Automatic Pet Feeder

Presenters:

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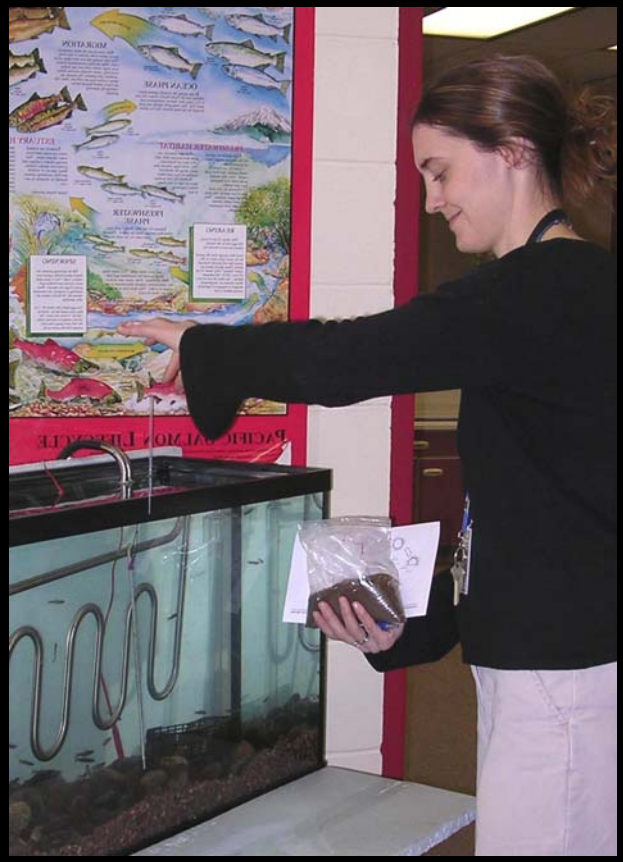
Mission Statement:	**We provide the best care for your pet fish at home all the time.**
Product Description:	**Lean, Mean, Automatic Fish Feeding Machine.**
Key Business Goals:	**Product will be introduced at the end of April 2005.** **Expected net revenue of 2~3 million Baht by 2006.**
Primary Market:	**Ornamental fish owners and aficionados in Thailand.**
Secondary Market:	**Ornamental fish farms in Thailand.**
Tertiary Market:	**Ornamental fish market in neighboring countries.**

INTRODUCTION



YESTERDAY

TODAY

CONCEPT DEVELOPMENT

Phase 0. Product Planning

Phase 1. Identifying Customer Needs

Phase 2. Establishing Product Specifications

Phase 3. Concept Generation

Phase 4. Concept Selection

PRODUCT PLANNING

1. Decompose the Problem.

2. Look for Existing Solutions.

3. Look for Creative Solutions.

4. Formulate Solution Space.

IDENTIFYING CUSTOMER NEEDS

1. Gather raw data from customers.

2. Interpret raw data in terms of customer needs.

3. Organize the needs into a hierarchy.

4. Rate the relative importance of needs.

IDENTIFYING CUSTOMER NEEDS

	Lead User	User
Homeowner (frequent use)	3	12
Professional (heavy use)	3	12

1. Interviews: Project collaborators were divided into two pairs to discuss needs with a single customer (30 mins. per interview).
2. Focus Groups: Project collaborators also interviewed two groups of customers. Each group included 7 people who are AIT students (since the team thinks they will be among the future users of the APF).

IDENTIFYING CUSTOMER NEEDS

	Customer Statements	Interpreted Needs
BASIC FUNCTION	I would like to have an APF whose dimensions are as small as possible.	The APF is small in size.
	I would like the APF to be strong and durable.	The APF is made out of good and strong materials.
	I would to be able to move the APF easily along with the aquarium.	The APF is light weight.
	I would like my pet fish to be fed on time everyday.	The APF operates on time.
	I would like to my pet fish to have the amount of food I choose.	The APF can feed the suggested amount of food.
	I would like the APF to operate as usual when I leave my home for a business excursion or travel.	The APF can self operate in a given period of time.
	I would like an APF that consumes the least electricity.	The APF is energy efficient.
	When the machine is not working properly, I would like to be able to fix the problem myself.	The APF is easy to maintain.
	I would like my son to be able to use the machine even if I am not around.	The APF is safe for everybody including kids.
	The machine can be directly utilized after I read the user manual.	The APF is easy to use.
	I only buy an APF if it costs 500 Bht.	The APF is affordable.
EXTRA FUNCTION	I would like to know when the feed box is empty.	The APF can indicate an empty feed container.
	The APF can protect my fish from high water temperature.	The APF can measure water temperature.
	I would like to adjust the feeding according to the number of fish.	The APF can self adjust the amount of feed if necessary.
UPGRADE FUNCTION	I would like a machine that can play music while feeding.	The APF can play some sort of music.

Functions	Customer Needs	Relative Importance
Appearance and Weight Function	The APF is small in size.	4
	The APF is made out of strong materials.	3
	The APF is lightweight.	4
Dispensing Function	The APF operates on time.	5
	The APF feeds the suggested amount of food.	4
	The APF can self operate in a given period of time.	5
Utility and Maintenance Function	The APF is easy to maintain.	4
	The APF is easy to use.	4
	The APF is safe for everybody including kids.	5
Economic Function	The APF is energy efficient.	3
	The APF is affordable.	4
Extra Function	The APF can indicate an empty feed container.	3
	The APF can measure water temperature.	5
Upgrade Function	The APF can self adjust the amount of feed.	4
	The APF can play some sort of music.	3

ESTABLISHING PRODUCT SPECIFICATIONS

1. Prepare the list of metrics.
2. Collect competitive benchmarking information.
3. Set ideal and marginally acceptable target values.
4. Set target specifications.
5. Construct House of Quality

ESTABLISHING PRODUCT SPECIFICATIONS

Metric No.	Need No.	Metrics	Imp.	Units
1	1,3	Dimensions.	4	cm
2	2	Material.	3	type
3	3	Total weight.	4	gram
4	5, 14	Amount of feed.	4	g/times
5	4, 6	Time to feed.	5	hr
6	6	Time to operate itself	5	day
7	8	Accessibility.	4	rank (1-5)
8	2,11	Price.	4	Baht
9	9	Contact voltage.	5	V
10	12	Number of light b	3	quantity
11	15	Sound device.	3	quantity
12	10	Motor capacity.	5	W
13	14,13	Number of senso	4	quantity
14	7	Service frequency	4	times/year

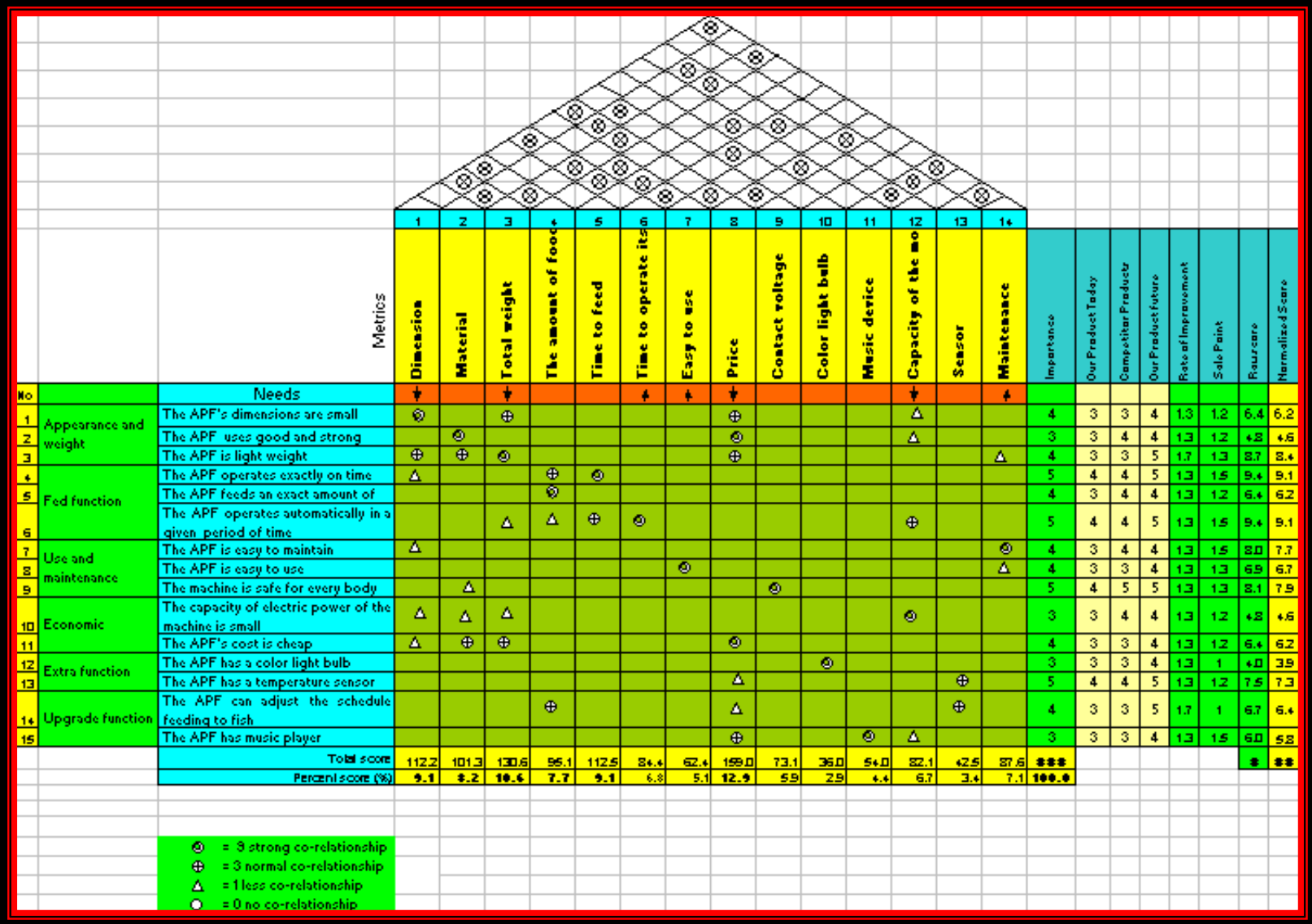
Metric No.	Need No.	Metrics	Imp.	Units	Company X
1	1,3	Dimensions.	4	cm	< 35x35x40
2	2	Material.	3	type	steel, plastic
3	3	Total weight	4	gram	< 2500
4	5, 14	The amount of food.	4	g/times	> 25
5	4, 6	Time to feed.	5	hr	> 2
6	6	Time to operate itself.	5	day	< 15
			4	rank (1-5)	> 3
			4	Baht	> 750
			5	V	< 6
			3	quantity	>1
			3	quantity	>1
			5	W	>15
			4	quantity	> 2
			4	times/year	< 2

Metric No.	Need No.	Metrics	Imp.	Units	Marginal value	Ideal value
1	1,3	Dimensions.	4	cm	< 35x35x40	20x20x10
2	2	Material.	3	type	steel, plastic	plastic
3	3	Total weight	4	gram	< 2000	< 1000
4	5, 14	The amount of food.	4	g/times	>25	< 50
5	4, 6	Time to feed.	5	hr	> 2	5
6	6	Time to operate itself.	5	day	< 15	20
7	8	Accessibility.	4	rank (1-5)	> 3	4
8	2,11	Price.	4	Baht	> 750	< 1000
9	9	Contact voltage.	5	V	< 6	< 5
10	12	Number of light bulbs.	3	quantity	> 1	< 2
11	15	Sound device.	3	Number	> 1	< 2
12	10	Motor capacity.	5	W	>15	< 30
13	14,13	Number of sensors.	4	quantity	> 2	< 3
14	7	Service frequency.	4	times/year	< 2	< 1

Needs	Metrics	1 Dimensions.	2 Material type.
Compact and small in size.	1	■	
Made out from strong materials.	2		■
Lightweight.	3	■	■
Operates on times.	4		
Feeds the suggested amount of food.	5		
Self operate in a given period of time.	6		
Easy to maintain.	7		
Easy to use.	8		
Safe for everybody including kids.	9		
Energy efficient.	10		
Affordable.	11		
Indicate empty feed container.	12		
Indicate water temperature.	13		
Self adjust the amount of food.	14		
Operates with a sound device.	15		

Imp.	Units	Company X
4	cm	< 35x35x40
3	type	steel, plastic
4	gram	< 2500
4	g/times	> 25
5	hr	> 2
6	6	Time to operate itself.	5	day	< 15
7	8	Accessibility.	4	rank (1-5)	> 3
8	2,11	Price.	4	Baht	> 750
9	9	Contact voltage.	5	V	< 6
10	12	Number of light bulbs.	3	quantity	>1
11	15	Sound device.	3	quantity	>1
12	10	Motor capacity.	5	W	>15
13	14,13	Number of sensors.	4	quantity	> 2
14	7	Service frequency.	4	times/year	< 2

House of Quality



No		Needs	1 Dimension ↓	2 Material	3 Total weight ↓	4 The amount of food ↑	5 Time to feed	6 Time to operate its ↑	7 Easy to use ↑	8 Price ↓	9 Contact voltage	10 Color light bulb	11 Music device	12 Capacity of the mo ↓	13 Seasor	14 Maintenance ↑	Importance	Our Product Today	Competitor Product	Our Product future	Rate of Improvement	Sale Point	Raw score	Normalized Score
1	Appearance and weight	The APF's dimensions are small	◎		⊕					⊕				△			4	3	3	4	1.3	1.2	6.4	6.2
2		The APF uses good and strong		◎						◎				△			3	3	4	4	1.3	1.2	4.8	4.6
3		The APF is light weight	⊕	⊕	◎					⊕						△	4	3	3	5	1.7	1.3	8.7	8.4
4	Fed function	The APF operates exactly on time	△			⊕	◎										5	4	4	5	1.3	1.5	9.4	9.1
5		The APF feeds an exact amount of				◎											4	3	4	4	1.3	1.2	6.4	6.2
6		The APF operates automatically in a given period of time			△	△	⊕	◎						⊕			5	4	4	5	1.3	1.5	9.4	9.1
7	Use and maintenance	The APF is easy to maintain	△													◎	4	3	4	4	1.3	1.5	8.0	7.7
8		The APF is easy to use							◎							△	4	3	3	4	1.3	1.3	6.9	6.7
9		The machine is safe for every body		△							◎						5	4	5	5	1.3	1.3	8.1	7.9
10	Economic	The capacity of electric power of the machine is small	△	△	△									◎			3	3	4	4	1.3	1.2	4.8	4.6
11		The APF's cost is cheap	△	⊕	⊕					◎							4	3	3	4	1.3	1.2	6.4	6.2
12	Extra function	The APF has a color light bulb										◎					3	3	3	4	1.3	1	4.0	3.9
13		The APF has a temperature sensor								△					⊕		5	4	4	5	1.3	1.2	7.5	7.3
14	Upgrade function	The APF can adjust the schedule feeding to fish				⊕				△					⊕		4	3	3	5	1.7	1	6.7	6.4
15		The APF has music player								⊕			◎	△			3	3	3	4	1.3	1.5	6.0	5.8
		Total score	112.2	101.3	130.6	95.1	112.5	84.4	62.4	159.0	73.1	36.0	54.0	82.1	42.5	87.6	###						#	##
		Percent score (%)	9.1	8.2	10.6	7.7	9.1	6.8	5.1	12.9	5.9	2.9	4.4	6.7	3.4	7.1	100.0							

◎ = 3 strong co-relationship
⊕ = 3 normal co-relationship
△ = 1 less co-relationship
○ = 0 no co-relationship

House of Quality

Dimensions	: 9.1%
Material	: 8.2%
Net weight	: 10.6%
Price	: 12.9%
Time to feed	: 9.1%
Amount of feed	: 7.7%

CONCEPT GENERATION

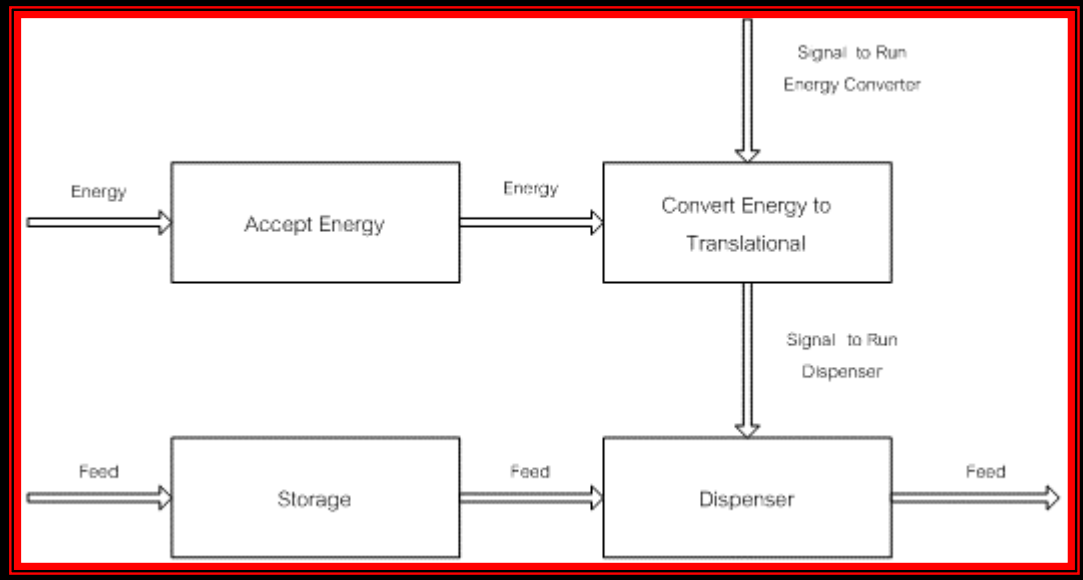
1. Clarify the problem.

2. Execute external search.

3. Execute internal search.

4. Explore systematically.

PRIMARY CONCEPT GENERATION



CONCEPT GENERATION

Interview Lead Users

- The motor for feeding should be of low capacity for less power consumption.
- The tank in which the feed is contained can be made from mica for good appearance, lightweight, and low cost.

Consulting Experts

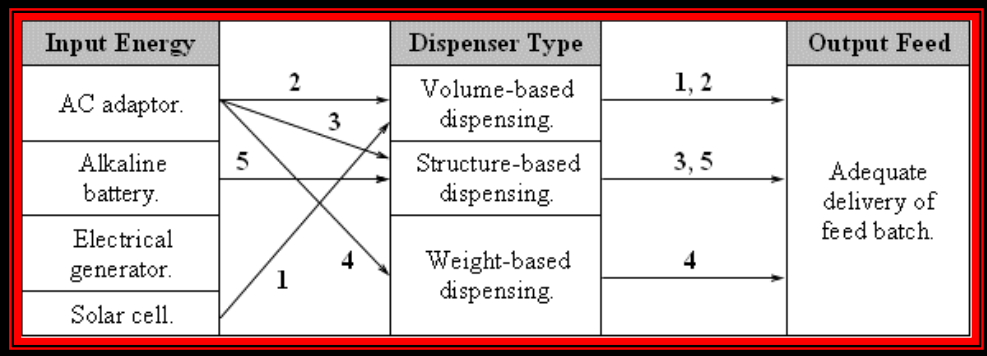
- The DC motor to be used has the ability of changing the rpm for ease of adjusting the frequency or feeding speed (the number of times to feed).

Search Catalogues

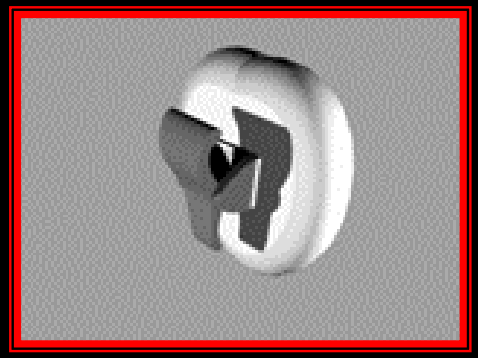
- It is better to have a colored light bulb to inform user when the container of the APF is empty.

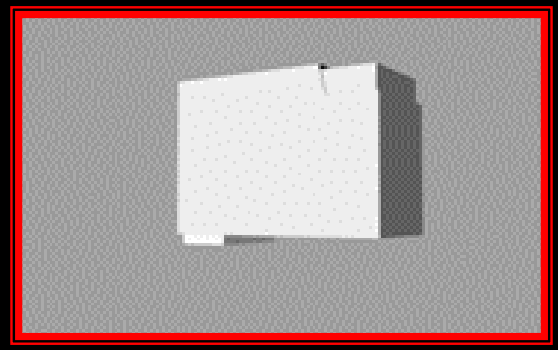
PRIMARY CONCEPT GENERATION

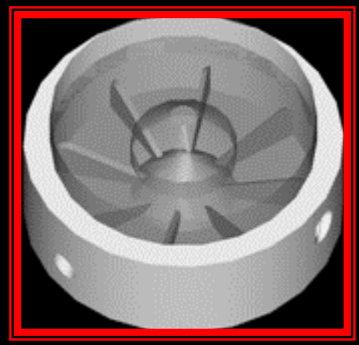
Elements	Solutions from Internal Search.
Dispenser Type	▪ Dispensing based on the volume of feed batch. ▪ Dispensing based on obliged structure. ▪ Dispensing based on weight of feed batch.
Input Energy	▪ Powered by AC adaptor. ▪ Powered by alkaline battery. ▪ Powered by electrical generator. ▪ Powered by solar cell.
Output Feed	▪ Adequate delivery of feed batch.



PRIMARY CONCEPT GENERATION







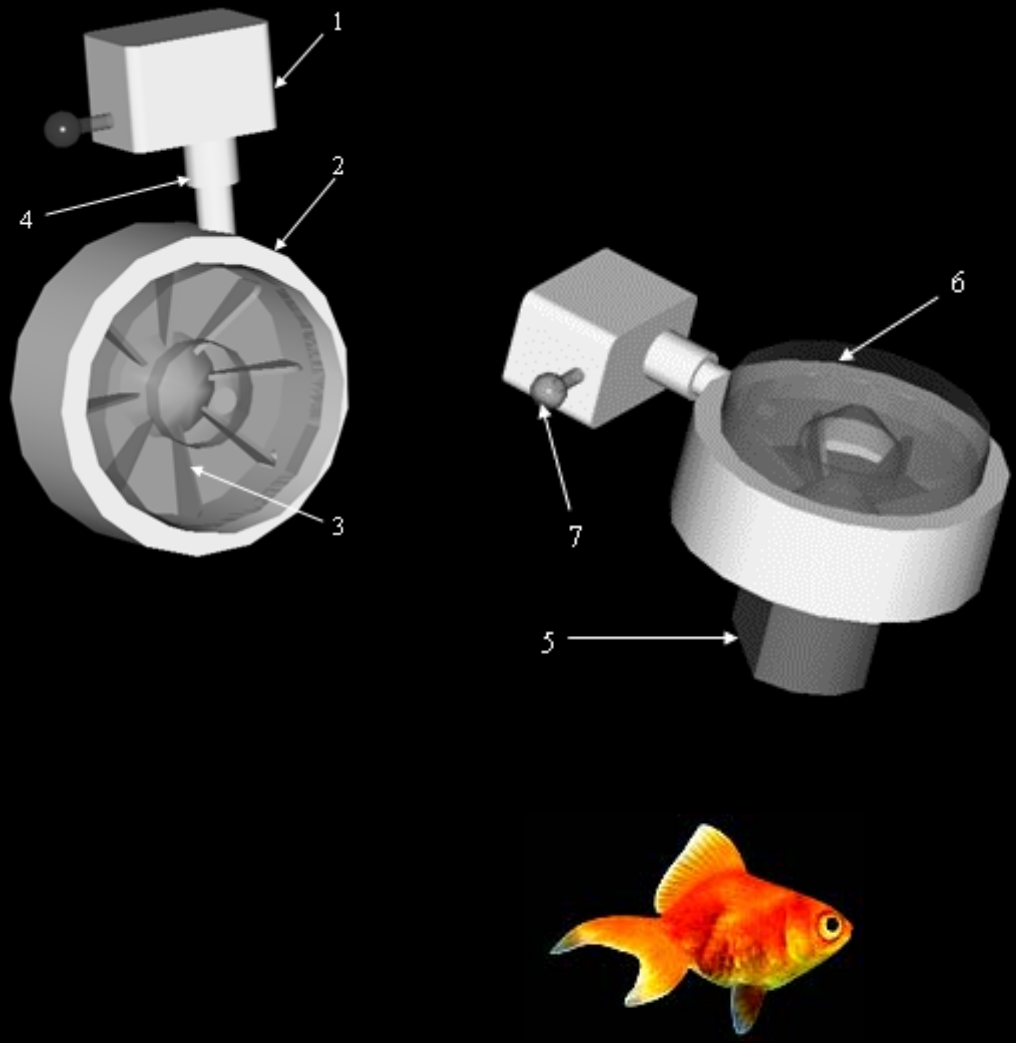
PRIMARY CONCEPT SELECTION

Selection Criteria	Concepts					Remark
	1	2	3	4 (ref.)	5	
Compact.	+	+	+	0	-	'+' for 'better than'
Durable.	0	+	-	0	-	
Lightweight.	0	-	+	0	+	
Operates on time.	-	0	+	0	+	
Dispenses adequate feed.	-	0	+	0	+	
Reliable.	-	+	0	0	0	
Ease of maintenance.	+	0	+	0	+	
Ease of use.	+	+	-	0	-	
Safe for children.	+	0	0	0	0	
Energy efficient.	+	+	0	0	-	'-' for 'worse than'
Affordable.	+	-	0	0	-	
Features a light indicator.	-	+	+	0	0	
Features a water temp. sensor.	0	0	+	0	+	'0' for 'same as'
Self-adjusting.	-	+	0	0	-	
Features a sound device.	0	0	-	0	-	
Sum +'s	6	7	7	0	4	
Sum 0's	4	5	5	15	4	
Sum –'s	5	4	3	0	7	
Net Score	**1**	**3**	**4**	**0**	**-2**	
Rank	**3**	**2**	**1**	**4**	**5**	
Continue?	**Comb**	**Yes**	**Yes**	**Comb**	**No**	

Selection Criteria	Weight (%)	Concepts					
		2 (Ref.)		3		(1 + 4)	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Compact.	7	3	0.21	3	0.21	3	0.21
Durable.	5	3	0.15	2	0.10	2	0.10
Lightweight.	7	3	0.21	4	0.28	3	0.21
Operates on time.	8	2	0.16	4	0.32	2	0.16
Feeds adequately.	7	3	0.21	4	0.28	2	0.14
Reliable.	8	2	0.16	3	0.24	2	0.16
Ease of maintenance.	7	3	0.21	3	0.21	4	0.28
Ease of use.	7	3	0.21	2	0.14	3	0.21
Safe for children.	8	3	0.24	3	0.24	3	0.24
Energy efficient.	5	3	0.15	3	0.15	3	0.15
Affordable.	7	3	0.21	3	0.21	3	0.21
Has a light indicator.	5	3	0.15	4	0.20	2	0.10
Has a temp. sensor.	8	3	0.24	4	0.32	3	0.24
Self-adjusting.	7	2	0.14	3	0.21	2	0.14
Has a sound device.	4	2	0.08	3	0.12	2	0.08
Total Score			**2.73**		**3.23**		**2.63**
Rank			**2**		**1**		**3**
Continue?			**No**		**Develop**		**No**

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

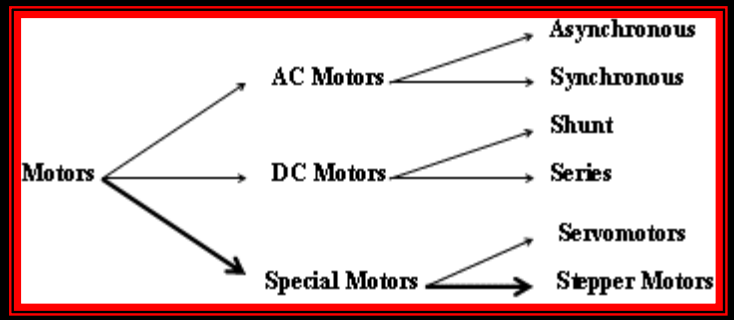
PRIMARY SELECTED CONCEPT

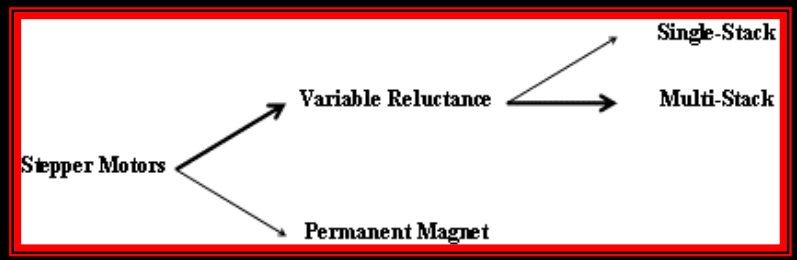


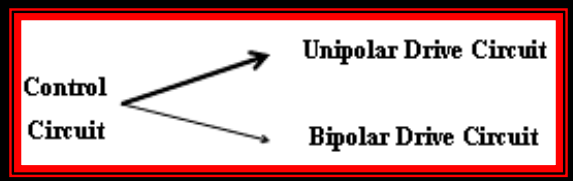
Components of Selected Design Concept

1 – Feed Container
2 – Dispenser Housing
3 – Propeller Blade
4 – Supply Tube
5 – Motor
6 – Dispenser Cover
7 – Light Indicator

SECONDARY CONCEPT GENERATION & SELECTION







PROCESS DRIVEN DESIGN

1. Develop manufacturability goals.

2. Develop a product and process plan.

3. Design components for ease of assembly.

4. Design components for ease of fabrication.

5. Review and Refine the design.

PROCESS DRIVEN DESIGN

Manufacturability Goals

- To facilitate part fabrication and final product installation.
- To have the shortest lead time with minimum cost.

Product & Process Plan

- Component types
- Product architecture
- Assembly concept
- Material & process selection

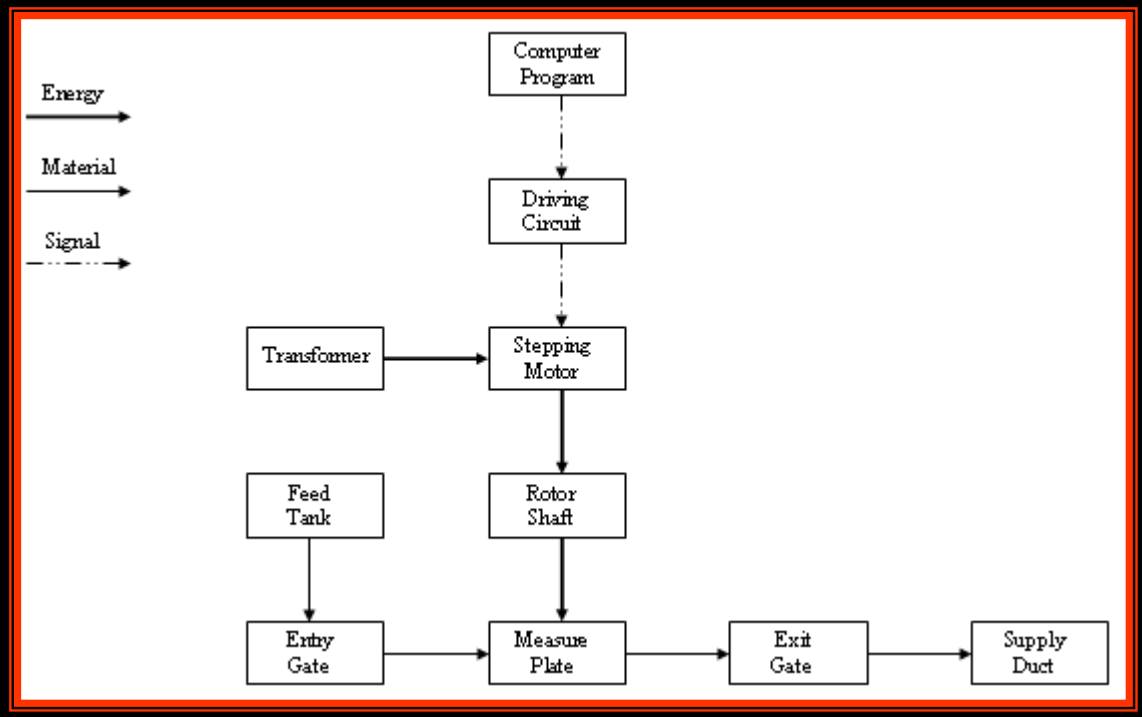
PROCESS DRIVEN DESIGN

Component types

- Complex geometry of dispensing propeller would require extensive remodeling for 5-axis machining.
- Insufficient time with the addition of inadequate facilities calls for optimal design solution.
- Reconfigure components to have simpler geometry and introduce standard off-the-shelf components.

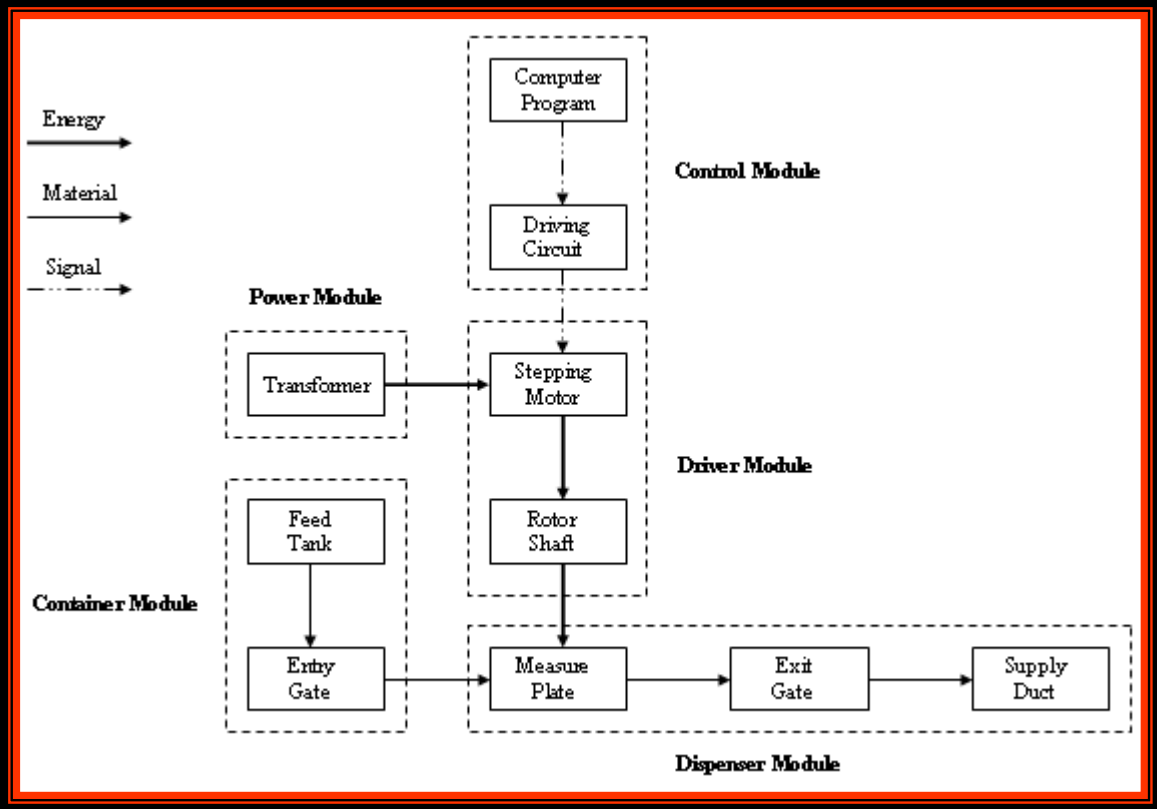
PROCESS DRIVEN DESIGN

Product Architecture



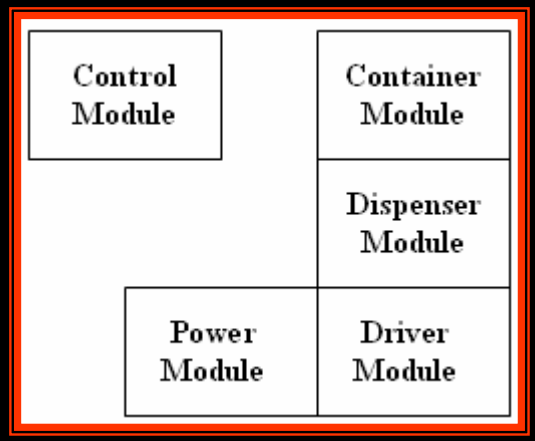
PROCESS DRIVEN DESIGN

Product Architecture



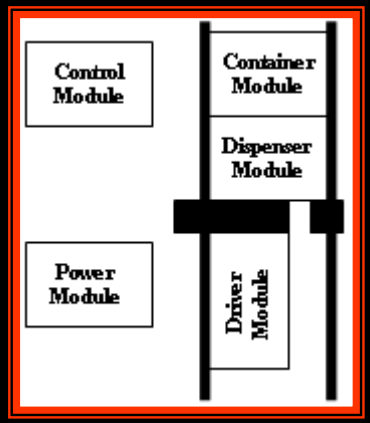
PROCESS DRIVEN DESIGN

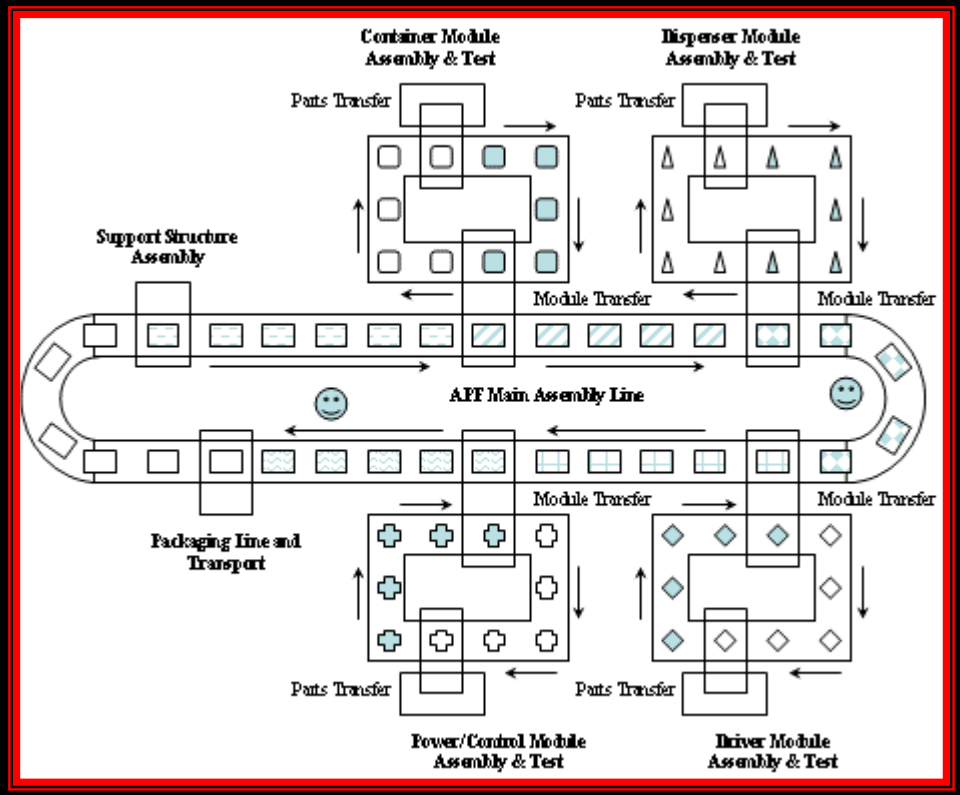
Product Architecture



PROCESS DRIVEN DESIGN

Assembly Concept





PROCESS DRIVEN DESIGN

Material & Process Selection

Selection Criteria	A ABS
Cost per unit weight	-
Mechanical properties	+
Impact resistance	+
Chemical resistance	+
Thermal resistance	-
Machinability	+
Transparency /Aesthetic	0
Density (weight unit volume)	0
Sum +'s	4
Sum 0's	2
Sum –'s	2
Net Score	2
Rank	3
Continue?	Yes (N/A)

Selection Criteria	A Steel
Cost per unit weight	0
Mechanical	+
Net Score	1
Rank	2
Continue?	Yes

Selection Criteria	Weight	Concept: A Steel Rating	A Steel Weight Score	C POM Rating	C POM Weighted Score	D Nylon Rating	D Nylon Weighted Score	E+ HDPE Reference Rating	E+ HDPE Reference Weighted Score
									0.8
									0.3
									0.15
									0.15
									0.3
									0.3
									0.45
									1.0
	Score								3.45
	Rank		4		1		3		2
	Cont.?				Yes				

Handibility, Transparency, Easy Fabrication & Easy Assembly → ABS, Acrylic, POM, PVC → Laser Cutting & Drilling → Very Low Production Volume, Compact Size, Circular & Rectangular Plates, Simple Geometry → Laser Cutting

PROCESS DRIVEN DESIGN

Design Components for Ease of Assembly

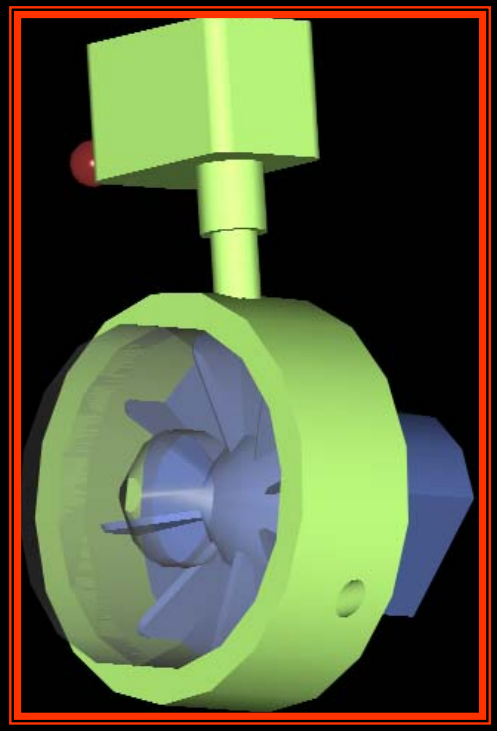
- Employ concept of stacked construction to facilitate final product installation.
- Limit orientation and alignment in the z-axis.
- Replacement of housing with strut based assembly would allow assembler to have complete view inside-out of the product.
- Acrylic material have the advantages of transparency, good surface finish and non-abrasiveness.
- Unlike metals, acrylic can be joined using adhesives without need of thermal joining process such as electric arc welding.

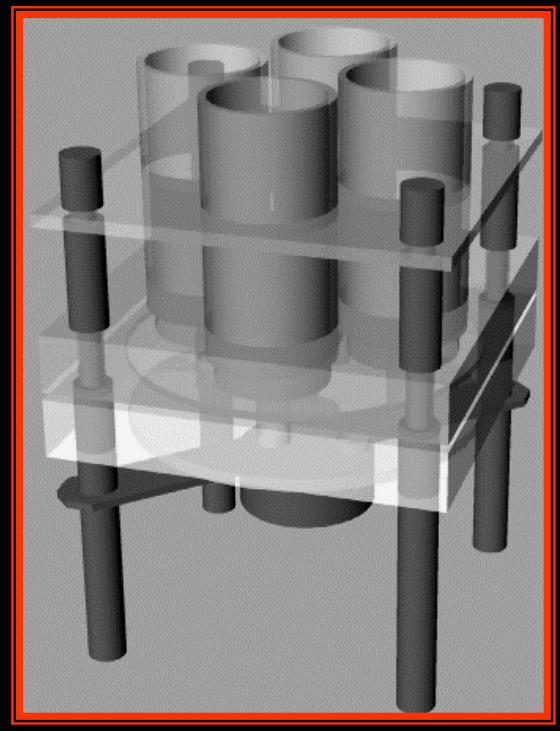
PROCESS DRIVEN DESIGN

Design Components for Ease of Fabrication

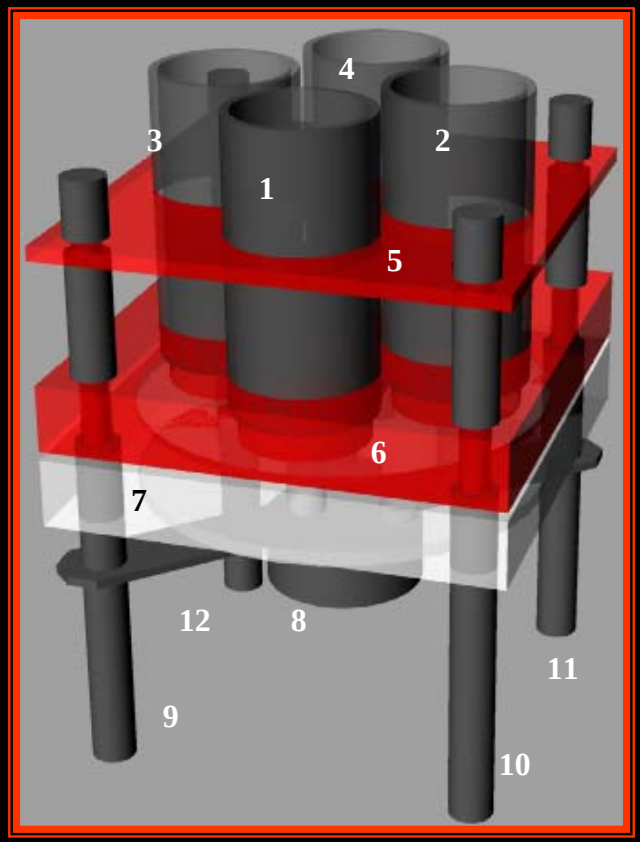
- In contrast to metals, plastics require less force for machining and in general does not require further finishing.
- The revised design features only circular insertion holes hence requiring only one operation.
- Use of laser cutting has the advantage of minimum cycle time and since most components are of the same material the former would also contribute to maximum process yield.

PROCESS DRIVEN DESIGN





PROCESS DRIVEN DESIGN



Components of
Final Design Concept

1,2,3,4 – Feed Containers
5 – Feed Containers Support
6 – Base Plate
7 – Measure Plate
8 – Stepper Motor
9,10,11,12 – Struts
13 – Motor Bar Support

Note: Rotating entry and exit gates are above and below of measure plate respectively.

PROCESS DRIVEN DESIGN

Review & Refine the Design

			Assembly				Part Elimination				Assessment			
1	2	3	4	5	6	7	8				9	10	11	12
Part or Operation	**Quantity**	**Type**	**H**	**I**	**S**	**C**	**Motion**	**Material**	**Assembly**	**CFE**	**V**	**M**	**UI**	**Remarks**
Feed Tank	4	2	+	+	+	0	Y	N	N	0	3	0	0	
Entry Gate	1	2	+	+	-	-	Y	N	Y	0	1	0	0	
Mid-Plate	1	2	+	+	-	0	N	N	Y	0	1	0	0	
Exit Gate	1	2	+	+	-	-	Y	N	Y	0	1	0	0	
STP. Motor	1	2	+	+	-	-	N	Y	Y	0	3	0	0	
Motor Support	1	2	+	0	0	0	N	Y	Y	0	1	0	0	
Supply Duct	1	2	+	-	-	-	N	N	N	2	3	0	0	
Base Plate	1	3	0	-	0	0	N	N	Y	0	1	0	0	
Struts	4	1								4	2	0	0	
Nuts	32	1								32				
Σ Quantity = 47							**Σ CFE = 38**							
Count Ratio = (47-38)/47 = 0.19														

PROCESS DRIVEN DESIGN

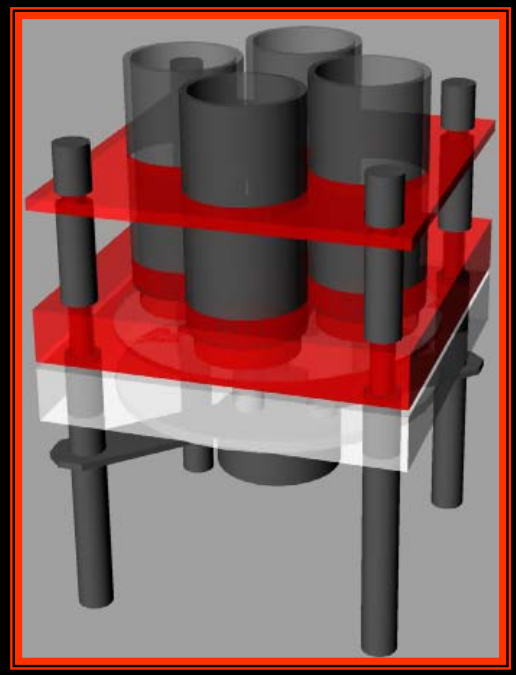
Review & Refine the Design

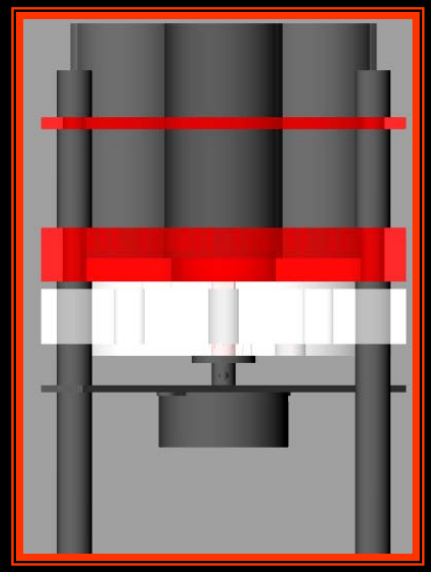
MODULE	COMPONENTS	DESIGN CHARACTERISTICS		REMARKS
		Preliminary Design Concept (1)	Selected Final Concept (2)	
Container	Feed Tank	Box Geometry (D)	Tubular Geometry (ES)	
	Entry Gate	Venturi Pipe (ES)	Circular Plate (D)	
Dispenser	Delivering Structure	Propeller Geometry (D)	Rotating Circular Plate (D)	
	Exit Gate	*Unspecified*	Circular Plate (D)	
Support	Holding Structure	Housing (D)	Struts and Nuts (ES)	
Power	Adaptor	*Unspecified*	Low Voltage	
Driver	Motor	Stepper Motor	Stepper Motor	
	Shaft	*Unspecified*		
Control	Computer Program	*Unspecified*	Visual Basic and/or Labview	
	Driving Circuit	*Unspecified*	Logic Circuit with CMOS Digital ICs	

Table 14. Process driven design summary.
(D) = Designed component
(ES) = External Standard component

MATERIAL	*Unspecified* Plastic	Acrylic and Steel *	** Acrylic for all major components with steel for motor shaft and support.*
PROCESSES	Plastic Injection, Milling, Turning, & Drilling	Laser Cutting & Turning *	** Laser Cutting for acrylic components and Turning for motor shaft.*

PROTOTYPE





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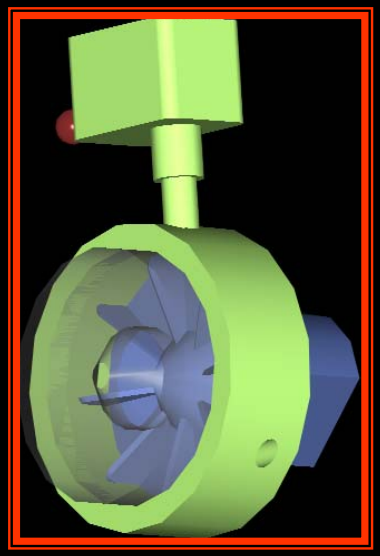

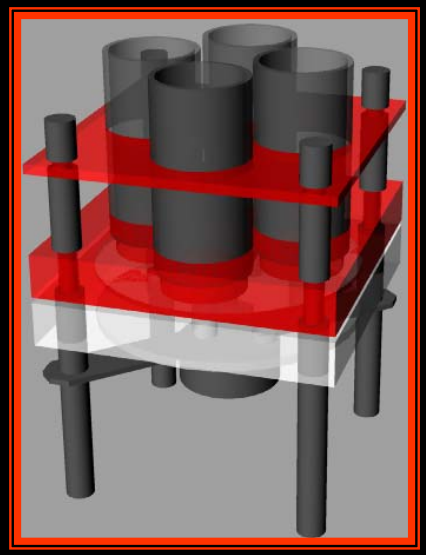

INDUSTRIAL DESIGN

	Product Statements	Rating	Remarks
Quality of User Interface	Ease of operation.	Good	*VB & Labview are user-friendly.*
	Safety features.	Good	*Low voltage and lightweight material.*
Emotional Appeal	Attractive features.	Good	*Transparent material and ease of assembly.*
	Pride of ownership.	Good	*Hi-tech pet feeder.*
Maintainability	Ease of maintenance.	Good	*Acrylic is easy to clean.*
	Capability for assembly and disassembly.	Fair	*Require replacements for steel struts and nuts.*
Resource Efficiency	Fulfillment of product requirements.	Good	*Fulfills most of known customer needs.*
	Extent of design.	Fair	*Improved design required extra spending.*
Product Differentiation	Original features.	Good	*DIY automatic pet feeder.*
	Product recognition.	Good	*Z-axis sandwich layout.*

FINAL REMARKS