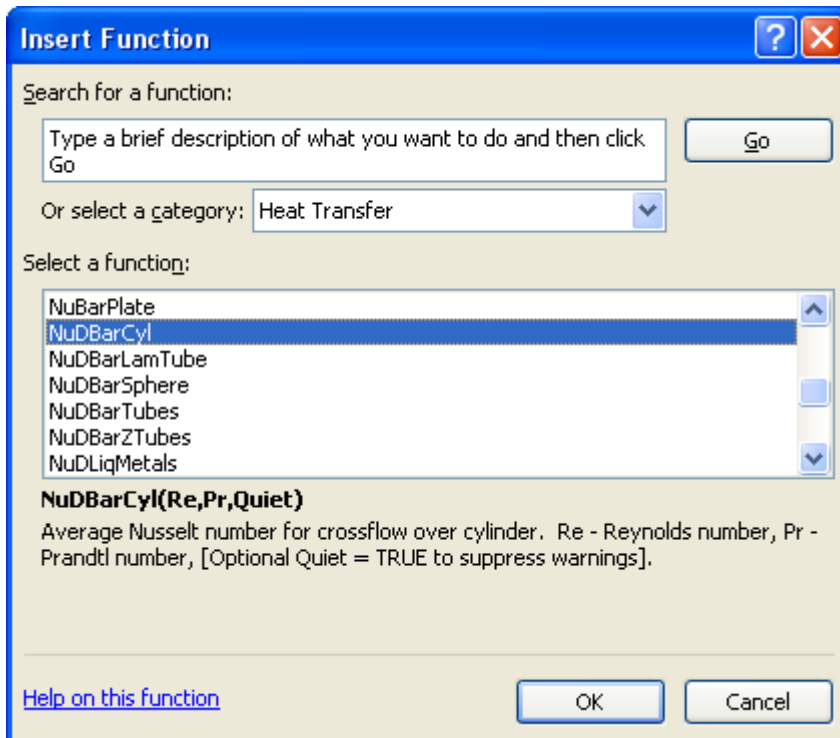The help description and detailed help for the pin fin are seen in Figures 20 and 21. The HTML

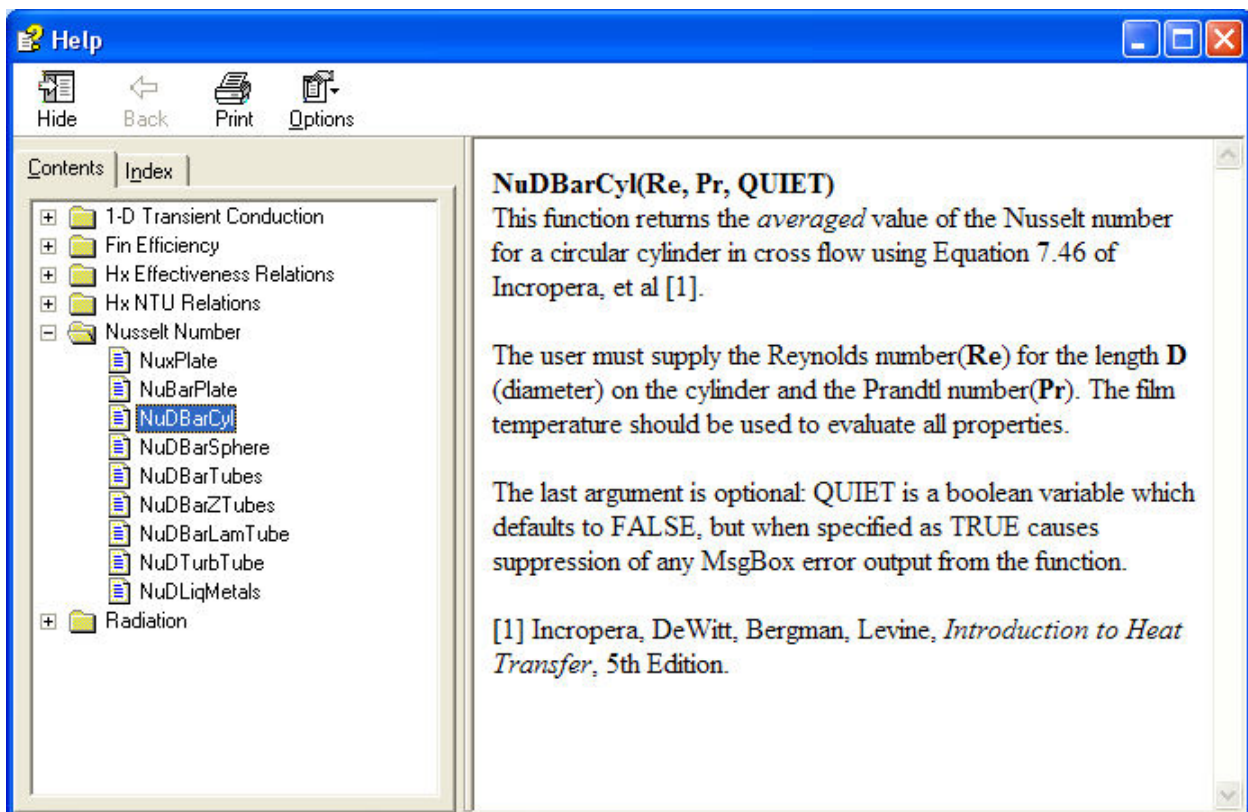**Figure 18. List of available functions for the heat transfer module.**

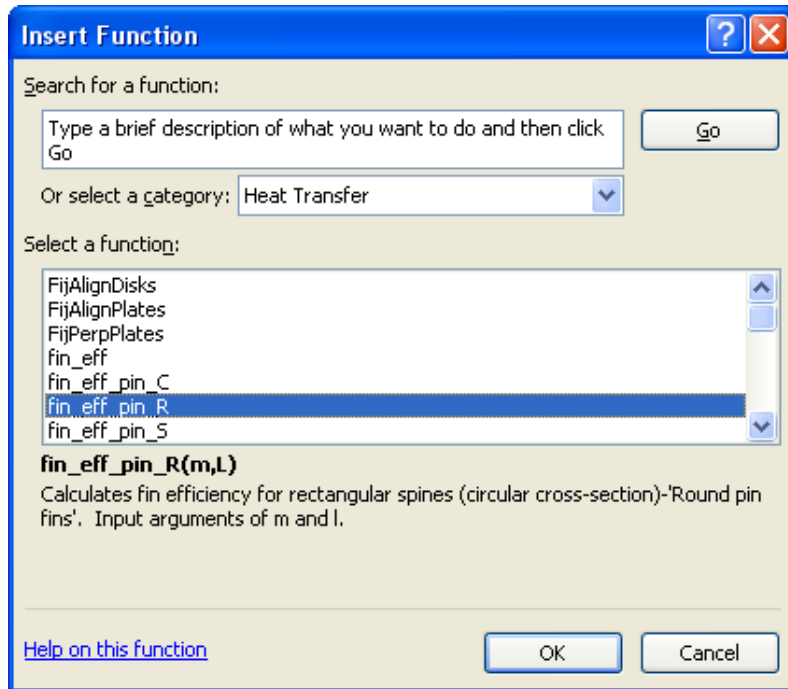**Figure 19. HTML help for the NuDBarCyl function.**

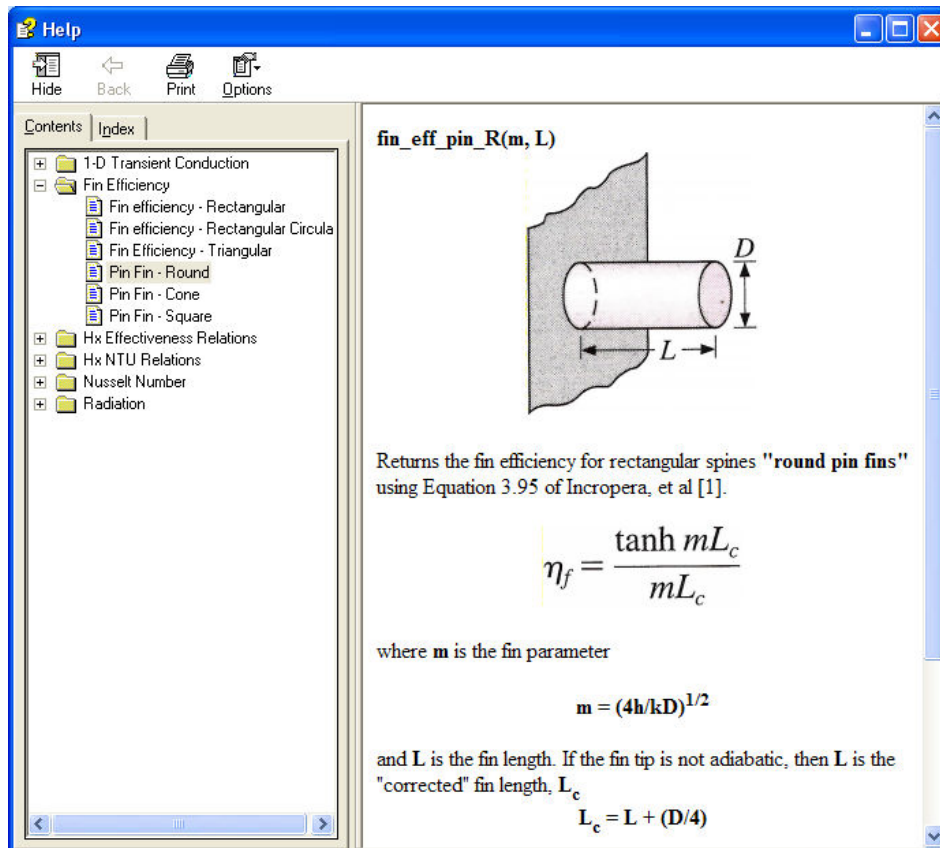**Figure 20. Help description for the fin efficiency function**

Figure 21. HTML help on the round pin fin efficiency function

help gives the definitions of the "m" and "L$_c$" parameters for the fin and these are incorporated into the spreadsheet.

The complete spreadsheet solution is seen in Figure 22 below.

Figure 22. Screen shot of Excel solution for the example.

Conclusions

Through the discovery of the extensive capabilities of VBA in Microsoft Excel and the Microsoft HTML Help Workshop, a valuable reorganized design of developed modules and additional "user help" was created to assist students in the use of Excel for spreadsheet-based solution techniques in the thermal mechanical engineering curriculum. Both relatively straightforward in nature, the Microsoft HTML Help Workshop and VBA in Microsoft Excel demonstrate excellent potential for creation of modules to assist in teaching and learning of thermal mechanical engineering concepts. Excel makes documentation of the solution neat and efficient and at the same time allows for review or reference in the future. The compiled help files created in the HTML Help Workshop compliment the modules by providing assistance to the user in areas where he or she lacks knowledge of a certain subject or the operation of user-defined functions. The compiled help files can also be valuable in the future for review or reference of material that has not been studied recently. The ease-of-use and ready availability of both pieces of software are essential to integration of Excel in the classroom. In engineering studies, uniform organization and consistent usage of software in the classroom and at home establishes practical techniques for problem solving.

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Disclaimer

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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