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Simplified design and fabrication of water sprinkler system: a survey based analysis

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Abstract

Whether it is for firefighting or for irrigation system, a water sprinkler system has founds its use both industrially and residencially for safety and watering purposes. But the use of proper technology required for specific purposes has never been surveyed before. In this paper we have analyzed the market, technology and application of water sprinkler system in Bangladesh and included a brief discussion on the design and fabrication of water sprinkler system. A field survey has been performed on the application of water sprinkler system in Bangladesh as well as abroad through online. The results obtained from the survey has been summarized, interpreted to develop valuable engineering data for the designing of a rotary type automated water sprinkler using Quality Function Deployment (QFD) and subsequently fabricated using standard engineering methods involving Material Selection, Manufacturing Process Selection, Black Box Diagram etc. The newly designed water sprinkler system has proofed to be efficient, safe and easy to use for a wide range of application.

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1. Introduction

Our greatest challenge today is to satisfy an increasing demand of population while simultaneously protecting the world’s precious natural resources. Since the 1960s, water demand has been extensively studied, with the focus on

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either aggregate municipal demand or residential demand [1-4]. Innovative products and solutions are helping to meet this demand. Water being one of the most crucial resources to sustain life the need to preserve it is of extreme importance. As [5] Marshal remarked, water has played a crucial role in the location, function, and growth of communities. One of the major sources of water waste is through inefficient use of water for irrigation/gardening etc. Even though people exhibits a low level of perception of the wastage, since water bills typically represent a small proportion of income [6-7], the need to minimize the wastage is of significant importance. To counter these proper sprinkler technology can be used which enhances water and energy savings in all sectors of agricultural, industrial and residential applications.

Water Sprinkler system is a mechanism through which water is distributed in a spray so that a residential lawn or garden is irrigated. Sprinklers may take extraordinarily large forms, such as the irrigation systems used by professional farmers, and also relatively smaller form such as the typical lawn or garden watering sprinklers and the fire suppression systems. Retired people tend to spend more time gardening than others [8] and in this case use of sprinkler would be ideal, but, even so, its use is quite limited residentially throughout Bangladesh. The use of sprinklers has a positive effect on garden/crop etc. which is evident as several authors reviewed development on this area [9-14]. The objective of this paper is to analyze the market, technology and application of Water Sprinkler System in Bangladesh and its scope in future. First, the paper provides the method used, findings and the analysis in determining the views of the general mass about water sprinkler system. Secondly, the paper provides a background on water sprinkler technology in Bangladesh with respect to international standards. Third, the designing and fabrication of a water sprinkler is briefly discussed. The final section contains the prospects, recommendations and conclusion of water sprinkler system in Bangladesh.

2. Sprinkler Technology

Automatic sprinkler systems consist of a configuration of water piping to which are connected to automatic sprinkler heads, devices which open discharge water in a specified pattern and density over a designated area. Sprinkler systems reduce the wastage of water by distributing it evenly and more efficiently than manual means. On the international market the Sprinkler technology is evolving fast and the need to preserve natural resource (water) is a reason for it. Water sprinkler of various types, designs along with sophisticated gadgets are readily available. The manufacturing companies nowadays are trying to achieve:

- Greater throw distance
- Targeted watering
- Operation in freezing conditions
- Quick-change nozzle systems
- Modularity, etc.

Sprinklers with high-tech gadgets/devices increases its efficiency and effectiveness. Some of them are:

- Water sense labelled controllers - These are weather based controllers that uses local data to determine whether the sprinkler system needs to be turned on.
- Soil Moisture Sensors - Some smart controllers use soil moisture sensors to water when the soil becomes too dry. It stops watering when the soil is wet.
- Rainfall Shutoff Devices - Rainfall shutoff devices turn off the system in rainy weather and help compensate for natural rainfall. This inexpensive device can be retrofitted to almost any system.
- Sprinkler Heads - Certain types of sprinkler heads apply water more efficiently than others. Rotary spray heads deliver water in a thicker stream than mist spray heads, ensuring more water reaches plants and less is lost to evaporation and wind.
- Micro-Irrigation - Micro-irrigation or drip systems are generally more efficient than conventional sprinklers because they deliver low volumes of water directly to plants' roots, minimizing the water lost to wind, runoff, evaporation, or overspray.
Compared to all these there is a great lag in Bangladeshi market. The availability of water sprinklers (lawn) itself are quite limited let alone the presence of high-tech gadgets and equipment. Here watering of garden and lawns are generally done by manual means i.e. use of garden showers or hoses, which usually results in wastage of water, time and energy. The knowledge of existence of proper and efficient technology is not known to many. Few of the sprinklers available on the market are the ones imported from abroad and are of limited designs with almost no gadgets to further its efficiency. No water sprinklers are manufactured locally. But according to the survey the use of sprinklers could be greatly enhanced if the sprinklers are made to be readily available and at affordable prices.

3. Survey

3.1. Questions, solution and results

The observations made, information collected and analysis performed are based on the results of the surveys. People were chosen randomly for the survey to give their valuable feedback. The survey consisted of a set of 21 questions (objective) and was conducted both online and in person. Some of the questions put on the survey are as follows:

- Do you know about water sprinkler?
- Do you know water sprinkler waters lawn more effectively than by other means?
- Would you be willing to change to the water sprinkler to water you lawn/garden?
- Would you want sensors/timers/high-tech gadgets along with the water sprinkler at the sacrifice of price?
- Would you want to buy the water sprinklers which are made in Bangladesh?
- In buying a water sprinkler, does brand value affect you?
- Does aesthetics matter for buying a water sprinkler?

The results of the survey were collected and all the responses were considered and summarized in order to understand the customers’ view, demand and impression. For each of the questions, summarized bar charts were drawn showing the respective percentages of each answer. These provided crucial information in prioritizing the demands of customer which finally contributed in designing a water Sprinkler.

3.2. Survey challenges, discussions, validation

One of the major difficulties faced during survey was that only around 40% of the people in Bangladesh had knowledge of water sprinklers prior to the survey. This could be accounted for the negligence of gardening/having lawn in front of houses in the urban areas. In order to overcome this we decided to give a brief introduction about the water sprinkler system (lawn) prior to the conduction thus assisting and validating the survey to a certain extent. Other issue faced deals with the online survey, which was accessible only to a minority of the people in Bangladesh as the internet users are quite small. Summarizing the results in graphical form tends to give a clearer understanding and thus making the survey more reliable.

3.3. Survey analysis

The major outcomes from the survey found are: Cost effectiveness, Corrosion/Wear resistance, Light Weight, Portability, Aesthetics, Ease of Maintenance, Coverage, Quality and Longevity of the Sprinklers. In order to meet these demands Quality Function Deployment (QFD) has been used to convert the customer requirements into appropriate technical specifications. A QFD can be defined as a matrix used to capture the voice of the customer and translate it into technical information that an organization can use to create or improve a product. The customer requirements and the corresponding technical specifications are shown in figure 1. Explanation of relationship between Customer Requirements and Technical Requirements:

- Use of Brass: Water presence in the vicinity hence need of a low corrosion/wear resistant material. Other factors are cost effective, good aesthetics, longevity etc.
- Use of Stainless Steel pipe: Corrosion/wear free, aesthetics, low weight etc.
- Exchangeable parts: Easier for maintenance, lowers cost.
- Spray head: Better coverage, fine spray.
- Multi stream: Large coverage, aesthetics etc.
- Product Size: Size plays a crucial role in cost effectiveness, low weight, portability etc.
- Use of paints: Paint acts as a coating to prevent rust/corrosion and enhances aesthetics.

![QFD matrix](image)

**Fig.1. QFD matrix**

### 4. Design and Fabrication

The proposed design of water sprinkler is the multi-streamed rotary sprinkler type. The rotary motion is achieved solely through the pressure of the flowing fluid. The base remains fixed and the water flows in through it via water piping system. The bolt is screwed with the base by means of screw thread system which allows the rotary cylindrical stem (lower), passing through it, and the rotary cylindrical stem (upper) to rotate with respect to the base. Three nozzles bent into three different angles vertically (approximately 10°, 12° and 14°) to achieve uniform coverage. The spray head converts the incoming water into sprays. The use of spray head is justified due to the fact that some investigators have found that raindrops of sprinklers break down aggregates and compact thin surface layers and lead to seal or crust formation and hard setting [15-17]. Larger sprinkler intensity produced greater changes and influenced deeper soil layers on properties of soil structure [18, 19]. However, soil structure is damaged very slightly when drops are very fine and so is the spray heads used at the tip of nozzle. The design is shown below:
A timer circuit mechanism, which is basically a time-responsive releasing mechanism for watering areas following a fixed pattern and time interval, has been connected to automate the watering to a certain degree. A schematic diagram is shown in figure 3. All the dimension of the sprinkler system has been shown in figure 2(c).

For the fabrication of the water Sprinkler standard engineering methods involving Material Selection, Manufacturing Process Selection and Black Box Diagram were followed. Material used being Mild Steel for the Lower Body (Base) and the rest from Brass. The manufacturing process involved is as shown in Table 1.

<table>
<thead>
<tr>
<th>Name of Parts</th>
<th>Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Body (Base)</td>
<td>Shear cutting, Bending, Gas welding</td>
</tr>
<tr>
<td>Rotary Cylindrical Stem (Lower)</td>
<td>Turning, Drilling, Thread cutting</td>
</tr>
<tr>
<td>Rotary Cylindrical Stem (Upper)</td>
<td>Turning, Drilling</td>
</tr>
<tr>
<td>Nozzle</td>
<td>Outsourcing, Bending, Threading</td>
</tr>
<tr>
<td>Spray-head</td>
<td>Turning, Drilling, Threading</td>
</tr>
</tbody>
</table>

Various standard guidelines such as DFM (Design for Manufacturing), DFA (Design for Assembly) etc. has been followed to ensure the product is up to the market standard. The designed Sprinkler has been tested in terms of its coverage, longevity, quality of spray produced, dispersing pattern of water etc. and compared with those available on market. The results obtained from the testing process were satisfactory.

5. Prospect and Recommendation

As of yet Water Sprinkler Systems are not manufactured locally in Bangladesh which is one of the reason due to its unavailability. Majority of the people are unaware about the extent of wastages imposed by the manual means of watering. The fact that using Sprinklers reduces wastages, reduces water bills, serves as good aesthetics, reduce time
and human attention, its demand can be significantly increased within a short time if brought into attention. Its application in the fire suppression system also of significant importance as it has proven to be the most effective means for protecting life and property against fire. With the number of industries booming in Bangladesh the need of the sprinkler to control the fire needs to be one of the base requirements. If somehow the production of water sprinkler systems can be stimulated locally then both the cost and application can be greatly enhanced.

6. Conclusion

A field survey has been performed to collect information about the current uses and prospects of water sprinkler system in Bangladesh. The current technology is also investigated during the survey. Based on the survey conducted, recommendation has been made on new design for the local application. Also a new design has been proposed, fabricated and tested in standardized condition. The new design has been performed efficiently with less water wastages. The survey results also showed that the ignorance of use of this kind of technology hampers the development of production line of such kind of devices. Though this kind of device may be thought of luxurious product, the proper development in design and manufacturing of a water sprinkler system is still required to reduce the wastages of water and energy. Also as it is used for protection against fire hazards in many office and industrial building, an improved design can limit the fire spreading and saves many lives and cost of money. Thus, it can be concluded that provided enough awareness about water loss, time consumption and efficiency can be raised the use of sprinklers residentially can be greatly enhanced. With the proper demand, production of sprinklers locally would be stimulated thus lowering costs and better availability

References