A COMPUTATIONAL COMPARISON MODEL TO ASSESS APPLIANCES APPLIED TO WATER TAPS

ROUBI A ZAIED

[1]Industrial Engineering Department, College of Engineering, Northern Border University, Saudi Arabia
[1,2]Mechanical Engineering Department, Benha Faculty of Engineering, Benha University, Egypt
Email: [1]roubi.zaied@nbu.edu.sa, [2]rouby.nasr@bhit.bu.edu.eg

Abstract - There are several available types of appliances differ in shapes, durability, appearance, functionality, sizes and prices which vary accordingly. To help the decision maker in selecting among alternative, it is suggested to use a six-measure model to assess public appliances. The six measures are: Worth, Appearance, Toughness, Ease of use, Repair-ability and Saving of resources (WATERS). The proposed model is applied to compare water taps intended for use in ablution (Wudu) facilities. The performance indicator is the model output used in the assessment and it is computed by dividing the system output by its input. The tap-system input is its price and the output is a sum accumulating the other weighted five measures score. Sensitivity analysis is performed on the model and it automatically finds the performance. The approach is characterized by its simplicity through using a generic software such as MICROSOFT-EXCEL for calculating the model outputs and making sensitivity analysis. This model can be generalized for other types of public appliances such as electric household appliances and cars since the used measures are common.

Keywords - Ablution Facilities; Assessment model; Appliance selection; Sensitivity analysis, Water taps; Resource saving; Wudu facilities g.

I. INTRODUCTION

There are several types of public appliances available and they differ in shapes, durability, appearance, functionality, sizes and prices which vary accordingly. Peter T. du Pont (Peter 1998) found that, in United States, price, features, and size were ranked as the top-three criteria by both consumers and salespeople. The consumer responses showed a greater variety of priorities: five criteria were ranked among the top three by at least 30% of respondents: price, features, size, quality, and brand. Energy efficiency was listed as a top-three criteria by only one in ten consumers and ranked ninth, after color, delivery, and finance. Annemie and van de Moosdijk (Annemie 2001) shown that saving 5% to 10% of the domestic energy use can be achieved by correct domestic behavior. Their project was to encourage energy saving by developing a set of some behavioral variables for energy efficient use of household appliances and lighting in addition to the purchasing energy efficient household appliances. The study of Imran Khan et al. (Imran 2012) revealed that impact of advertisement and knowledge about brand increases as customer age increase. All the brand related factors show positive relationship with purchase intention of customers.

Wa'elHussien et al. (Wa'el 2017) used a bottom-up approach to develop a model comprising the interactions between water, energy and food at end-use level. CharalamposTriantafyllidis et al. (Charalampos 2018) presented a platform to evaluate new infrastructure projects by assessing their design and effectiveness in meeting growing resource demands, simulated using Agent-Based Modelling. B. Kareem and A. Adekiigb (2017) carried out a study of the cost and benefit of adopting modern communication channels/media in industry aside from traditional human messengers. They recommended a development of a generalized system, which can accommodate varying organizational complexities and attitudes associated with personnel.

To cover additional water demand, demand management is employed to reduce the water demand per capita (Evangelos 2013). Christos Makropoulos et al. (Christos 2008) developed a decision support tool to facilitate the selection of combinations of water saving strategies and technologies and to support the delivery of integrated, sustainable water management for new developments. The technology selection is driven by a GA algorithm allowing efficient exploration of the decision space. Quantitative and qualitative sustainability criteria and indicators are used to compare between alternative composite water management strategies while preserving the multiobjective nature of the problem. For selection of a prime mover for combined cooling, Kibria et al. (Kibria 2016) used three evaluating measures; economic, energy and emissions savings.

In this study, it is suggested to employ a six-measure in a computational model. The model is to be used for comparison purpose to help in selection among offered appliances. These main measures used to assess appliances are: Worth, Appearance, Toughness, Ease of use, Repair-ability and Saving of resources (WATERS). Thus, a positive correlation must exist between the worth and the goodness of the other five measures. It can be generalized for different types of public appliances through fixing the relative weights of measures and determining suitable values of these measures for each alternative. The method is applied on some water tap alternative designs to assess the effectiveness of tap price against its five measures of assessment.

II. A PROPOSED SIX-MEASURE MODEL TO ASSESS APPLIANCES

Examination revealed that there are almost six main measures used practically in selection among available alternatives. A diversity of modern designs is commercially offered for use in private properties. Suitable price, durability and resources saving are used where the appearance is less considered. Usually, the appearance is the key factor considered in selection of individuals. So, he has these measures arranged in a descending order of significance that is (WATERS). Meanwhile usual user give priority to the first two measures, an environmental engineer has a different view when he selects an appliance for public use. The environmental specialist may arrange them as (WSERTA) because he concentrates more on saving of resources. Further, civil professional may arrange them as (WTRESA). A featured clarification of the measures, a method to assign their suitable numerical values and how the price paid is compared to its effectiveness within the rest five measures are defined far ahead in a case study.

The mentioned six-measures (WATERS) are hired in a mathematical model whose inputs are eleven numerical values represent the worth; W, other 5 measures and their corresponding relative weights (A, WA, T, WT, E, WE, R, WR, S, and WS). The model output is a single value represents an indicator of performance. The first measure, worth; defines the price paid. The Flowchart in Fig.1 shows planned steps of applying the proposed six-measure model to assess appliances.

The first step to apply the approach is to assign suitable numerical values of the eleven variables. The output values of each run in the loop presented in the flowchart are dimensionless indicator values. These values are sorted in descending order in the last step for comparison purpose to be used for selection decision making.

III. APPLICATION OF THE METHOD ON SELECTION OF WATER TAP DESIGNS

3.1. Definition of Model Variables

For public use, there are different criteria for selection of water taps to be installed in pubic W.Cs. Suitable price, durability and water saving are used when the appearance is less considered. When talking about hotels and those competitive profitable facilities, the appearance is more considered. Now, let's apply the proposed six-variable scale (WATERS) to assess some tapsfor selection among their available designs. Here is an explanation of the six variables:

- Worth: refers to the monetary value of the tap. This includes the brand because a brandreputationis built with time according to the confidence of costumers in the tap quality. Thus, a good brand usually implies high price and great features.
- Appearance: refers to the attractiveness of the tap shape. Internal factors embraced in attractiveness may involve brilliance, purity of materials, colors, novelty, smoothness, consistency and size.

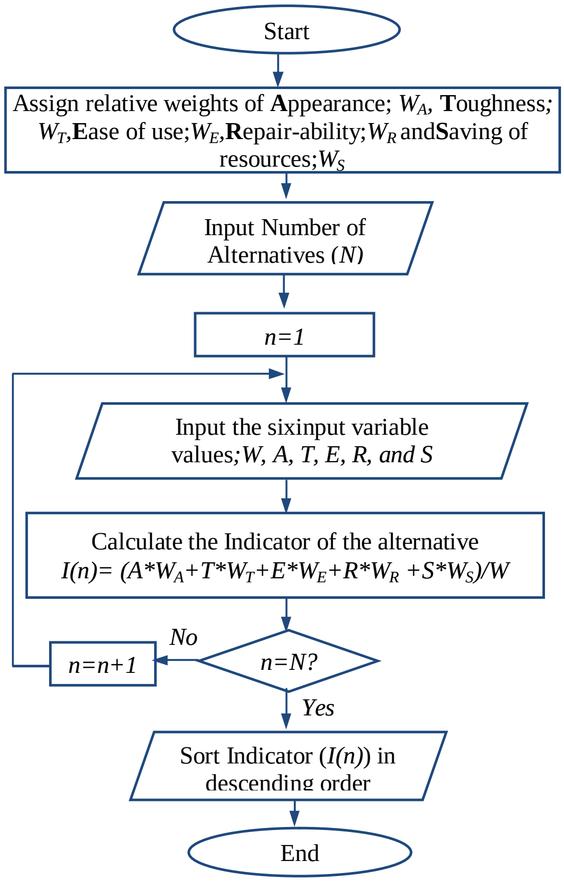


Fig.1. A Flowchart of Applying the Proposed Six-Measure Model to Assess Appliances

- Toughness: refers to mechanical resistance to break or wear and robustness against stuck or water leakage. The durability of the tap structure depends mainly on the strength and quantity of the tap materials.
- Ease of use: means how small is the force and movement needed to open, close and control the water flowrate and temperature.
- Repair-ability: how easy is to find spare parts and a repairer for a faulty tap.
- Saving of resources: refers to saving of water and energy.

The last variable has high importance especially with increased need for rationalization and tendency of governments to increase the fees of water consumption. Millock, and Nauges(Millock 2010) Used survey data of around 10,000 households from 10 countries. The results indicated that environmental attitudes and ownership status are strong predictors of adoption of water-efficient equipment. In terms of policy, they found that households that were both metered and charged for their water individually had a much higher probability to invest in water-efficient equipment compared to households that pay a flat fee.In a previous work [5], a mathematical model is proposed to estimate the economic feasibility of using a specific sort of taps and it is applied to taps of washing basins in a public facility. The variables used are:water supply price, tap deterioration cost, tap running cost and tap monthly maintenance cost

Now, the assessment is economic in base as well and the indicator of performance (I) for a specific tap which is the model output will be calculated from the next proposed equation:

$$I = \frac{A \cdot w_A + T \cdot w_T + E \cdot w_E + R \cdot w_R + S \cdot w_S}{W}$$

The value of I isa performance indicator for the assessed tap by dividing its output by itsinput. Here the pricepaid for the tap (W)is the tap system input and its output is sum in brackets accumulating the five measures weighted score. This formulation evaluates the price paid for the tap to its effectiveness within the rest five measures. To be bear in mind that this model is used for comparison among different available taps when prices are known.

3.2. Setting theValues of Model Input Variables

The first measure, Worth, will be thought-out having a direct monetary value or selling price of the tap sort. But, setting the other five measures and their weights is most important and problematic task in the approach. The user can use his experience to assign relative weights of Appearance; WA, Toughness; WT, Ease of use; WE, Repair-ability; WR and Saving of resources; WS.

The model itself can be used for sensitivity analysis by changing the relative weights of the measures and getting their effect on the model output. A submodule can be designed to help user in setting these weights by asking him successive closed questions about relative benefits of the measure considering and problems associated with ignoring it. His selected answers are quantized and scores of each measure are used to estimate the relative weights of the five measures. The measure relative weights can be introduced to the model as percentages or numbers from 0 to 10 and it is not necessary that the sum of weights is 1 or 100.

Setting the numerical values of the five measures can be achieved using historical data if they are available, direct undistinctive or even distinctive testing of the tap otherwise the third way is to guess their values depending on a professional experience. Over again, a submodule can be designed for each measure to estimate its value more precisely. The measure values similarly can be introduced to the model as numbers from 0 to 10 or from 1 to 100 provided that the same scale is used with all alternatives to be assessed or compared. Again, if the value of each measure is assigned values up to 10, estimation can be set as follows:

- Excellent (from 8 to 10),
- Good (from 6 to 8),
- Moderate (from 4 to 6),
- Bad (from 2 to 4), and
- Terrible (less than 2).

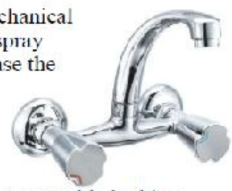
3.3. A Case Study

The proposed six-measure model is used to assess five ablution taps shown in Table1. Ablution is a mandatory religious routine for Muslims that is repeated several times daily for prayers and other deeds (Roubi 2016). Ablution actions indeed include washing of hands, face, mouth, nose, arms, swabbing on head, ears and washing feet. For typical application, prices of taps are obtained from real online suppliers and measures are assigned values according to each tap performance through the author experience. Then, each of the five measures is given flat weight of 2. Table 2 figures the measure values for each tap and the calculated model output. These output-indicators are assessed based on their realization of the proposed measures. The serial numbering of taps is same in Table1.

The proposed six-measure system is applied to assess the five taps using 2.0 as a flat weight for all measures. It was revealed that mechanical knobs type-tap showed highest indicator (I = 0.56) because of their reasonable price relative to its other good characteristics. Automatic taps have the minimum indicator (I = 0.14) due to its high price.

Sensitivity analyses make it possible to identify the most important parameters in relation to building performance and to focus design and optimization of sustainable buildings on these fewer, but most important parameters (Per Kvols 2009). For sensitivity analysis, weights are not considered alike and indicators are recalculated. A MICROSOFT-EXCEL sheet is used to calculate the model outputs as presented in Table3. Shaded cells are automatically calculated by inserted functions and other cells are manually filled using associated data for each tap.

Table1: Specifications of Assessed Water Taps Used in Ablution

No.	Description
1	A traditional wall mount-mechanical knobs-mixer tap with water spray attached to its spout to increase the spread area of water. Knobs open and close the tap through several revolutions.  **Advantages:**Sensible Price - Acceptable looking - Availability of spare parts **Disadvantages:**Slow opening and closing and water wasting-Sticky fingers slide on knobs and loss control

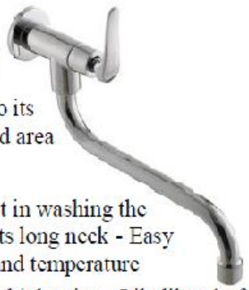
2	A wall mount-mixing tap with single lever and long rotatable outlet. A water spray is attached to its spout to increase the spread area of water.  **Advantages**: More comfort in washing the arms and legs because of its long neck - Easy control of water flowrate and temperature **Disadvantages:** Relatively high price - Likelihood of breaking or leaking because of long movable outlet
3	Vertical downward water exit- U-shape spout-mixing tap with single-vertical lever to control water flow and temperature.  **Advantages**: Good-looking-Easy control of water flowrate and temperature. **Disadvantages:**Not suitable for washing the arms because of its low spout -Most users do not close it while hands are busy
4	Single short lever-short pillar-mixer tap with inclined spout. The lever controls water flow andtemperature.  **Advantages**: Reasonable price -Good-looking -Easy control of water flowrate and temperature **Disadvantages:**The short neck isuncomfortable-Most users do not close it while hands are busy-Water direction can be affected if water pressure is high or low.
5	Automatic mixer tap with small side lever to adjust mixing to control theexit water temperature  **Advantages**: Goodlooking-Endurance -Quick open and close-Relative water saving **Disadvantages:**-More expensive - Needs electrical energy -Wastes water because of delay time- It is difficult to determine the suitable position for hands to cut the ray

Table2: Model Outputs of the Five Assessed Water Taps and Measure Proposed Values

Tap No.	Proposed Values of Measures	Model Output(I)
1	Worth: 100 Appearance: 7; Good Toughness:6; Moderate Ease of use: 3; Bad Repairability:10; Excellent Saving of resources: 1; Terrible	0.56
2	Worth: 120 Appearance: 7; Good Toughness:6; Good Ease of use: 7; Good Repairability:4; Bad Saving of resources: 6; Good	0.50
3	Worth: 120 Appearance: 8; Good Toughness:8; Good Ease of use: 8; Good Repairability:3; Bad Saving of resources: 5; Moderate	0.41
4	Worth: 150 Appearance: 9; Excellent Toughness:9; Excellent Ease of use: 8; Good Repairability:3; Bad Saving of resources: 5; Moderate	0.45
5	Worth: 600 Appearance: 10; Excellent Toughness:10; Excellent Ease of use: 9; Excellent Repairability:3; Bad Saving of resources: 9; Good	0.14

When the priority is given to one measure from the five measures in the model (ATERS), it is realized by setting the measure weight to 10 and the other four measure weights are set to 1.0 each. Obtained results are presented in Fig. 2. To recognize the effect of changing measure weights on the indicators, just change the relevant cell value and the effect appears simultaneously in the shaded cells and in the plot.

RESULTS AND DISCUSSION

Applying the model to assess the different five taps confirmed the model applicability and its ease of use. Results obtained for the taps indicates that the tap purchasing price is the key factor in selecting among the five taps when all the five measures (Appearance, Toughness, Ease of use, Repair-ability and Saving of resources) are given the same weights. For the specific data used in modelling, automatic taps can be competitive to other taps only if its price decreased to 30% of its used price.

Already some Chinese manufacturers recently offer automatic taps in this range of competitive low price. The two taps having single control lever (Tap No. 2 and No. 3) have similar behavior as an ablution tap with all priorities where No. 2 is always dominant and both taps dominate the automatic tap No. 5. In general, the traditional mechanical knobs-tap is ruling except for Ease of use and Saving of resources.

Table3: The MICROSOFT-EXCEL sheet cells used to analyze the model

Tap No.	Tap No.1	Tap No.2	Tap No.3	Tap No.4	Tap No.5
Worth	100	120	150	150	600
Appearance:	7	7	8	9	10
Toughness:	7	6	7	9	10
Ease of use:	3	7	8	8	9
Repair-ability:	10	4	3	3	3
Saving of resources:	1	6	5	5	9
Weight Change Case	W_1	W_2	W_3	W_4	W_5
Priority for Appearance	10	1	1	1	1
Priority for Toughness	1	10	1	1	1
Priority for Ease of use	1	1	10	1	1
Priority for Repair-ability	1	1	1	10	1
iority for Saving of resources	1	1	1	1	10
	Indicator of Performance				
Flat weights	0.56	0.50	0.41	0.45	0.14
Priority for Appearance	0.91	0.78	0.69	0.77	0.22
Priority for Toughness	0.91	0.70	0.63	0.77	0.22
Priority for Ease of use	0.55	0.78	0.69	0.71	0.20
Priority for Repair-ability	1.18	0.55	0.39	0.71	0.11
iority for Saving of resources	0.37	0.70	0.51	0.41	0.20

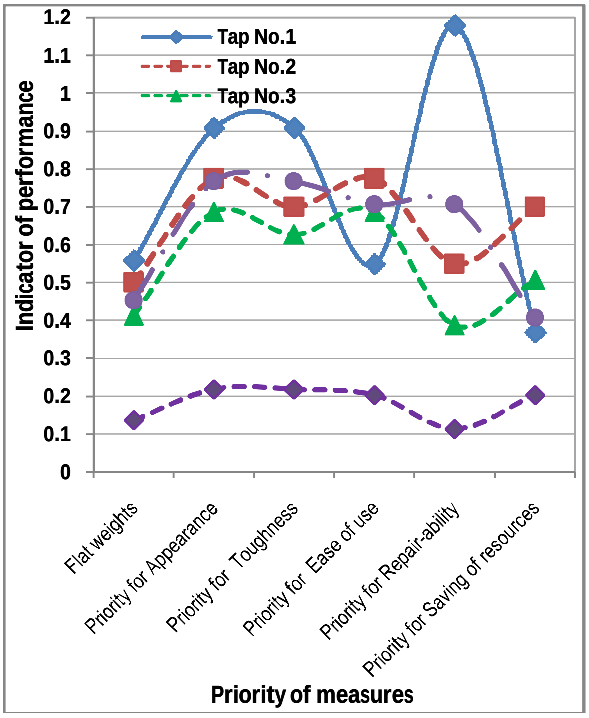


Fig.2. Change of Indicator of performance with weights of the measures

For using these taps in ablution, when the priority is for saving of recourses, taps are arranged in descending order as: single lever and long rotatable outlet, single-lever U-shape spout tap, short lever-mixer tap with inclined spout, mechanical knobs-tap and finally the automatic one. If other alternatives are offered, their data can be introduced to the model and it gives their indicators of performance to help the decision maker in selecting the most suitable alternative.

CONCLUSIONS

In this work, a computational model is proposed to assess the performance of appliances and it is applied to compare five water taps intended for use in ablution facilities. The criteria used in the comparison include six measures; Worth, Appearance, Toughness, Ease of use, Repair-ability and Saving of resources (WATERS). A performance indicator used in the assessed is computed by dividing the system output by its input. The input is the price paid for the tap and the output is a sum accumulating the five measures weighted score. The major conclusions are as follows:

1. For using taps having specific features in ablution, when the priority is for saving of recourses, single lever with long rotatable outlet-tap comes first as best choice and the automatic one comes last due to its high price.
2. Automatic tap can be competitive to other taps presented in this work only if its price decreased to 30% of its price.
3. For sensitivity analysis, data are introduced to the model and it gives their indicators of performance to help the decision maker in selecting the most suitable alternative.

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