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Propellant Mixing and Loading in Pyrotechs using Virtual Instrumentation

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Abstract : Fireworks field plays an important role in Indian economy. The production of the firecrackers depends fully on man power only in southern India. There is no fire safety instruments found in this firecrackers production till now. So if there is any fire accident occurring in the workplace, its consequences will be devastating for both man power and the products. The main raw material used to make the fire crackers is flash powder which is used as propellant and it must be used as soaked material to maintain this wet condition, continuous sprinkling of water by the people under work is necessary. The drying of the flash powder depends on many parameters like humidity, moisture, room temperature and atmospheric temperature. If the flash powder gets dried, it will explode immediately as well as it will be dangerous to all working personnel inside the factory. This paper deals with the maintaining of safety condition in the working environment by continuously monitoring the wet condition of flash powder. For this process, temperature monitoring sensors are used to check with the wet condition of the raw material. In this paper, we introduce a system to mix the flash powder with the water by using a sprinkling system inside a chamber which contains 4 outlets that gives the propellant in the pasty form. This paste can be easily loaded inside the cracker skeleton so the production will be enhanced. The above work is being done in a virtual instrumentation(VI) environment for pre testing purposes.

Keywords : Fire Safety, Mixing Process, Temperature Control, Non-linear process control, Cracker Production.

1. INTRODUCTION

A firework is a device that utilizes combustion or explosion to produce a visual or auditory effect. Modern pyrotechnics includes devices similar to fireworks, such as flares, matches, and even solid-fuel rocket boosters used in spaceflight. One of the earliest ancestors of fireworks were paper or bamboo tubes filled with finely ground charcoal and sulfur used in china two thousand years ago. Fireworks are a class of low explosive pyrotechnic devices used for aesthetic and entertainment purpose. Most common use of a firework is as part of a fireworks display. A fireworks event is a display of the visual and auditory effects produced by firework devices. Firework competitions are also regularly held at a number of places. Fireworks take so many forms to produce the four primary effects: noise, light, smoke, floating materials. Displays are quite common throughout the world and are the focal point of many cultural and religious celebrations. Improper usage of fireworks may be dangerous, both to the person operating them (risks of burns and wounds) and to bystanders[2]. Sometimes, they may start fires after landing on flammable material. For this reason, the use of fireworks is legally restricted in some environments.

2. PRODUCTION OF FIRE CRACKERS

Blushes in fireworks are usually generated by *pyrotechnic stars* usually called *stars* which produce intense light when ignited. Stars comprises of five basic types of ingredients.

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- A fuel which allows the star to glow
- An oxidizer — The compound which usually produces oxygen to support the combustion of the feed fuel
- Color-producing chemical compound
- A binder which holds the pellet together.

A modern firework is prepared using a of shell of plastic, paper-mache or heavy paper surrounding compartments isolated by cardboard. A tiny compartment at the base of the shell contains dark black powder to propel the firework to the sky from a mortar made of iron, aluminum, plastic, or heavy cardboard. Black powder contains the mixture of salt-peter (potassium nitrate), charcoal, and sulfur in a 75: 15:10 ratios by weight. Flash powder contains a mixture of potassium chlorate or potassium chromate, sulfur, and aluminum. Stars consist of a fuel that flames to provide heat, a coloring agent that provides color when heated, and an oxidizer to burn the fuel.

Table 1

List of chemical compounds used in crackers

S.No.	*Color*	*Metal*	*Example compounds*
1.	Red	Strontium (intense red) Lithium (medium red)	$SrCO_3$ (strontiu m carbonate) Li_2CO_3 (lithium carbonate) LiCl (lithium chloride)
2.	Orange	Calcium	$CaCl_2$ (calcium chloride)
3.	Yellow	Sodium	$NaNO_3$ (sodium nitrate)
4.	Green	Barium	$BaCl_2$ (barium chloride)
5.	Blue	Copper halids	$CuCl_2$ (copper
6.	Indigo	Cesium	$CsNO_3$ (cesium
7.	Violet	Potassium Rubidium (violet-red)	KNO_3 (potassiu
8.	Gold	Charcoal, iron, or lampblack	
9.	White	Titanium, aluminum, berylliu m, or magnesium powders	

Fuels which may be slow-burning such as charcoal, dextrin (derived from corn starch), or red gum (a tree secretion) to provide a dim, long-lasting display, or fast-burning, such as aluminum, magnesium, or titanium, to produce a bright, short-liviing display. Sugar may be used as a fuel to produce smoke.

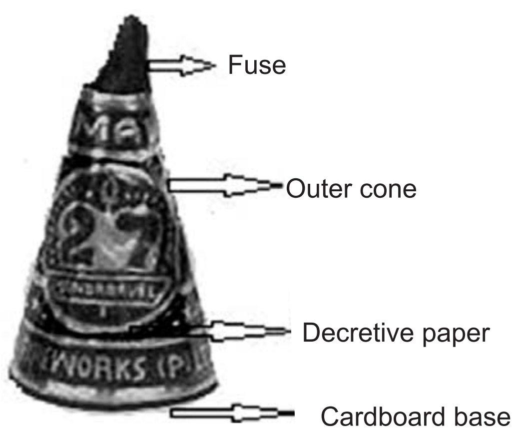

Figure 1: General structure of the flowerpot

There are many types of firecrackers used in India. General types of firecracker are anars or flowerpots or fountain, ground spinner, sparklers or phuljhari, rockets, bombs or sounding crackers or gralands or ladis.

3. PRODUCTION PROCESS OF FLOWERPOTS

Conventional method

There are five general steps to make a simple flowerpot cracker.

Figure 2: Manual handling of flash powder

STEP1: Preparation of cones

Cones are cardboards, beautifully cut as rounds and joined to form cones. While it's lighted it emits light as if flowers are spread out from a pot. A special gum extracted from plant stain is used. Later it is dried and kept one above the other for future uses. It varies in sizes from small to large.

STEP2: Preparation of flash powder for cones

Flash powder is an explosive granular powder prepared for filling the cone which is simple aluminum grains. It adds glitters to flowerpots. In addition to it, 3-6 aluminum powder, barium nitrate and sulphur are used and this combination gives silver color. If you want to add colors a certain quantity of another chemicals like Strontium nitrate, Barium nitrate, Cupric Oxide,etc.

STEP3: Filling of cones

Figure 3: Manual filling of flowerpots

A small aperture will be present. So, it is needed to be covered first before filling the flash powder. For that, a colored paper is used. Desired amount of the above substance is filled in the cones. If you fill more amounts, it will illuminate for more time. A round shaped card board is placed to partition the flash powder and mud mixture. That means, before putting the sand-soil mixture to the cone, a round shaped cardboard is placed to avoid the contact between these two. Then finally its pore is covered using paper and gum.

STEP4: Giving black threads to cone

For lighting a thread a black thread is placed in the mouth of the flower pot. In addition to charcoal, potassium nitrate and sulphur, 3-9 Aluminum powder is used to get a perfect finish for the flowerpot. In normal gunpowder Aluminum-999(atomic weight) powder is used. The black thread of 4 or 5 cm length is fixed.

STEP5: Decoration

Everyone goes for crackers that are decorated well. So, flower pots are also made attractive with multi-colored and designed papers before selling. Usually a thin, colored, square shaped paper is used to cover its mouth and a glittering paper to cover its body. While covering the body, the worker should ensure that black thread is not covered.

Factors influenced in production

The main problem is maintaining the wet condition of the flash powder throughout the production process. Now-a-days, the flash powder is handled by hands only. The workers in the fire cracker production gives more effort to maintain the wet condition of the flash powder by the manual sprinkling system ie., the spraying of water just by using the hands over the heap of the flash powder. Due to handling the flash powder by hands, there are many health issues are occurred to the workers like the lung cancer, skin diseases and the other respiratory diseases [10]. To avoid these problems, we proposed a semi automatic mixing process. In this paper, we have also added an automatic loading system specially for the production flower pot crackers.

4. VIRTUAL INSTRUMENTATION INTRODUCTION TO LABVIEW

LabVIEW is an advanced graphical development environment for creating flexible, measurement and control applications at minimal cost. Using LabVIEW, engineers and scientists interface with real-world signals, analyze data with meaningful statistics and share results. LabVIEW creates development very fast and easy for all users. The key features of LabVIEW are graphical Programming, built-in measurement and control function, multiple development tools, etc.

Lab VIEW programming for mixing and loading process

A Sequence structure Consists of one or more sub VIs, or frames, that execute sequentially. When Right-click the structure border we can add and delete frames or to create sequence locals to pass data between frames. Stacked Sequence structure is used to ensure a sub VI executes before or after another sub VI.

Frames in the Flat Sequence Structure execute in order from left to right. The data is passed between the frames using tunnels. We can add N numbers of frames just by right click the fame and select add frame before or add frame after.

Below an example is given for the practice of Local Sequence, which means passing a value from one sequence to the next.

A Flat Sequence Structure is created within the While Loop used for the sequence operation. There are 6 frames are created with the sequence structure for this program.

The first frame is used for the filling of flash powder and the water in tank 1. To start the filling process from zero an adder is used and initializes the input as 0. The total capacity of the tank 1 is 10 liter. The filling process continues till the output of the adder reaches 10.

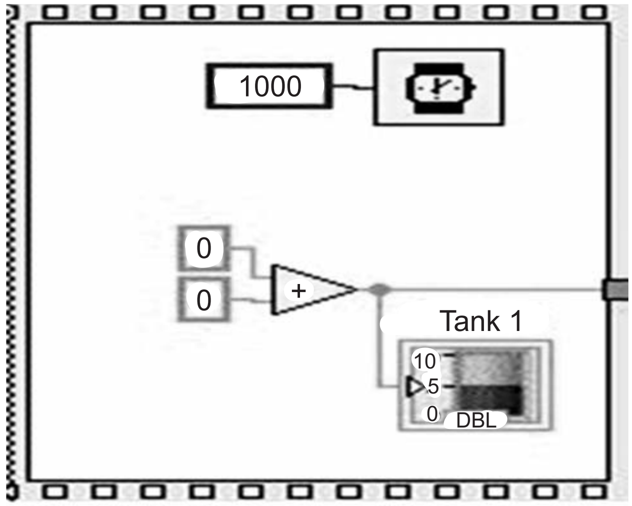

Figure 4: VI for Filling Process

The 2, 4, 5 frames are used for the mixing process. In these frames For Loop are created to perform the repeat operation. The number of times we want to repeat the task is given as the input for the Loop Count (N). Each For Loop is assigned for a desired time delay for an efficient and the proper mixing process. The output of the each loop is given as the input for the next loop by using Shift Register. As in the first frame, the output of the adder is given as input to the local variable of tank 1.

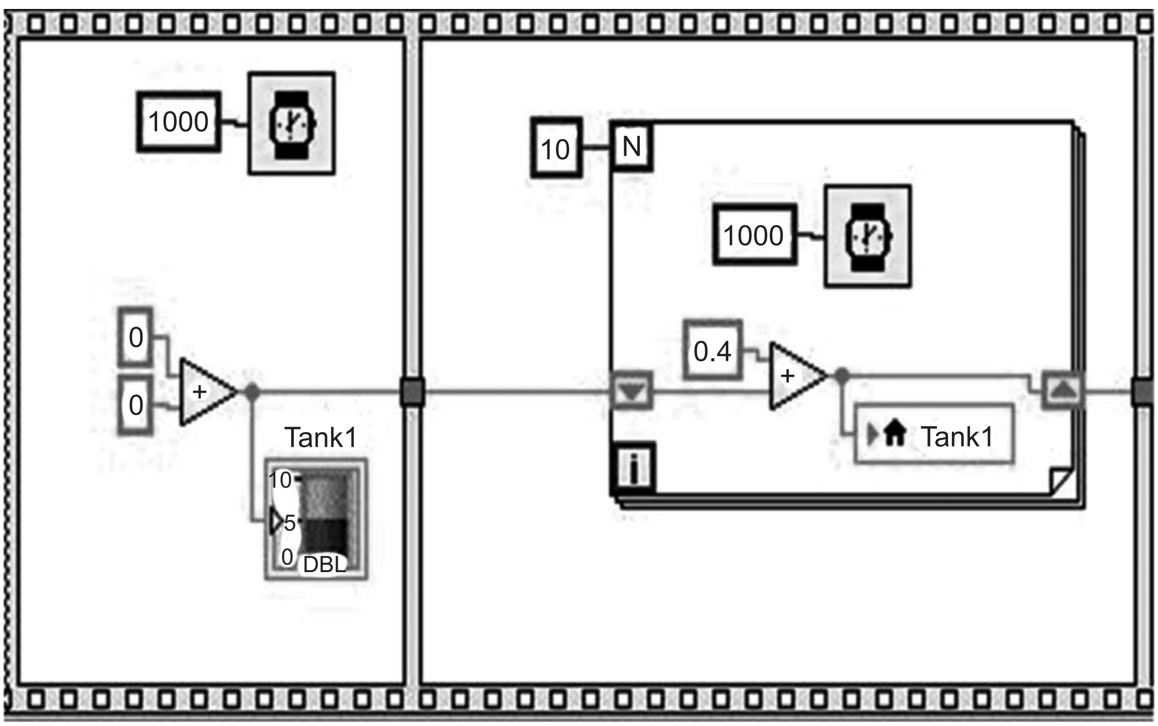

Figure 5: VI for Filling and Mixing Process

The third frame is used to give the time delay in between the mixing process. So we can get fine pasty form of flash powder which can be easily loaded to the flowerpots.

The sixth frame is used for the compressing process. The For Loop is used as same in the mixing process but the adder is replaced with the subtractor block. So once the mixing process is completed, the propellant is given for the tank 2 and it is compressed by using a stem.

Another one Sequence structure is created within the sixth frame for the sequence filling the propellant within the flower pots. The flower pots are created using the DSC module in the front panel.

A While Loop is created outside of the Flat Sequence Structure. This loop is used for the opening and closing of inlet valves. When the inlet valves are open they are indicated by blinking of the valves. The valve gets closed on complete filling and mixing. A stop button is given to stop this continuous process of mixing, compressing and loading.

In between the filling process, a time delay is given by using a timer. The delay time is assigned for the timer in terms of milliseconds (ms). This time delay is given for improving the mixing process. By this we can get high quality of propellant (pasty form of flash powder) as the output [15].

5. MIXING & FILLING PROCESS

Stage 1: Filling of flash powder and water

The initial stage of the process is filling the tank with flash powder and the water. The inputs are controlled by using the valve 1 and valve 2.

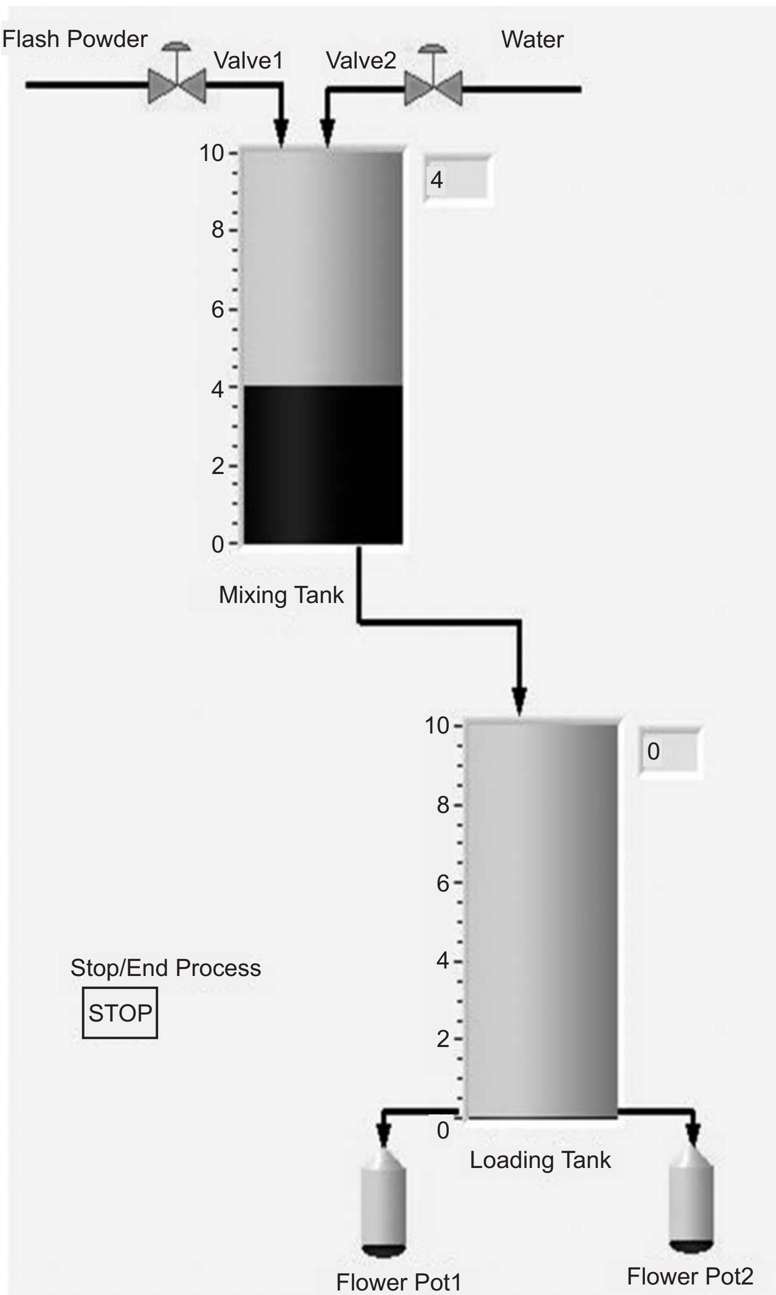

Figure 6: Filling of flash powder and water

When the program is started, the flash powder and the water are filled in tank 1 through the inlet pipes. The inflows of raw materials are indicated by the blinking of valve 1 and valve 2. As the tank level rises, the mixing is carried out along with the filling process and it continues till the tank reaches its full volume, and then the inlet valves are automatically closed. The fig.6 shows the front panel of opening the inlet valves during the filling of flash powder and the water and the level increasing in the tank 1 that is the mixing tank.

Stage 2: Draining process

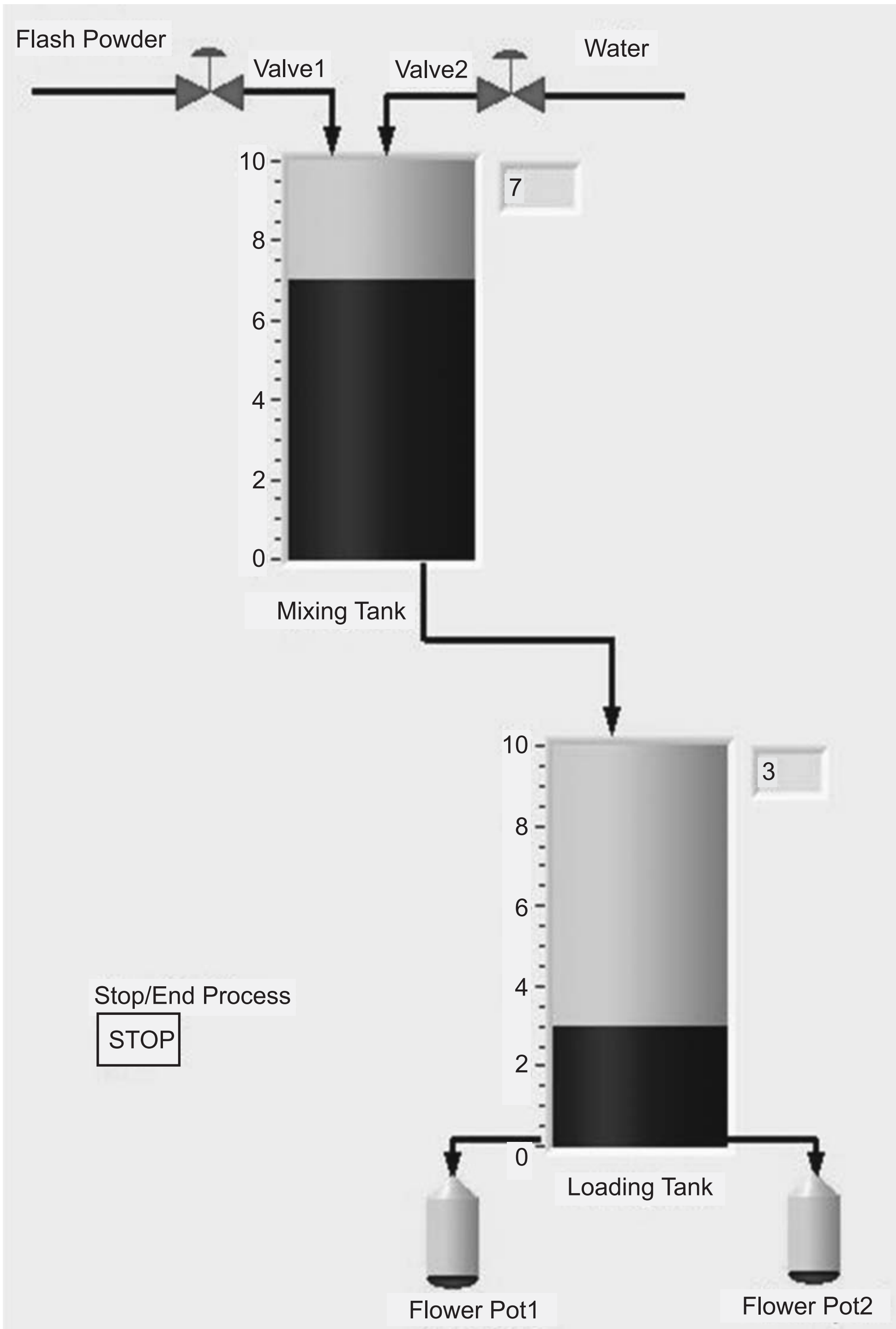

Figure 7: Draining process

When the inlet valves are closed mixing process is stopped and the propellant gets loaded in tank2. The amount of mixed propellant in the loading tank is equal to the amount of the propellant ejected by the mixing tank. The mixing tank is ejecting the propellant in step by step to the loading tank. Here the both tank has the same capacity. When the mixing is completed, both the inlet valve gets closed.

As the tank 1 drains, tank 2 gets filled up and after complete filling up, the compressing piston compresses the propellant in tank 2. This is carried out in the next step of processing.

Stage 3: Compressing and loading process

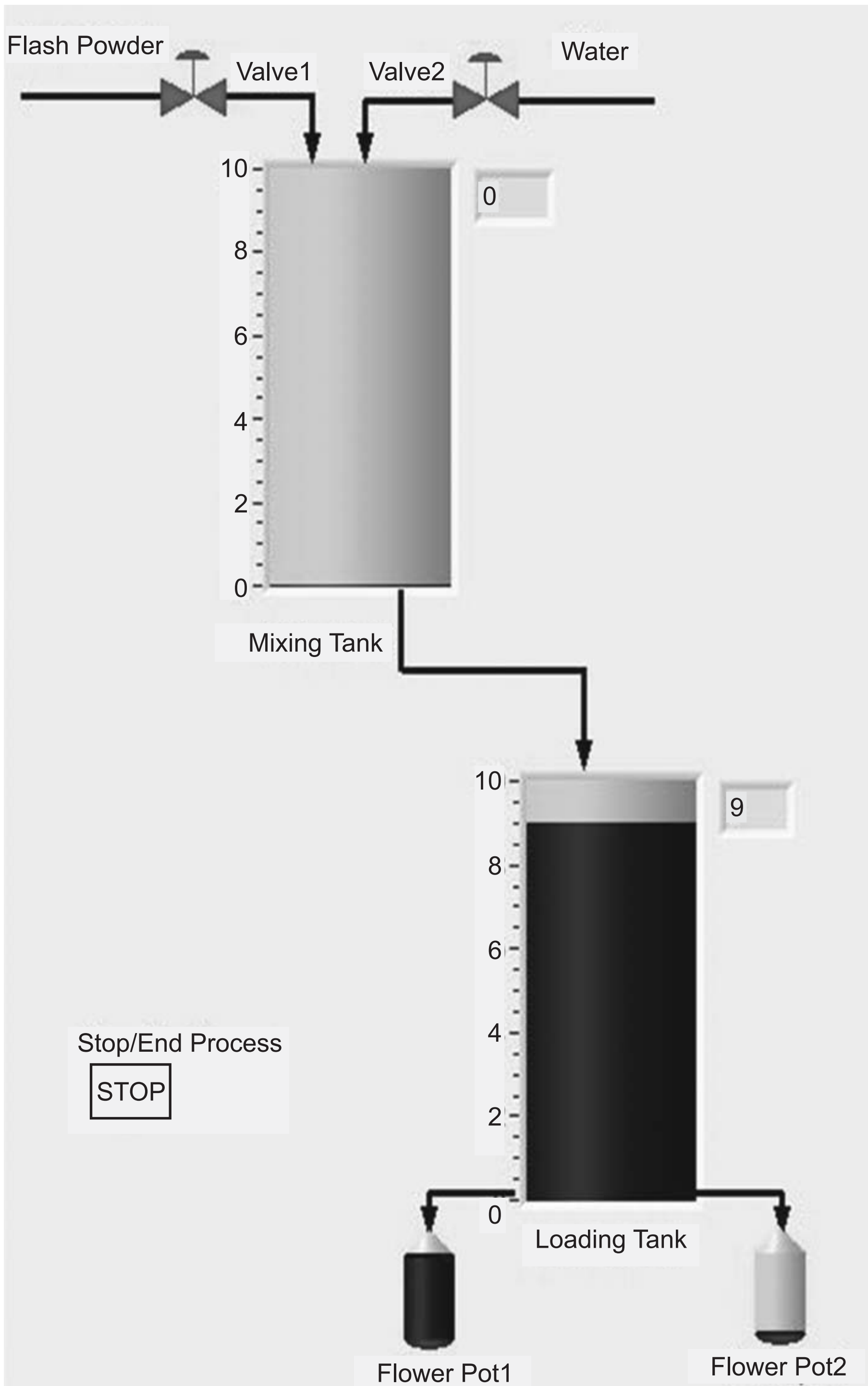

Figure 8: Compressing and loading process

After the mixing process, the propellant is drained into the second tank for loading. After the tank 1 drains, tank 2 gets filled up and after complete filling up, the compressing piston compresses the propellant in tank 2. This loads the propellant into the flowerpots which are connected to the output valve of the tank 2. The output valves are provided with a notch like structure which will be pressed using the flowerpot cone by the worker and this loads the propellant into the cone like filling an ice cream cone.

6. CONCLUSION

In this paper mixing and safe loading of the propellant into the flowerpots is done using the simulation. The filling process is carried out simultaneously with the mixing process. There is no need of human interference for handling the flash powder during the mixing process. Thereby this avoids the skin and the respiratory diseases for the workers. But the cones are needed to be filled only with human worker.

This work was designed for the small scale industries of pyrotech especially as a batch process with human intervention. We hope to extend the system as a fully automated for the large scale industries using the PLC. Here the process in performed in virtual instrumentation and in future the same process can be deployed with smart sensor networks for monitoring the temperature, humidity, pressure, viscosity, etc. By that we can maintain the temperature and humidity which would increase the production rate, and avoid the fire accidents.

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