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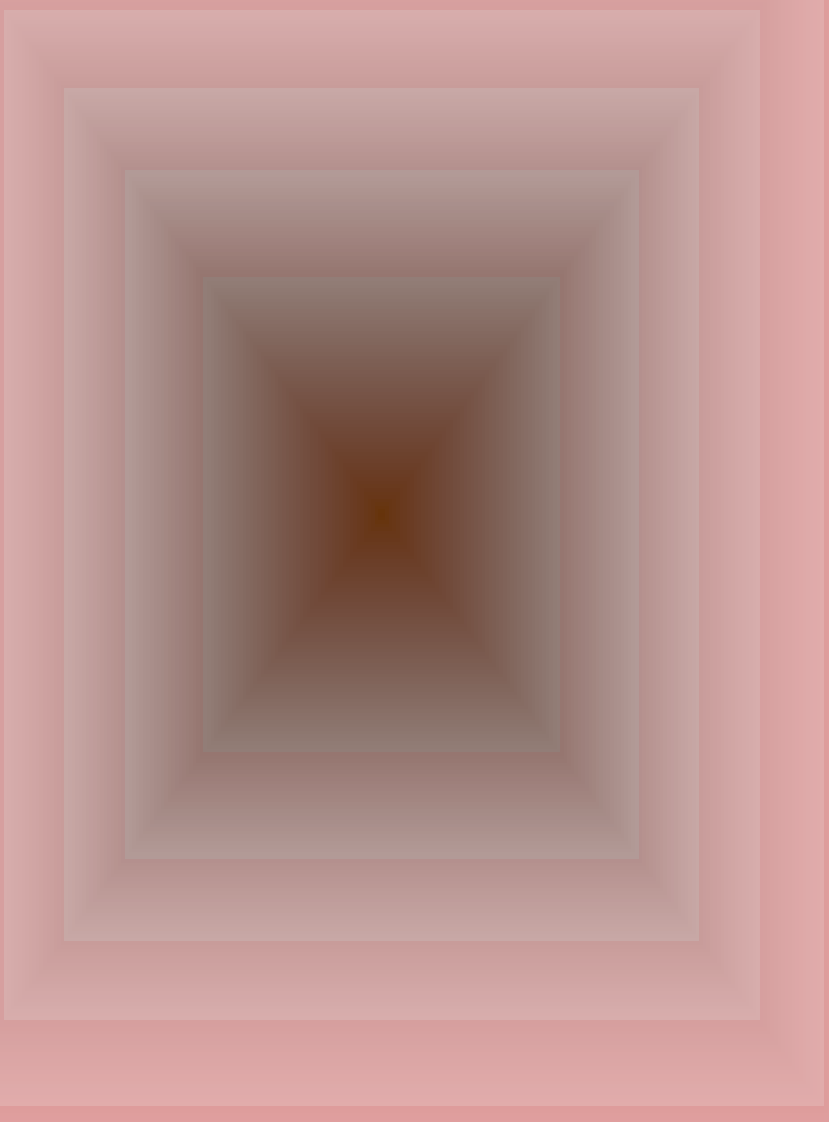

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International Journal of Water Resources and Environmental Engineering

Review

Two offers to prevent excessive water consumption: A proposal for industrial design departments of universities

Murat Sönmez

Mechanical Engineering Program, Northern Cyprus Campus, Middle East Technical University, Guzelyurt TRNC Mersin 10 Turkey.

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Water resources play an important role in the development of the socio-economic status of a country. The world's population increased from one billion to six billions in less than 200 years. With the rapid increase in population and advancement in technology, demand for water increases steadily and the limited amount of available fresh water sources are subjected to severe environmental problems. Available fresh water in the world, which is less than 1% of the total volume of water on the Earth, is unevenly distributed. Therefore, management of water resources is very important. Limited fresh water resources are to be conserved against growing demands. In arid regions, it is extremely important to use water efficiently. This article aims to draw attention to the errors in the design of some shower mixers and disk type faucets, that cause excessive water consumption, and offers a retrofit and compression type faucets, respectively for having better water utilization efficiency. Additionally, in this article, considering the errors in the design of shower mixers and some other products, which are formed by the graduates of industrial design departments of faculties, it is commented that to be able to prevent or at least minimize errors in conceptual designs, the industrial design departments should be restructured to offer only 2nd tier programs for the graduates of engineering faculties.

Key words: Water conservation, shower mixer valve, faucet valve, industrial design departments

INTRODUCTION

Growing population, environmental concern, climate change, droughts highlight the importance of freshwater conservation. The total quantity of water on the Earth is estimated to be 1.4 billion cubic meters. However, nearly 96.5% of it is in oceans, seas and bays. Only 3.5% of the total is freshwater, and more than two-thirds of it is in polar ice caps, glaciers and permanent snow (Anand, 2007). This means available fresh water in the world is less than 1% of the total. Freshwater is a highly valuable resource for a large number of competing demands, including drinking water, irrigation, hydroelectricity, waste disposal, industrial processes, transport and recreation, as well as ecosystem functions and services. Water demand dramatically increased as a consequence of

E-mail: sonmez@metu.edu.tr.

population and income growth, and the expansion of industry and irrigated agriculture, so that demand now exceeds supply in many developed and developing countries. Today, freshwater scarcity affects more than a billion people and the integrity of many of the world's ecosystems (UNEP Report, 2013). It is reported that more than 1 billion people cannot have access to safe drinking water, and 3 million die each year from avoidable water-related diseases (Thornton, 2002).

In these circumstances, water conservation becomes a necessity in the regions where fresh water sources are insufficient (Yanmaz, 2006). Water conservation can be shortly described as any beneficial reduction in water use or in water losses. In general, the ways to conserve water can be grouped into two categories:

1. Technical measures; via using water-saving fixtures and retrofits (such as; by installing low-volume toilets and urinals, waterless urinals, low-flow showerheads and faucets, water-efficient clothes washers and dishwashers in residential domestic water usage…), applying efficient irrigation systems (such as the ones having automatic shut-off hoses, rain sensors…), replacing some industrial processes with more water efficient ones (such as cooling towers with recirculated water, systems which use recycled process water…), using drip irrigation systems, recovering tail-water in agriculture, using intelligent water supply systems which detect leakages and the plumbing element that is to be replaced or repaired.
2. Behavior or management practices: Organizing education programs and campaigns to raise awareness of insufficient water supply resources, to educate customers about wasteful water use practices (such as highlighting the importance of shutting off unnecessary flows from showerheads and faucets, running cloth and dish washers only in full loads, using water-efficient equipment and of preventing water losses due to leakages and dripping from pipes and fittings, reusing water (gray water usage), applying disincentive metering and pricing policies, forcing consumers to save water via regulatory action (Green, 2010; Vickers, 2001).

Here, it is noticeable that benefits of water conservation are not restricted only to water saving, reduced waste-water flow, reduced piping and fluid machinery size as well as their installation costs. Via water conservation it is also possible to reduce energy consumption for pumping water and via which to reduce pollutants and greenhouse gasses emitted in power plants where the electricity is produced.

In this article, a simple retrofit to modify shower mixers is proposed for preventing unnecessary water consumption and also disc and ball faucets are recommended to be replaced with classical compression faucets in residential use. Additionally, considering the errors in the design of shower mixers and some other products, which are formed by the graduates of industrial design departments of faculties today, it is commented that to be able to prevent or at least minimize errors in conceptual designs, the industrial design departments should be restructured to offer only 2nd tier programs for the graduates of engineering faculties.

RESIDENTIAL AND DOMESTIC WATER USE- A SIMPLE RETROFIT TO RECTIFY DESIGN ERROR OF SHOWER MIXTURES FOR WATER CONSERVATION

Residential water use has a considerable percentage of the total. Water consumption for residential purposes constitutes about 26% of total use in the United States (Vickers, 2001), 15% in Turkey (Karakaya and Gönenç, 2013), and 16% as an average in EU countries (Knight and Bakewell, 2007). Several factors affect the amount of water used in homes: efficiency of plumbing fixtures and appliances, household income, climate of the region, lifestyle and awareness of the need to conserve water of residents, policy and the corresponding legislation of the country on water use, etc. Water is used mainly for cleaning and sanitation inside the home. While the amount of indoor water use for a single-family house typically ranges from 200 to 300 ltpcd (liter per capita per day), it finds the value between 170 and 260 ltpcd in multifamily residences (that is, apartments). As average, water consumption percentages in a non-conserving single-family home are almost 27% in toilets, 17% in showers, 16% in faucets, 22% in clothes washers, 14% system leaks. Water may be wasted inside the home from old, inefficient plumbing fixtures and appliances, leaking toilets and faucets, design errors of appliances, as well as wasteful water-use habits.

Today, new industrial and domestic products are formed by industrial designers at the conceptual design stage. Unfortunately, since some basic engineering courses do not exist or are not sufficient in the curriculum of industrial design departments, the graduates may only focus their attention on the appearance and some artistic details of the products, not to the engineering details, manufacturability, and efficiency. If the conceptual design is not completed by professional engineers then, the product may be marketed with some technical errors and cause waste of energy, water and/or some other natural sources, and also cannot satisfy the expected demands of customers. This article subjects such an error in the design of one of the type of modern shower mixers and proposes a simple, but effective retrofit to rectify it.

A shower mixer blends the hot and cold water and supplies the conditioned water either to the spout or to the shower-head. Water is routed in one of the ways depending on the position of the diverter, which is a special valve. In the design of the mixers shown in Figure 1, if the diverter is in its down position when the faucet is levered on, water flows directly through the spout. If the

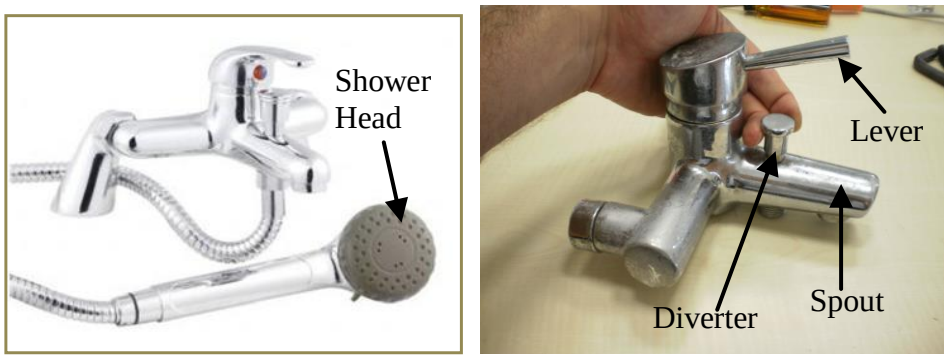

Figure 1. Single-lever shower mixer.

diverter is pulled up, then water changes its way and flows up to the shower-head. After bringing the diverter to its up position, to hold it at that level, the dynamic pressure of the water flow must be sufficiently high. This condition is normally satisfied if the water flow rate, another words, water consumption is high. Although the flow rate is to be decreased during the soaping/ shampooing and cleaning for saving water, whenever it is attempted the diverter stem drops to down position and cuts the flow. Such a working principle of the diverter prevents water from flowing through the shower head when the lever of the mixer tilted on at the beginning of taking a shower; but since household needs to set the flow to maximum rate to be able to prevent undesirable flow interruptions, it makes this type of shower mixers low efficient. From water conservation point of view, that working principle actually is a design error. In the staff houses of the Middle East Technical University Northern Cyprus Campus (METU NCC), unfortunately, this type of shower mixers is in use. There are a total of 140 houses on the campus. Northern Cyprus has a subtropical semi-arid climate. Water resources are insufficient. Ground-water resources are exposed to salt water from the sea due to insufficient rainfall and excessive consumption relative to the capacity of basin. Considering the scarcity of fresh water and difficulty exercised to keep water flow through the shower head in taking shower, the author of this article has proposed a simple retrofit to rectify the design error of that type of shower mixers. The retrofit is a disk, which is made of polyethylene-1000, with a channel that is to fit to the space, which is under the rim of the diverter head when the diverter is in its up position (Figure 2). Simply, by wedging the disk between the head of diverter and the body of spout it becomes possible to keep the stem of diverter at the up position and via which to decrease the rate of water flow from the shower head. The hole of the retrofit is to rope it to the faucet with a piece of rope to make the retrofit removable. The proposal has been claimed and supported by METU NCC Energy Society, which is one of the student societies founded by the author in 2009, and became the subject of one of the “Green Campus Initiative” action projects. The “Green Campus Initiative”, has started in 2012 at the Middle East Technical University Northern Cyprus Campus with the notions of sustainability and environ-mental friendliness. Within the framework of national and international norms and related legal regulations; increasing the efficiency of energy utilization on the Campus, prevention of unconscious consumption of water and energy resources, decreasing the greenhouse gas emission, preventing environmental pollution with the waste management plan and raising awareness among students and public about the issues concerning energy and the environment are the prior and essential components of the initiative.

The retrofit shown in Figure 2 has been modeled, prototyped and tested (Figure 3). The experiment showed that, thanks to the retrofit, it is possible to decrease the water flow rate from 7 lt/min about to 1.5 lt/min during shampooing/soaping. Considering two persons in each house and assuming the number of showers taken per day minimum 1 time, it is calculated that, a total of 7000 lt water can be saved per day. Since the weather is very hot in Cyprus, in summer season, indeed it would not be overstated to take the number of showers taken per day as two times. In that case the amount of water saving becomes 14 m^3/day.

Groundwater is supplied from wells in Guzelyurt (one of the towns of Northern Cyprus near to the campus) along a pipe line of 7 km to the campus by pumping. The power needed to drive water to the campus reservoir is about 25 kW and the power of the pump installed is 37 kW. The electricity consumed in Northern Cyprus is generated in fuel oil firing thermal power plants. Considering these and some other parameters, it can be calculated that water saving on the campus via using the prototyped retrofit, also saves electrical energy 8 kWh/day (about 2700 kWh/year), and resultantly decreases fuel oil consumption at the power plant, 3 kgfuel oil/day (about 1000 kg/year). Of course, fuel oil saving at a power plant means reduction in the amount of pollutant emitted to the atmosphere. 1000 kg fuel oil saving corresponds to 2000 kg decrease

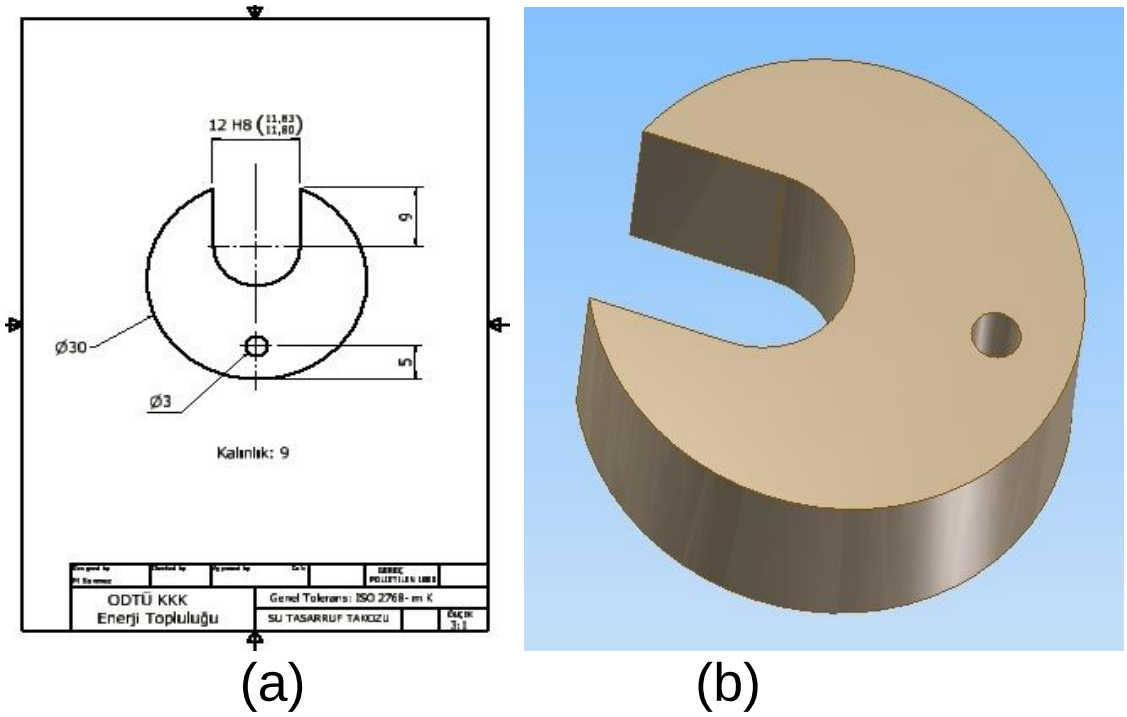

Figure 2. Shower mixer retrofit proposed for water conservation. (a) Technical drawing, (b) Solid model.

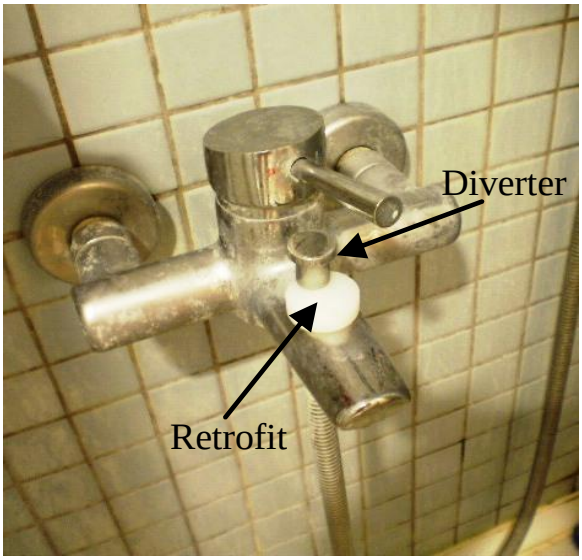

Figure 3. A photograph from the test of the retrofit, retrofit keeps the diverter at its up-position.

in CO_2 emission (Klaassen, 2011; Hoeven, 2012).

CLASSICAL COMPRESSION FAUCETS VERSUS DISK TYPE FAUCETS

Today, three different types of faucets; classical compression, ceramic disc and ball faucets, are used in residential installations; in kitchens, bathrooms and toilets.

A compression faucet uses a soft rubber washer which is screwed down onto a valve seat by rotating the faucet handle in order to adjust/stop the flow rate (Figure 4). It is also called "globe valve" in engineering, while it gives a

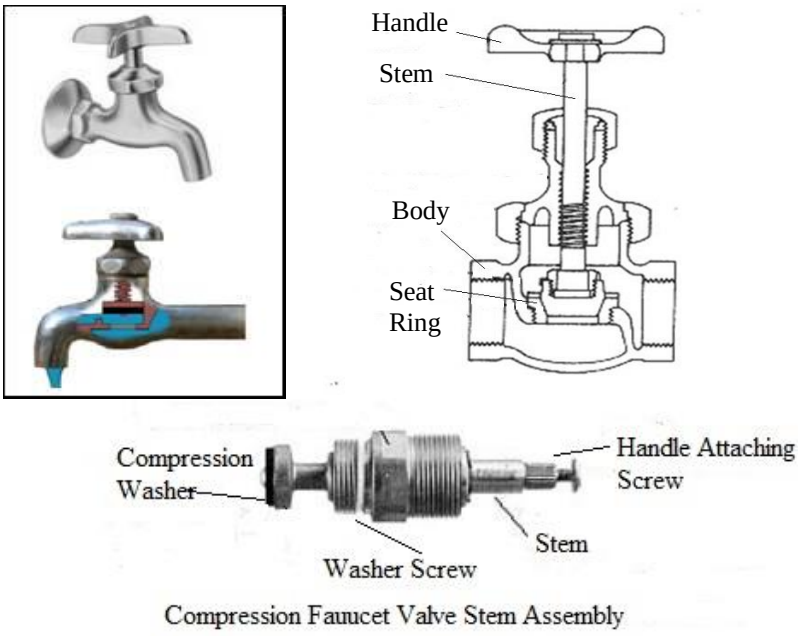

Figure 4. Classical compression type faucet.

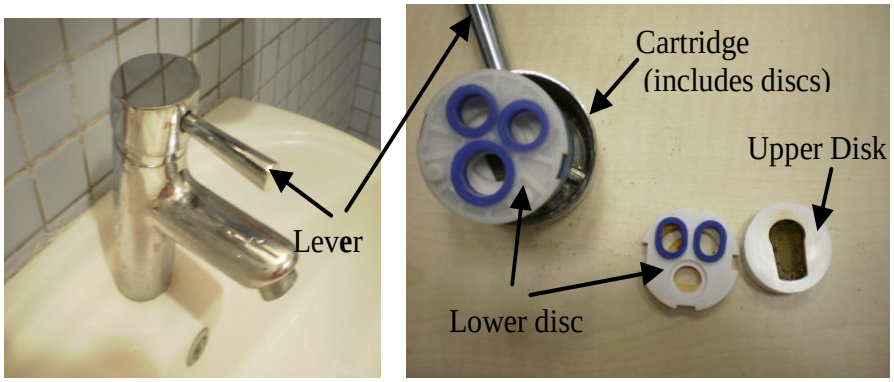

Figure 5. Ceramic disc type faucet.

leak-proof seal and good fine adjustment of flow. The precision of the adjustment depends on the pitch of the screw, smaller pitch means higher precision. To this working principle, this type of faucets has very high water use efficiency. The rubber washer, which seats on the edge of the valve throttle, is subjected to wear over time, so that eventually no tight seal is formed in the closed position, resulting in a leaking tap. When this occurs, the washer is to be replaced. Although the thing to do for the replacement is not difficult, disregarding the superiority of compression faucets on flow rate adjustment, it has been underlined by the industrial designers and their companies as if it were a very important disadvantage in advertising disk type faucets for few decades.

Ceramic disc faucets are the latest development in modern faucet technology. A ceramic disc faucet has two ceramic discs - an upper one that moves and a fixed lower one. The two discs move against each other in a shearing action, blocking water or allowing it to pass through (Figure 5). The seal between the two discs is watertight because they are polished to near-perfect flatness. Ceramic disk faucets are nearly maintenance free and are generally guaranteed not to wear out. But they get fouled with mineral deposits from water, or a peeling from galvanized pipe or a sand particle may get into the valve in time and can jam between the surfaces of the disks. When this occurrs it becomes difficult to adjust the flow rate of water. A greater force is required to apply to the lever of the faucet to be able to slide the upper disk. The applied force may be sufficient to impend

sliding and to set the disk to a position at which the water is throttled to the required flow rate, by chance! Most probably faucet valve becomes, likely equal, either fully opened or completely closed, till the correct value of the force can be found. Nonetheless, achieving this requires sufficient time. After making some trials, getting bored, household will set the valve to the maximum flow rate and the excessive water will be wasted. Under such a working condition the water use efficiency of disc type faucet is very low. Although industrial designers advertise disk type faucets marketing glamorous ones, author of this article strongly recommends disk type faucets to be replaced with classical compression faucets, especially in arid regions.

PROPOSAL FOR INDUSTRIAL DESIGN DEPARTMENTS OF UNIVERSITIES

The following paragraph is from the web page of METU Industrial Design Department, Undergraduate Program

“Industrial designers are the creative agents and facilitators of change who develop products and systems which are inspirational and creative, which offer an aesthetic experience to the user, engage the user with its functional and interactional qualities, empower and enable the user, allow personalization, evolve in accordance with changing needs and preferences, promote local resources, knowledge and skills, and use resources such as materials, energy and water effectively during the production and use phase. In order to bridge the gap between product development and product use, industrial designers benefit from various human-centered design research methods.” In this paragraph the role of industrial designers in professional life is briefly described. They are mainly to be appointed for the conceptual design, product development, and marketing stages of manufacturing and marketing process of an industrial product. Although in the paragraph it is written that industrial designers are to develop products which use resources such as materials, energy and water effectively during the production and use phases, it can be seen from the curriculum of the program, and the catalog description of the courses that there is no engineering course to teach the students on the principles of science and technology, such as thermodynamics, fluid mechanics, heat transfer, system dynamics, strength of material, etc. for the realization of that objective. The courses offered in the program mainly focus attention of the students on the aesthetic, artistic and ergonomic details (Table 1). Actually, an optimum design, which satisfies the demands of customer securely with maximum efficiency and minimum cost, starting from conceptual design stage, requires detailed knowledge on basic engineering courses and experience on engineering application. Today, industrial and domestic products are formed by industrial designers at the conceptual design stage. Unfortunately, due to the lack of engineering knowledge and notion, the graduates of industrial design departments can only focus their attention to the appearance, and some artistic details of the products, not to the engineering details, manufacturability, and efficiency. If the conceptual design does not completed by professional engineers then, the product may be marketed with some technical errors and cause waste of energy, water and/or some other natural sources, and also can not satisfy the expected demands of customers.

CONCLUSIONS

In this article it is recommended that disc type faucets are to be replaced with classical compression faucets to save water thanks to their capability in controlling water flow rate, although today disk type faucets are advertised by industrial designers. Also a simple retrofit is introduced to rectify the design error of some shower mixers and reported that when it is used it saves water, via which decreases electricity consumption and CO_2 emission.

Today, in the large scale companies, the graduates of industrial design programs of universities are positioned as the responsible designer of industrial and domestic products at the product development departments. In this article, considering the errors in the design of shower mixers, modern domestic faucets and some other products, it is commented that due to the lack of engineering knowledge and notion, the graduates of industrial design departments can only focus their attention to the appearance, and some artistic details of the products, not to the engineering details, manufacturability, and efficiency. If the conceptual design does not completed by professional engineers then, the product may be marketed with some technical errors and cause waste of energy, water and/or some other natural sources, and also cannot satisfy the expected demands of customers. To be able to prevent (or minimize) errors in conceptual designs, it is proposed that the industrial design departments should be restructured to offer only the 2nd tier programs for the graduates of basic engineering departments, preferably for mechanical engineers. It is important to note that, although in this article the curriculum of the Industrial Design Department of METU is subjected and discussed only, since METU engineering curricula are structured partially copying the structure of engineering education programs of USA, and METU is a top notched university in Turkey and in its region so it is a model university for lots of universities, the comment and the proposal mentioned in the conclusion part can be extended for the other universities.

Conflict of Interests

The authors have not declared any conflict of interests.

Table 1. List of undergraduate courses in METU Industrial Design Department (Web Page METU, 2013).

Course code	Course title
ID 121	Intro. to Industrial Design
ID 101	Basic Design
ID 111	Design Communication I
ID 102	Basic Design II
ID 112	Design Communication II
ID 122	Origins and Attitudes in Industrial Design I
ID 201	Industrial Design I
ID 233	Structures
ID 221	Origins and Attitudes in Industrial Design II
ID 211	Design Communication III
ID 236	Manufacturing Materials
ID 242	Ergonomics
ID 222	Origins and Attitudes in Industrial Design III
ID 202	Industrial Design II
ID 212	Design Communication IV
ID 290	Elementary Workshop Practice & Computer Literacy in Design
ID 301	Industrial Design III
ID 313	Interactive Multi-Media Design I
ID 311	Computers in Design
ID 305	Design Presentation I
ID 371	Digital Art: Designing Audio- Visual Realm
ID 312	Computer Graphics I
ID 314	Interactive Multi- Media Design II
ID 302	Industrial Design IV
ID 306	Design Presentation II
ID 321	Meaning in Design
ID 363	Visual Narrative in Design I
ID 317	Introduction to Visual Media
ID 390	Summer Practice in Product Establishment and Computer Literacy in Design
ID 365	Color in Product Design
ID 451	Professional Practice
ID 401	Industrial Design V
ID 427	Automobile Design and Designers in the 20^{th} Century
ID 406	Jewellery beyond Tradition
ID 429	Seminars and Workshop in Automotive Styling
ID 409	Graphic Design I
ID 402	Graduation Project
ID 495	Portfolio Presentation
ID 489	Design and Cinema
ID 485	Ceramic Form I
ID 486	Ceramic Form II
ID 424	Intellectual Property Rights
ID 437	The New Office
ID 483	Jewellery beyond Tradition II

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