

Automatic paint mixing process using LabView

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Abstract—The paint industry is one kind of process that depends on the automatic control techniques. The paint composition is the most important issue in paint industry. Therefore, many techniques have been developed to overcome this problem. In the past, paint composition has been done manually where sometimes dose not meet the required color. For this reason, the automatic paint preparation techniques take place to solve the manual paint composition. In this research, an automatic color machine depends on the LabVIEW techniques as a control algorithm is designed and fabricated. The proposed control technique is one kind of graphical control techniques that uses a block diagram and icons as a control algorithm. The LabVIEW program is divided in two parts. The first is the front panel (user interface) and the second is Block diagram (algorithm code). The LabVIEW provided the user with user interface panel which will help the user to feed the quantity of the desired new color. The precision of the output color was acceptable compared to the original color. The outcome of the project will help researchers and those interested in the area of paint industry to explore the features of LabVIEW and its usage.

Keywords—Paint mixing, control algorithm, LabView, software tools.

I. INTRODUCTION

PAIN is one of the oldest synthetic substances known, with a history stretching back into prehistoric times. It was made more than 3500 years ago by prehistoric man as they mixed clays and chalks with animal fats and used these paints to depict their hunts on cave walls. By 2500 BC the Egyptians had improved this technology considerably. They had developed a clear blue pigment by grinding azurite, and instead of animal fats they used gums, wax and maybe also albumen (egg white) as binders and solvents for their paints. The technology improved still further during the first millennium BC as the Greeks learnt to blend paints with hot wax, rather than water, making a paint that was both thicker and easier to spread and thus making it possible to blend colors. By this time many colors were available from both natural and synthetic sources, one of the most interesting being a purple pigment made from heating yellow earth till it turned red and then plunging it into vinegar. The technology then lapsed for many years, with techniques being passed down from generation to generation by travelling craftsmen. This continued until the eighteenth century, when paint

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factories began to be opened in Europe and America, and by the nineteenth century this mass production had brought prices down to such an extent that houses began to be painted. Color is the visual perceptual property corresponding in humans to the categories called red, blue, yellow, green and others. Color derives from the spectrum of light (distribution of light power versus wavelength) interacting in the eye with the spectral sensitivities of the light receptors. Color categories and physical specifications of color are also associated with objects or materials based on their physical properties such as light absorption, reflection, or emission spectra. By defining a color space, colors can be identified numerically by their coordinates. Now, in the twentieth century, the chemistry of many aspects of paint manufacture and function is understood, meaning that paint manufacture has finally moved from being an art to being a science. The science of color is sometimes called chromatics, chromatography, colorimetry, or simply color science. It includes the perception of color by the human eye and brain, the origin of color in materials, color theory in art, and the physics of electromagnetic radiation in the visible range (that is, what we commonly refer to simply as light).

II. HISTORICAL BACKGROUND

Color theory was originally formulated in terms of three "primary" or "primitive" colors red, yellow and blue (RYB) because these colors were believed capable of mixing all other colors. This color mixing behavior had long been known to printers, dyers and painters, but these trades preferred pure pigments to primary color mixtures, because the mixtures were too dull (unsaturated). The RYB primary colors became the foundation of 18th century theories of color vision, as the fundamental sensory qualities that are blended in the perception of all physical colors and equally in the physical mixture of pigments or dyes. These theories were enhanced by 18th-century investigations of a variety of purely psychological color effects, in particular the contrast between "complementary" or opposing hues that are produced by color afterimages and in the contrasting shadows in colored light. These ideas and many personal color observations were summarized in two founding documents in color theory: the Theory of Colors (1810) by the German poet and government minister Johann Wolfgang von Goethe, and The Law of Simultaneous Color Contrast (1839) by the French industrial chemist Michel Eugène Chevreul. Subsequently, German and English scientists established in the late 19th century that color perception is best described in terms of a different set of primary colors red, green and blue violet (RGB) modeled through the additive mixture of three monochromatic lights. Subsequent research anchored these primary colors in the differing responses to light by three types of color receptors or

cones in the retina (trichromacy). On this basis the quantitative description of color mixture or colorimetry developed in the early 20th century, along with a series of increasingly sophisticated models of color space and color perception, such as the opponent process theory.

A. Primary Color Models

Primary colors are sets of colors that can be combined to make a useful range of colors. For human applications, three primary colors are usually used, since human color vision is trichromatic. For additive combination of colors, as in overlapping projected lights or in CRT displays, the primary colors normally used are red, green, and blue. For subtractive combination of colors, as in mixing of pigments or dyes, such as in printing, the primaries normally used are cyan, magenta, and yellow, though the set of red, yellow, blue is popular among artists. See RGB color model, CMYK color model, and RYB color model for more on these popular sets of primary colors. Any particular choice for a given set of primary colors is derived from the spectral sensitivity of each of the human cone photoreceptors; three colors that fall within each of the sensitivity ranges of each of the human cone cells are red, green, and blue. Other sets of colors can be used, though not all will well approximate the full range of color perception. The combination of any two primary colors creates a secondary color. The most commonly used additive color primaries are the secondary colors of the most commonly used subtractive color primaries, and vice versa.

B. RGB Color Model

The RGB color model, shown in figure 1, is an additive color model in which red, green, and blue light are added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue.

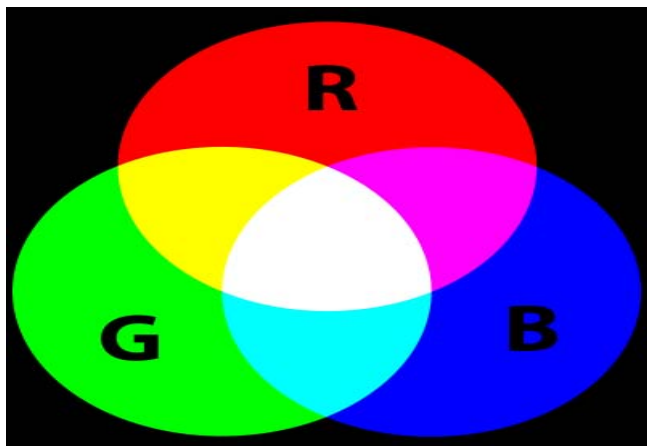


Fig. 1 RGB color model

The main purpose of the RGB color model is for the sensing, representation, and display of images in electronic systems, such as televisions and computers, though it has also been used in conventional photography. Before the electronic age, the RGB color model already had a solid theory behind it, based in human perception of colors. Typical RGB input devices are color TV and video cameras, image scanners, and

digital cameras. Typical RGB output devices are TV sets of various technologies (CRT, LCD, plasma, etc.), computer and mobile phone displays, video projectors, multicolor LED displays, and large screens such as Jumbo Tron. Color printers, on the other hand, are not RGB devices, but subtractive color devices (typically CMYK color model).

C. CMYK Color Model

The CMYK color model (process color, four color) is a subtractive color model, used in color printing, and is also used to describe the printing process itself. CMYK refers to the four inks used in some color printing: cyan, magenta, yellow, and key (black). Though it varies by print house, press operator, press manufacturer, and press run, ink is typically applied in the order of the abbreviation. The "K" in CMYK stands for key because in four-color printing, cyan, magenta, and yellow printing plates are carefully keyed, or aligned, with the key of the black key plate. Some sources suggest that the "K" in CMYK comes from the last letter in "black" and was chosen because B already means blue. However, this explanation, although useful as a mnemonic, is incorrect. The CMYK model works by partially or entirely masking colors on a lighter, usually white, background. The ink reduces the light that would otherwise be reflected. Such a model is called subtractive because inks "subtract" brightness from white. In additive color models such as RGB, white is the "additive" combination of all primary colored lights, while black is the absence of light. In the CMYK model, it is the opposite: white is the natural color of the paper or other background, while black results from a full combination of colored inks. To save money on ink, and to produce deeper black tones, unsaturated and dark colors are produced by using black ink instead of the combination of cyan, magenta and yellow.

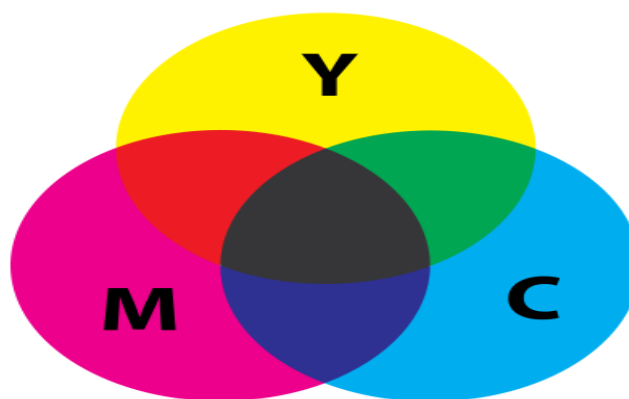


Fig. 2 CMYK color model

D. RYB Color Model

RYB (an abbreviation of red–yellow–blue) is a historical set of colors used in subtractive color mixing, and is one commonly used set of primary colors. It is primarily used in art and design education, particularly painting. RYB predates modern scientific color theory, which argues that magenta, yellow, and cyan are the best set of three colorants to combine, for the widest range of high-chroma colors. Red can be produced by mixing magenta and yellow, blue can be produced by mixing cyan and magenta, and green can be

produced by mixing yellow and cyan. In the RYB model, red takes the place of magenta, and blue takes the place of cyan. However, reproducing the entire range of human color vision with three primaries either in an additive or subtractive fashion is generally not possible; see gamut for more information.

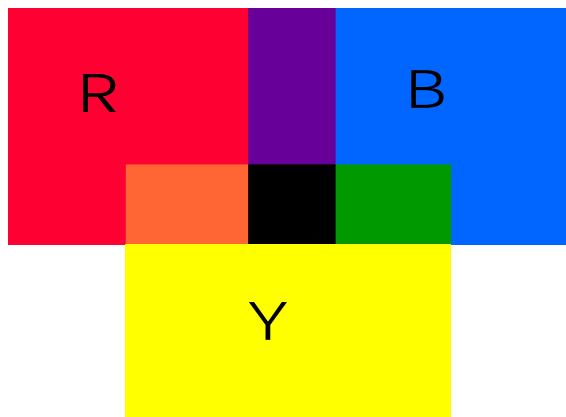


Fig. 3 RYB color model

E. Secondary Color

A secondary color is a color made by mixing two primary colors in a given color space. Examples include the following:

T Additive secondaries (Light RGB), For the human eye, the best primary colors of light are red, green, and blue. Combining the wavelengths of light we see as these colors produces the greatest range of visible color. Since color is defined as the wavelengths of the emitted light, combining RGB colors means adding light (thus the term "additive color"), and the combinations are brighter. When all three primaries (or for that matter all three secondaries) are combined in equal amounts, the result is white. The RGB secondary colors produced by the addition of light turn out to be the best primary colors for pigments, the mixing of which subtracts light.

- 1) Additive secondaries (Light RGB), For the human eye, the best primary colors of light are red, green, and blue. Combining the wavelengths of light we see as these colors produces the greatest range of visible color. Since color is defined as the wavelengths of the emitted light, combining RGB colors means adding light (thus the term "additive color"), and the combinations are brighter. When all three primaries (or for that matter all three secondaries) are combined in equal amounts, the result is white. The RGB secondary colors produced by the addition of light turn out to be the best primary colors for pigments, the mixing of which subtracts light.
- 2) Subtractive Secondaries, Pigments, such as inks and paint, display color by absorbing some wavelengths of light and reflecting the remainder. When pigments are combined, they absorb the combination of their colors, and reflect less. Thus, combining pigments results in a darker color. This is called subtractive color-mixing, as mixing pigments subtracts wavelengths from the light that is reflected.

i) Printing (CMY), The mixture of equal amounts of these colors produce the secondary colors red, blue, and "lime" green (the RGB primary colors of light). That is, the primary and secondary CMY colors (with secondary colors in boldface) Ideally, combining three perfect primary colors in equal amounts would produce black, but this is impossible to achieve in practice. Therefore a "key" pigment, usually black, is added to printing to produce dark shades more efficiently. This combination is referred to as CMYK, where K stands for Key.

ii) Traditional painting (RYB) Before the discovery of CMY, at least as far back as Goethe, the best primary colors were thought to be red, yellow, and blue. These are used even today in painting. Mixing these pigments in equal amounts produces orange, green, and purple. That is, the primary and secondary RYB colors (with secondary colors in boldface)

F. Tertiary Color

A tertiary color is a color made by mixing either one primary color with one secondary color, or two secondary colors, in a given color space such as RGB (more modern) or RYB (traditional). Tertiary colors are a combination of full saturation of one primary color plus half saturation of another primary color and none of a third primary color. Tertiary colors have specific names, one set of names for the RGB color wheel and a different set of names and colors for the RYB color wheel. These names are shown below. Brown and grey colors can be made by mixing complementary colors.

- 1) **RGB or CMY primary, secondary, and tertiary colors;** The primary colors in an RGB color wheel are red, green, and blue, because these are the three additive colors—the primary colors of light. The secondary colors in an RGB color wheel are cyan, magenta, and yellow because these are the three subtractive colors—the primary colors of pigment.
- 2) **Traditional painting (RYB);** The primary colors in an RYB color wheel are red, yellow, and blue. The secondary colors in an RYB color wheel are made by combining the primary colors orange, green, and violet. In the red-yellow-blue system as used in traditional painting, and interior design, tertiary colors are typically named by combining the names of the adjacent primary and secondary.
- 3) **Tertiary-and quaternary-color terms;** The terms for the RYB tertiary colors are not set. For the six RYB hues intermediate between the RYB primary and secondary colors, the names amber (yellow-orange), vermilion/cinnabar (red-orange), magenta (red-purple), violet (blue-purple), viridian (blue-green), and chartreuse (yellow-green) are commonly found. The names for the twelve quaternary colors are more variable, if they exist at all, though indigo and scarlet are standard for (blue–violet) and (red-vermilion).

III. LABVIEW FOR COLOR MIXING PROCESS

In this section, the LabView software is used to control the paint mixing process in the system. The overall structure of the Automatic mixer paint machine is illustrated in figure 4. The control strategy of this machine can be summarized as follows; firstly, the desired or specified quantity of raw material (white paint) can be controlled by adjusting the wait time of the opening (SVRM), where SVRM is a solenoid valve, and then the new color can be prepared by adjusting the duration of the opening of the three valves SVR, SVG, SVB for the three tinctures. After this feeding, the mixer will turn ON to mix and to achieve good construction of the new color. Then SVO will be opened to take the new color. After that, the cleaner liquid in tank and will be pumped to the mixer tank to clean the inner surface of the mixing tank.

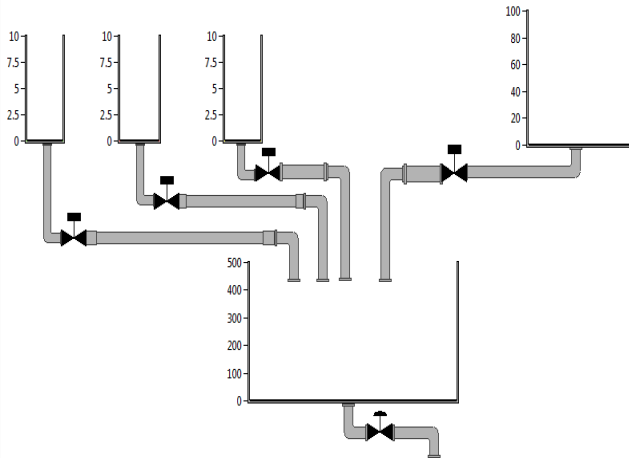


Fig. 4 Paint mixing machine

A. LabView Program Configuration

From the introduction of LabVIEW program in the chapter three, the code will be written in this chapter. The new VI will be opened by clicking on the Blank VI. After opening the new VI, two windows will be emerged, the block diagram and the front panel. They are the main components of the LabVIEW. While the front panel consists of the input and the output, which is seen by the user. Since, the block diagram is code window, where the functions are connected graphically. The following sections will illustrate the block diagram and front panel respectively. In block diagram, the flat sequence will be added by clicking on the right mouse button the function palette will be emerged, click the structure and then the flat sequence will appear. The other frame will be added to the flat sequence automatically. With the same way, another frame will be added to the flat sequence, which is the main window in the program, consists of three frames. Frame 2 will not executed till the frame 1 executes and the frame 3 will not executed till the frame 1 and frame 2 executes and so on.

B. Frame 1 (white paint quantity control)

The first frame has an input which is the quantity of the paint that need to be mixed. The quantity of the white paint raw can be controlled by using time delay (wait) in this frame, the value of wait in (ms) determine the duration of valve

opening, which is connected between the tank 1 and the mixed tank. Figure 5 illustrates frame 1.

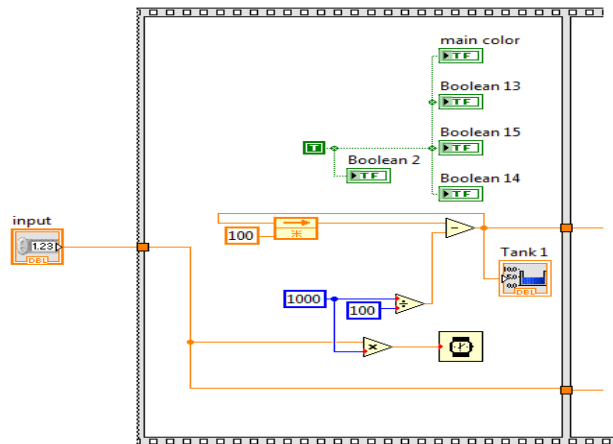


Fig. 5 Frame 1

C. Frame 2

Frame 2 have two inputs, first input is the same input as the frame 1. The second input, represent the code of the required paint from data base. Figure 6 shows the frame 2 and the container case structure, each case devoted to one paint color, and the data of the case are presented from the color data base. In addition the control of each valve of the threetinctures is depends on the value of wait (ms), which is calculated from the data base of each color. The number of case in frame 2 depends on the number of required color paints. This mean, every color paint has one case structure. In this project, three color have been selected which are (RGB1, RGB7, and RGB10). Every case has three tinctures, which are needed to be added to the main color to get the needed paint. The input to the case structure is Enum consists of 3 options, which are the needed colors. The required color is chosen from the front panel, every color has a unique number to distinguish between them. In addition to the case structure, there are three flat sequence, every one consists of two frames responsible on opening and closing the valves for the tanks, which are consists of the colors. The frame 2 has the value of the quantity of the mixer tank, which consists of the mixed color in addition to the tinctures.

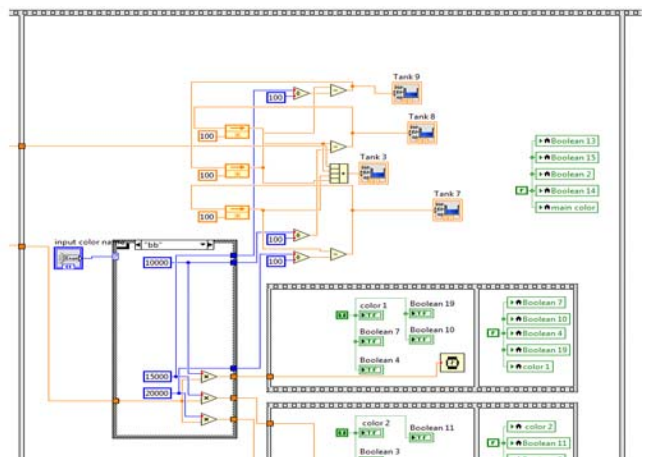


Fig. 6 Frame 2

D. Frame 3

Frame 3 as shown in figure 5.9, consists of the flat sequence which consists of three frames. The first frame responsible on turn ON the mixer with the specific time delay. The second frame consists of time delay which is responsible on the opening of the output valve (required paint), also responsible on the turning off the mixer. The third frame responsible on the turning off the output valve, also responsible on the reset of the value of the main tank

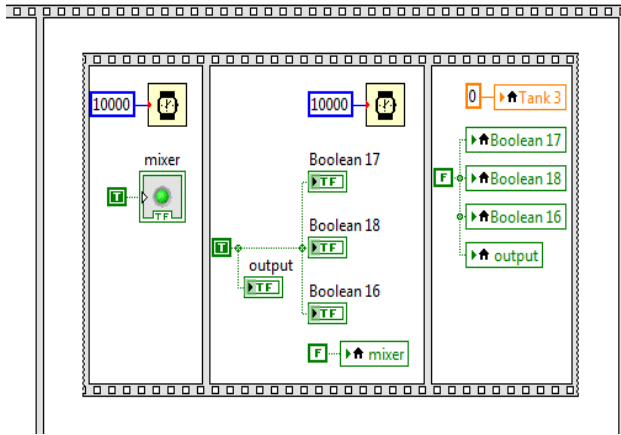


Fig. 7 Frame 3

E. Front Panel Programming

The second part of the LabVIEW program is called front panel which consists of the 'Tab control', which is consist of two pages. The page 1 , as shown in figure 8, consists of two parts, part one devoted to the user input data, which is include the value of paint quantity (each quantity equal to one litter), also include the code of required paint. Part two devoted to equipment states, which include several LEDs indicators for the states of valves, mixer, and cleaner pump.

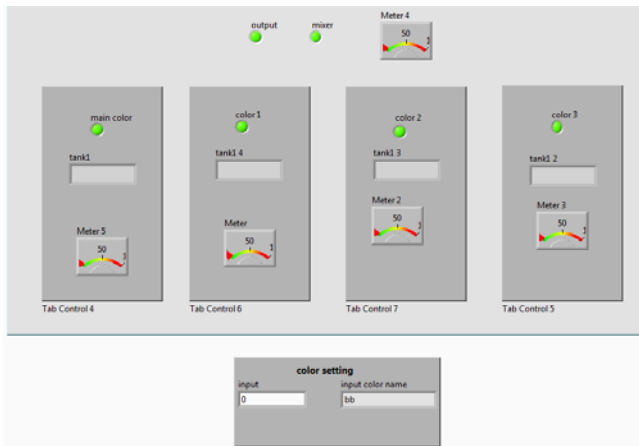


Fig. 8 Front panel page 1

The page 2, as shown in figure 8, illustrates the whole system. It consists of three tanks for tinctures, white color raw tank, the mixer tank, and the cleaner trainer tank. The new color is prepared by mixing the raw with the three tinctures by using the mixer tank and the laboratory color database.

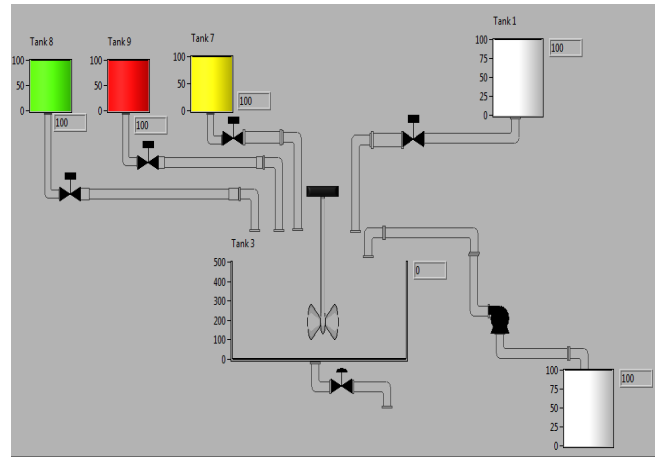


Fig. 9 Front panel page 2

IV. DATA LOGGING AND SUPERVISORY CONTROL MODULE

The DSC Module extends the LabVIEW graphical development environment with additional functionality for the rapid development of distributed measurement, control, and high-channel-count monitoring applications. The DSC technique is used to give a good animation of the virtual implementation of the real project. This technique will show the flow rate of the three tinctures, and the white paint, also show the level of the paint and tinctures in the tanks. Also, it will show the state of all equipments in the project. The DSC module can be added by using the front panel of (VI), this can be done by selecting the controls menu in the front panel, and by select the DSC module menu from the controls menu, then 2D controls and vessels will be appeared as shown in figure 10.

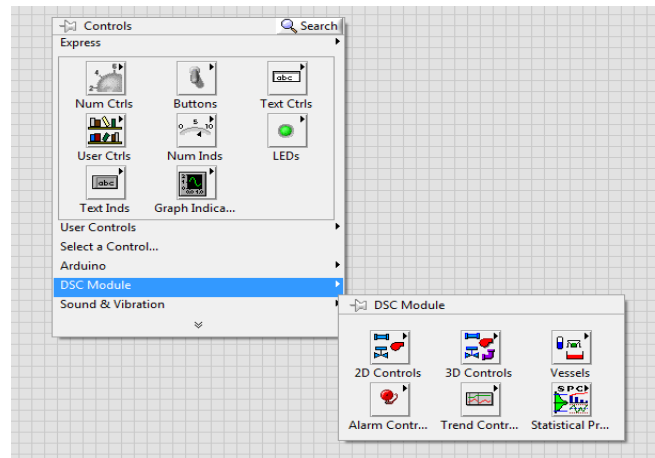


Fig. 10 2D controls and vessels

If (2D controls) are chosen, the other menu will be appeared which has (2D pipes) application. The pipes and connectors are chosen from this menu. Also the valves can be selected from the (2D valves) from (2D controls) menu. The cleaner liquid pump can be selected from (2D pumps) in the same control window. Figure 11 shows these selections. The tanks are chosen from (vessels) in the (2D controls) menu.

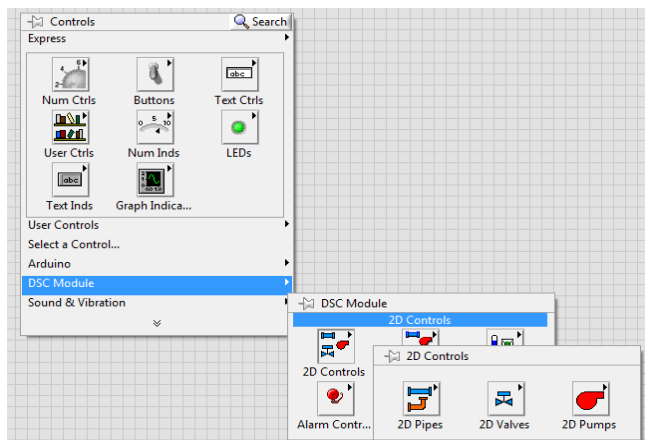


Fig. 11 2D pipes, valves and pumps

Figure 12 shows the suitable form for tanks which can be chosen from (open tank) in (vessels) menu, as shown in. After these selections, the overall implementation of this project can be done by connect the tanks, valves, and pump by using the suitable virtual pipes.

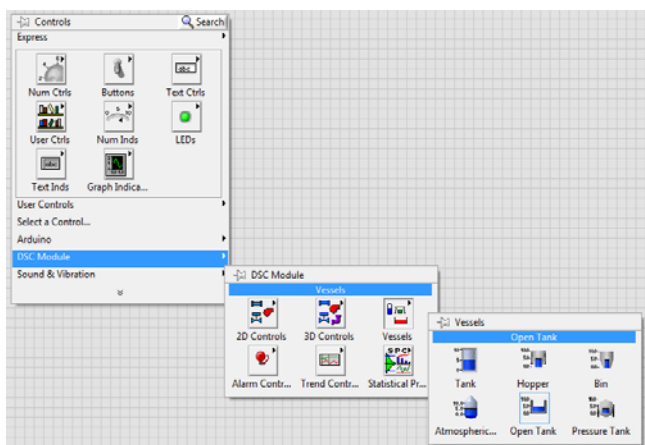


Fig. 12 The overall implementation of the process

The block diagram of the implemented system is built by using suitable blocks in (VI) and their connections for the front panel of the overall implementation, shown in figure 9, is shown in figure 13.

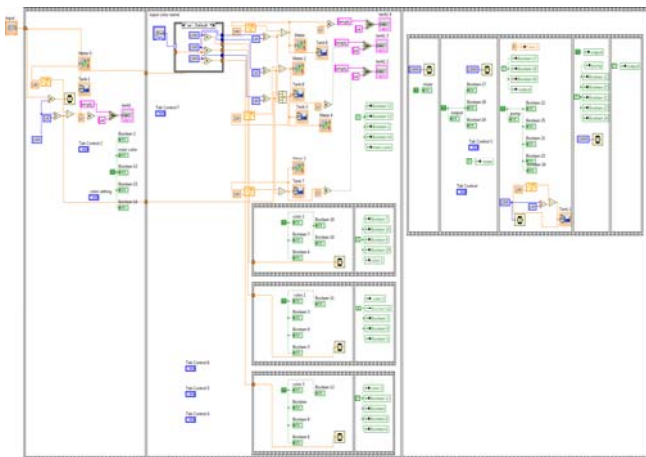


Fig. 13

V. CONCLUSION

The automatic paint mixing machine has been designed and implemented successfully in the LabVIEW environment. The main goal for this work has been achieved to overcome problems related to manual paint mixing. LabVIEW technique has offered a powerful tool to design and implement a complete operation to automate the color mixing machine. This has been archived through the virtual screen on the computer to monitor and control the mixing process. The LabVIEW software made the PC controls the fabricated machine through the data acquisition interface and required programming. The data base which encompasses all colors has been fed to the LabVIEW to control the amount of tinctures for each color. The amount of tinctures, which necessary to produce the desired color, has been controlled by adjusting the time interval of the valve opening. A front panel (graphic user interface GUI) has been designed to assist the user in how to feed the required amount of tincture to produce the specified color. It also provides the user with information about the state of tincture control valves and the availability of the tinctures in the tanks as well as the raw material tanks. It also informs the user by sending a message whether if the tinctures and raw material tanks are empty (Empty) or full (OK).

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