CHAPTER 3

VOLUMETRIC FAUCET DESIGN AND DEVELOPMENT

3.1 Design plan for volumetric faucet

According to literature review on Chapter2, volumetric faucet have been plan and scheduled show in table 3.1.

Task	Week 1-3	Week 4-6	Week 7-10
Customer requirement	⟺		
Generate concept	⟺		
Screening and scoring concept		⟺	
Design and build prototype		⟺	
Test prototype			⟺

Table 3.1 Prototype development schedule

This schedule show by rough estimate time on each development task. Time scale estimates from prior developer experience and add time of unexpected errors in building a prototype.

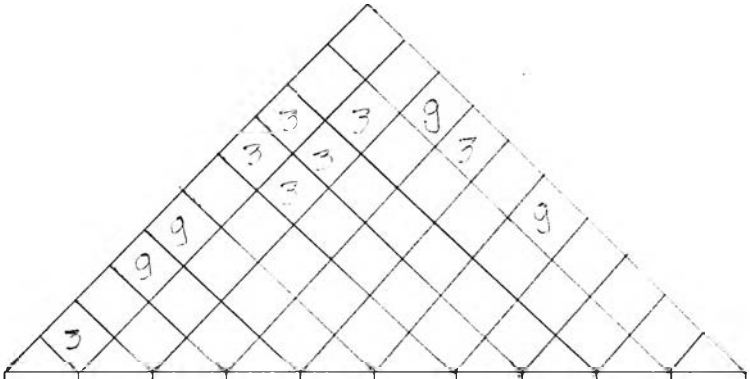
3.2 Develop volumetric faucet engineering specifications

According to transform customers' requirement to engineering specification, the QFD technique is selected to use in this project. The customer are identified first. Because volumetric faucet concept is developed to solve the over flow of ordinal faucet problem, the user of ordinal faucet is general people who use water for washing, showering etc. In consider more specific customers, we can classify home-based water users into 4 categories.

1. Home user who directly installs water pump with water tube from Authority Metropolitan Water Work (Illegal).
2. Home user who install water pump and has buffer tank locate on top of his house and use water from the tank.

3. Home user who normally uses water from water tube
   (not install water pump).
4. Home user who installs water pump from buffer tank and pump to water line
   in house.

Target group of volumetric faucet is focus on category three who get a problem of unsteady water flow. From this point, QFD table are developed, customer requirements are identify and list in who's section, and engineering specification list on how's section. The complete QFD table is show in table 3.2.



	Inlet diameter (inch)	Weight (Kg)	Step to install	% Volume change on different flow rate	Maximum volume range (litre)	Open torque require (N.m)	Width (mm.)	Thickness (mm.)	Length (mm.)	Electrical require (no/yes)	First prototype
Functional performance											
Precise operation	1			9	3					9	3
Easy to install	3	3	9			3	3	3	3		1
Easy to maintenance		1		3	1		1	1	1		3
Show working status											2
Human factors											
Easy to open		1				9				3	3
Easy to close		1				9				3	3
Easy to setup volume		1				3				9	3
Safety										9	2
First prototype	1/2	0.9	1	-	-	0.65	80	0	133	No	
Target	1/2	0.5	1	15	100	0.5	65	65	100	No	
Important rating	4	7	11	12	4	27	4	4	4	36	
Relative importance	6	5	4	3	6	2	6	6	6	1	

Table 3.2 Volumetric faucet QFD table

Relative important of engineering specifications from the QFD table are :

1. No electricity required
2. Open faucet torque = 0.5 newton-metre
3. Volume change on different flow rate = 15% or less
4. Step to install = 1
5. Weight = 0.5 Kg. or less
6. Inlet diameter = 1/2 inch.
7. Thickness = 65 mm. or less
8. Maximum volume rang = 100 litre
9. Width = 65 mm. or less
10. Length = 100 mm. or less

3.3 Volumetric faucet concept generation

In order to generate concept, engineering specifications which derive from QFD method are considered. The method of function decomposition, systematically procedure, decried in chapter 2 is used for generating the concept.

3.3.1 Evaluate existing prototype

The existing prototype of volumetric faucet develops in aspect of technical feasibility. Existing prototype's testing data will be help in development and generating concept. Open volumetric faucet requires torque is 0.658 newton-metre. and maximum average pressure is 2.075 ponds/in^2. Average Torque require to release ratchet is 0.18 newton-metre (Chonwilai, 1995). First prototype is shown in figure 1.1.

3.3.2 Function decomposition

When consider existing prototype and engineering specification information from table 3.2 the whole concept of volumetric valve can be separated to 4 sub-functions. Figure 3.1 shows each sub-function and table 3.1 show each function in detail.

1 Adjust Volume	2 Transmission
3 Open/Close faucet	4 Measure volume

Figure 3.1 Sub-function of volumetric faucet

Sub function	Function in detail
Adjustable volume	Individual volumetric faucet user can adjust their require water volume by their own.
Transmission	Transmit power to release position lock of volumetric faucet
Open/Close faucet	Switch between turn on and turn off faucet
Measure volume	Change water flow to other measurable form (rotating or else)

Table 3.1 Volumetric faucet function detail

- Adjustable volume sub function

Adjustable function can be generated from the concept of one way ratchet which the precision is no the number divide of ratchet. Because the adjust volume function is based on open/close faucet function, so it need to proof the open/close faucet function before developing adjustable volume function. On this project, only guided idea of adjustable volume sub-function is concerned. The sketch of ratchet is shown in figure 3.2.

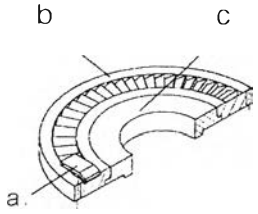


Figure 3.2 Adjustable volume ratchet

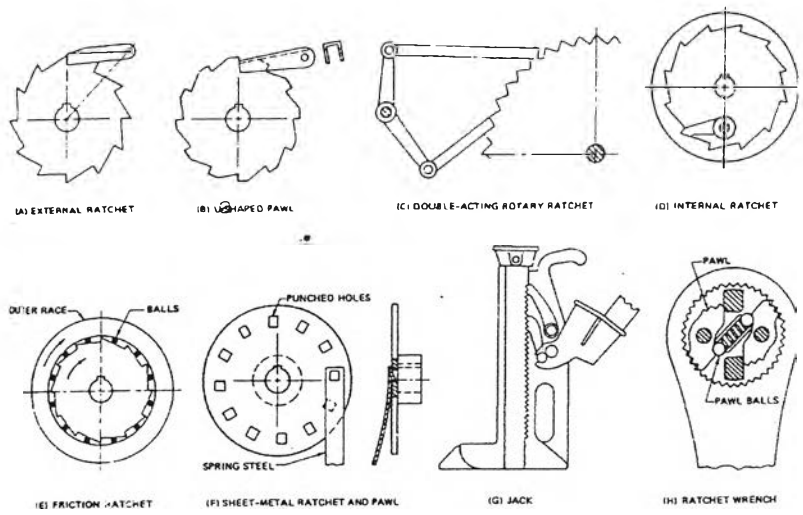


Figure 3.3 Sample of one way ratchet

♦ Transmission system

From the information of prior prototype the transmission gear system is work appropriately only on the alignment of gear which needs to calculate for correction the measure volume. On development this volumetric faucet prototype which focusing on the open/close mechanism and feasibility of mechanism. The gear system from early prototype develop by using existing gear package of water metre show in figure 3.4.

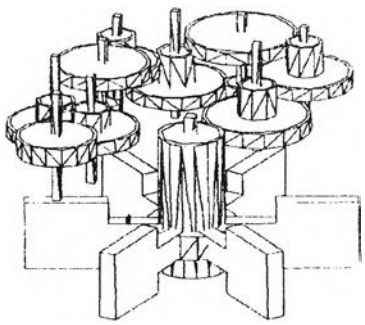
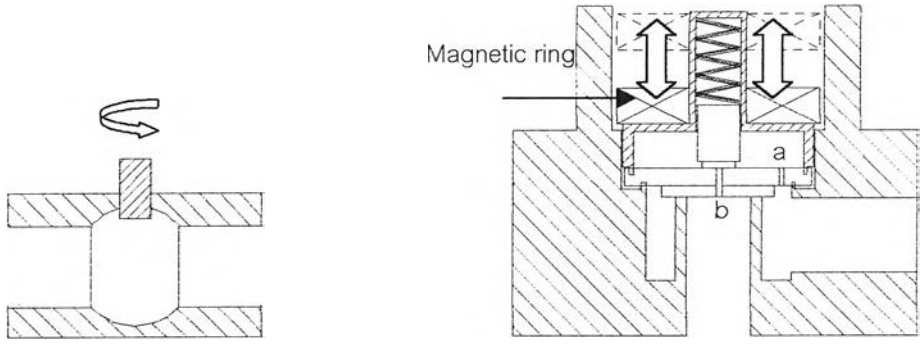


Figure 3.4 Transmission function concept

It is notice that gear transmission system work in the same concept of water meter and volumetric faucet but there is torsion occurred on gear transmission system of volumetric faucet on its axis more than torsion of gear system in water meter (Chonwilai, 1995).

♦ Open/Close faucet



a. Ball Valve b. Fill Valve

Figure 3.5 Open/Close faucet function concept

Two type of valve, ball and fill valves, are considered in open/close faucet sub-function. First, ball valve operate by turning ball to 90 degree (full open position) and turn it backward 90 degree to close position. Second, fill valve operates by pressure of fluid intake valve. Pressure is controlled by small rod located in valve center when this rod move up. Fluid can flow through hole (a) to hole (b) and the pressure in valve balance let diaphragm move up and fluid flow through outlet. And control is controlled by magnetic ring or solenoid, electric generated magnetic field.

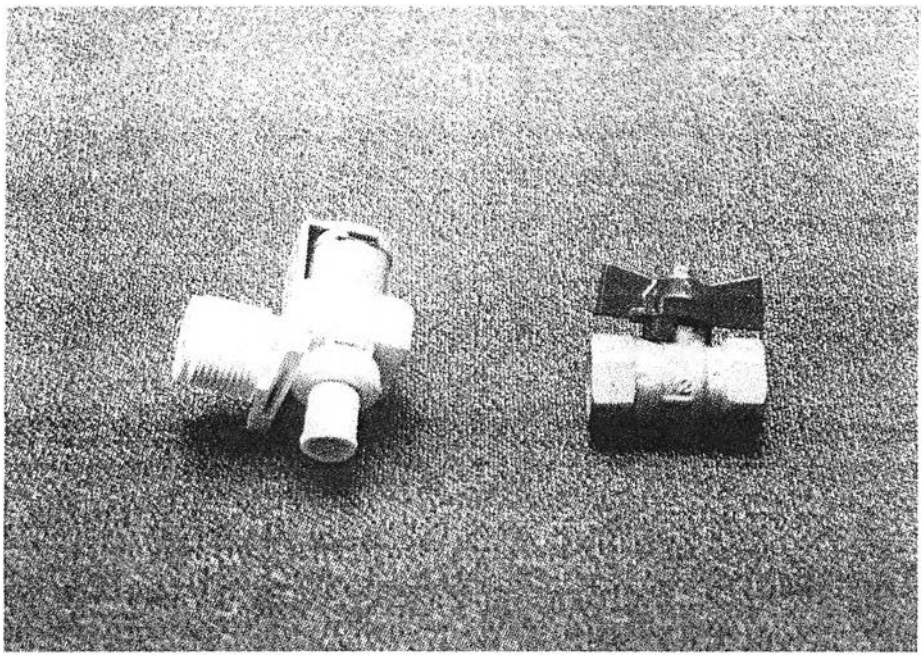
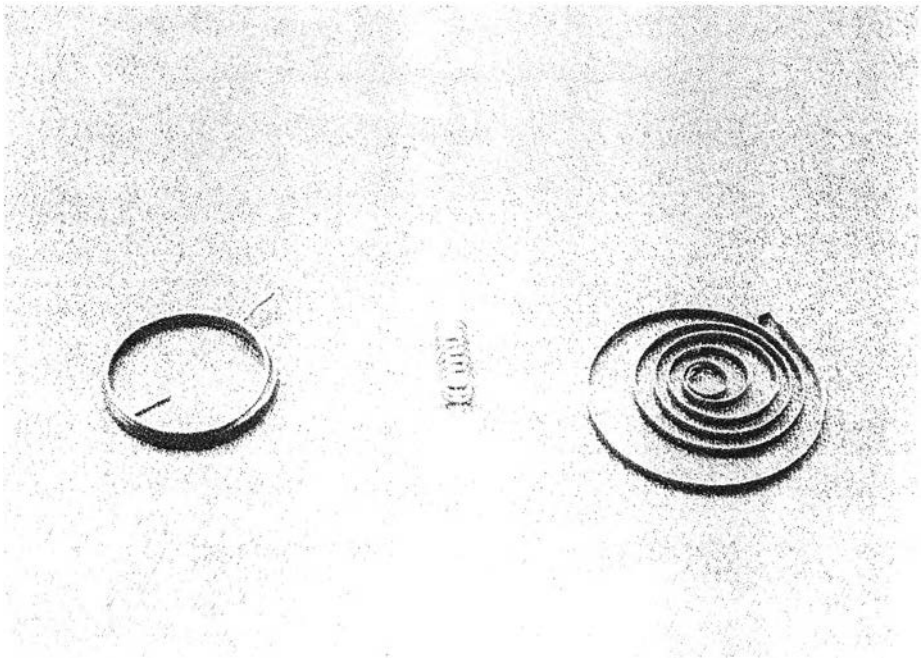


Figure 3.6 Existing fill valve and ball valve in market

The spring is used to store energy for turning valve back to close position. Type of spring that can be used has to match with the characteristic of valve operated. Ball valve needs rotational force to turn it back while fill valve need to move up/down (compression) so that torsion spring (figure 3.7 a, c) can be use with ball valve and compression spring (figure 3.7 b) can be used with fill valve.



Helical torsion Compression Spiral torsion spring

Figure 3.7 Sample of torsion and compression spring

- Measure volume

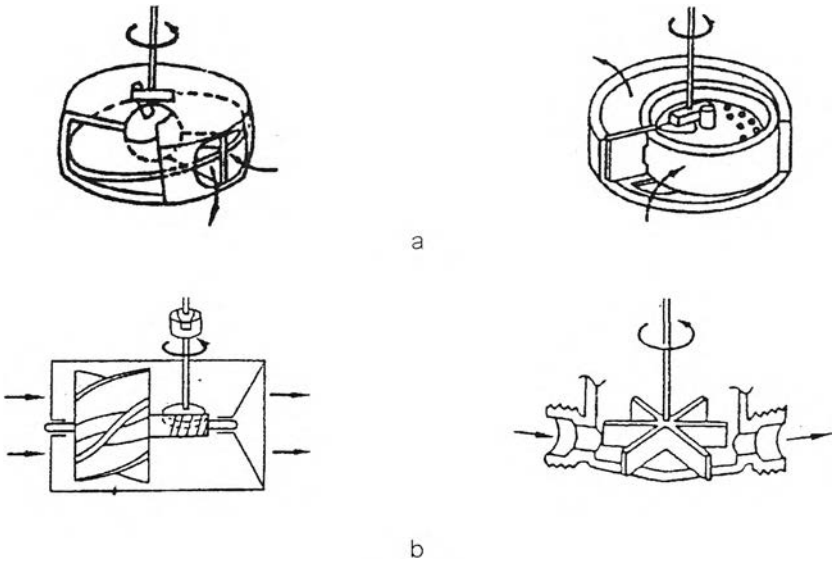


Figure 3.8 Measure volume concept

In order to measure water volume, there are two principle to do so. First, change moving fluid energy to kinetic energy by turbine (figure 3.8 b). Second, change moving fluid energy to kinetic energy by volume displacement (figure 3.8 a).

3.3.3 Concept generation

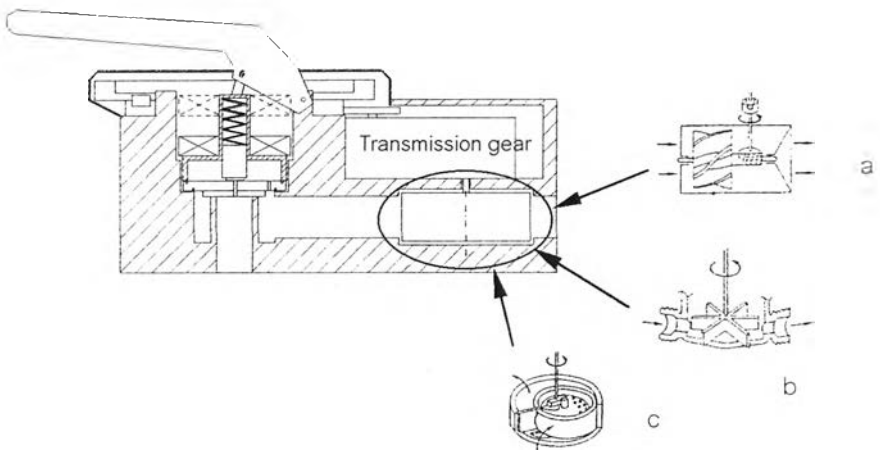


Figure 3.9 Volumetric faucet apply fill valve concept

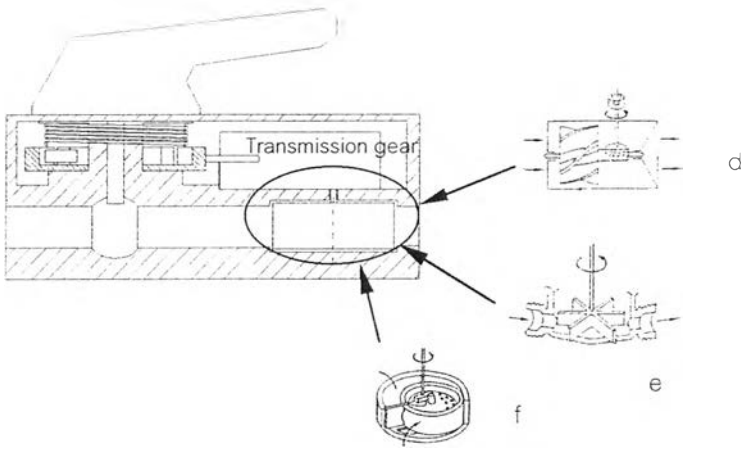


Figure 3.10 Volumetric faucet apply ball valve concept

From the basic concept of volumetric faucet, when faucet working it is no need to adjust water flow rate, it only works on concept of volume. Both fill valve and ball valve have this characteristic so it selected to generate concept with other sub function. Two main concepts of volumetric faucet's sketch are show in figure 3.9 and 3.10.

Working principle of volumetric faucet applied fill valve concept

On the initial status, faucet is close There is no moving part. Where water pressure pushes diaphragm attached faucet outlet, water can not flow passed the diaphragm. When user lifts faucet handle up the connecting rod link between fill valve pin also move up and the pressure in valve chamber reduces effect of different pressure between outside and inside causing the diaphragm to move up and water can flow pass the outlet. The handle has a lock in open position (compression spring was compressed). The water flows through faucet and flow energy causes the turbine to rotate and make transmission gear to rotate. The speed of ratchet gear rotate proportion on the flow energy of water flow through faucet. When the release tip of ratchet gear rotate till attach and push ratchet locker. The locker swings back and releases the handle back to close position cause fill valve pin move back and closing diaphragm hole at center. The pressure in fill valve chamber increase and diaphragm moves down and closes faucet outlet. The three type of measure volume systems can be replaced in section of faucet inlet. Figures 3.3.a, 3.3.b, and 3.3.c show three type of measure volume system.

Working principle of volumetric faucet applied ball valve concept

Volumetric faucet start at ball valve's close position. Water can not flow pass faucet. When user turn faucet handle 90 degree clockwise, Torsion spring wire round faucet axis loaded the torque while rotating. The ball valve rotates and opens faucet flow channel. The ratchet which connects with faucet axis rotate and pending in lock position. Water can flow pass through faucet outlet and flow energy causes measure volume system rotate. Ratchet gear gets torque from transmission gear which connect with measure volume system. The speed of ratchet gear rotate on proportion of flow energy (volume). When ratchet gear tip rotates to position of lock's ratchet and pushes them. The lock's ratchet swings back and the energy in torsion spring turns the faucet's axis to close position. Same as fill valve apply concept, three types of measure volumes can replace at inlet faucet (figures 3.3.a, 3.3.b, and 3.3.c show its positions).

3.4 Volumetric faucet concept evaluate

The scoring technique proposed by (Ulrich and Eppinger, 1995) use in evaluate all concept that generate from concept generation phase. Screening matrix list all selection criteria on left column, the first prototype use as datum. Three people who directly suffer from water tank over filled were invited to help for evaluation. All concepts from generating design (include first prototype concept) were shown to them with concept's review and each equation in selection criteria have been asked and filled score. Template of evaluation table show in table D.1 (appendix D).

Selection Criteria	DATUM	Concept					
		Fill valve			Ball valve		
		a	b	c	d	e	f
Ease of use	0	-	0	-	-	0	-
Ease of install	0	+	+	+	+	+	+
Ease of maintenance	0	-	-	-	-	0	-
Portability	0	+	+	+	+	+	+
Flexible in use	0	-	+	-	+	+	+
Working accuracy	0	+	0	+	+	0	+
Sum +'s	0	3	3	3	4	3	4
Sum 0's	6	0	2	0	0	3	0
Sum -'s	0	3	1	3	2	0	2
Net Score	0	0	2	0	2	3	2
Rank	3	3	2	3	2	1	2
Continue?	No	No	No	No	No	Yes	No

Table 3.3 Concept evaluation matrix

Each selection criterion is considered and gives plus sign (+) where the concept better than datum, minus sign (-) where the concept worse than datum, and zero (0) when where the concept same as datum. The sum of signs is calculated and ranked. Last row show the decision-making on which concept is better than the other concept. Table 3.3 shows that ball valve apply for volumetric faucet concept is better than the other concept.