Paper Title: FUNCTION ANALYSIS ON GEROTOR MOTOR

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Abstract:

Danfoss engineers the technologies that enable the world of tomorrow to do more with less. We meet the growing need for infrastructure, food supply, energy efficiency and climate-friendly solutions. We engineer tomorrow and build a better future with leading expertise in refrigeration and air conditioning, controls for electric motors, heating systems for buildings and cities, and hydraulic solutions to power agricultural and construction machinery, our impact can be felt everywhere. We're one of the largest companies in the mobile hydraulics industry, and we offer a complete range of energy-efficient and intelligent hydraulic, electronic and electric solutions for the construction, agriculture and other off-highway vehicle markets.

Product maintenance and improvement projects for existing products are carried out regularly in Danfoss to improve product performance, increase the profit and to increase the market share. Function analysis is one of the important tools used in product maintenance and improvement projects. The tools like function cost worth analysis (FCW), function cost worksheet and FAST diagrams are developed and used in brainstorming to generate ideas. It is always done with dedicated cross functional team.

A hydraulic motor is a mechanical actuator that converts hydraulic pressure and flow into torque and angular displacement. Hydraulic motors are very closely resembling to hydraulic pumps in construction. Gerotor motors are used in low speed and high torque (LSHT) application and uses gerotor unit to convert the hydraulic pressure and flow into torque. This paper covers how function analysis is used in gerotor motor to improve the product performance and increase the profit to the organization. Also, this paper covers how we executed the systematic Value Methodology process in our project.

1. Value Methodology Job Plan:

The value methodology is a systematic process and has a specific "Job Plan" that must be followed to maximize the benefits of value methodology projects. We used below job plan (Fig.1) in our project.

2. Pre-Workshop

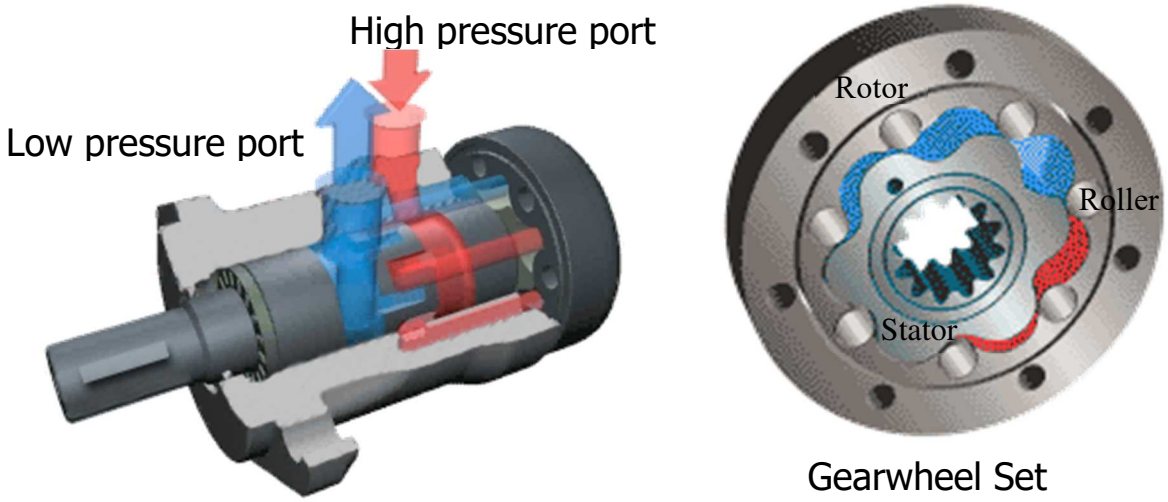
Pre-workshop phase is to determine appropriate project which needs to be studied, ensure required data has been properly prepared and obtain commitment from required team members. We have selected gerotor motors to carry out Value analysis study. The rationale behind to choose the gerotor motor is below,

- Main stream business for danfoss in work function division
- Necessity to defend our dominant position in the market, especially in the Air way platform (AWP) sector as new potential local competitors.
- Cost increase in the past several years in terms of both material cost and labor cost
- Price reduction pressure from customers in the medium to long term

The rationale is presented to the management for approval and then cross functional team is formed to run product improvement project using value methodology. The cross-function team consist of members from Engineering, Procurement, Product management, Quality, Manufacturing Engineering, sales, Marketing, Finance and VA/VE.

3. Information Phase

The heart of the gerotor motors is a gearwheel set. The fixed exterior gearwheel – Stator, interior gearwheel – Rotor. The rotor has one (1) tooth less than the stator. Chambers are formed between the stator inner teeth and rotor outer teeth. When these chambers are connected to the high-pressure port (in red) and low-pressure port (in blue), the pressure differential causes a rotary movement of the rotor. As the rotor rotates, the high pressure/low pressure chamber rotates as well. A valving system ensures hydraulic oil be continuously pumped in and out the gearwheel to sustain this motion. The circular movement of the gearwheel center transfers to the rotation of the shaft in the opposite direction. It results in an approx. six times higher turning torque at a six times lower speed without the use of a reduction gear.



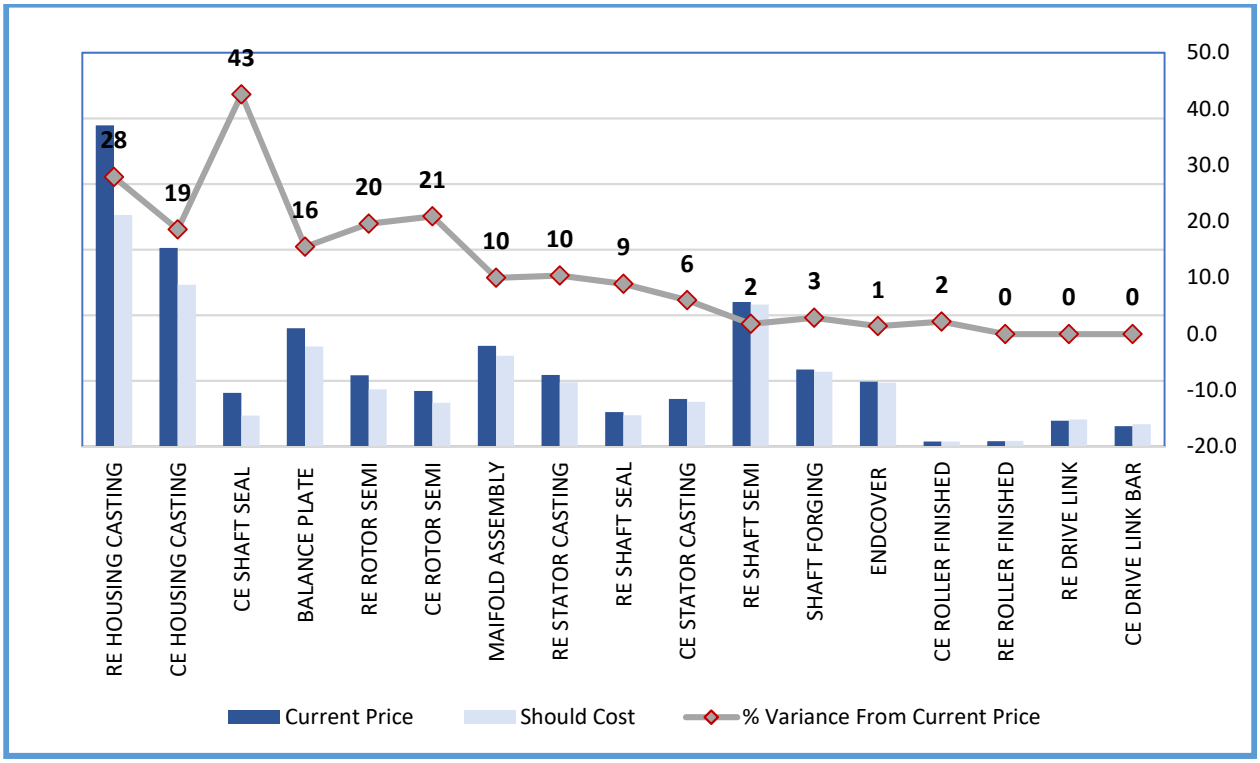
3.1 Competitor Benchmarking

Competitor product selection for benchmarking is done based on the application and performance parameters. Detailed tear down and benchmarking analysis is done to collect all the necessary inputs from the competitor products. All information like drawings, BOM, cost, quality, manufacturing process, performance test results and voice of customer are prepared as part of information phase and provided to all team members during the workshop. Below table shows the product specification data from competitor benchmarking.

Image			
Make		**Danfoss**	**Competitor**
Displacement cm3		375	371
Max. Speed RPM	Continuous	200	200
	Intermittent	250	240
Max.Flow lpm	Continuous	76	75
	Intermittent	91	90
Max. Torque Nm	Continuous	1006	990
	Intermittent	1158	1140
Max. Pressure bar	Continuous	207	205
	Intermittent	241	240
	peak	276	276
Mount and port option		4-Hole, Wheel Mount, Aligned Ports, G 1/2	4 Hole, Wheel Mount,7/8-14 UNF1
Shaft option		1-1/2” Tapered	1-1/4" Tapered
Paint		Black Painted	Black Painted
Length (mtg) mm		174	140.5
Weight Kg		15	13.5
Over all LxWxB mm		258x132x132	247.5x133x138
Number of components		30	30

3.2 Should cost Estimation:

Should costing is used to understand the right price for the components with most economical process routing. Should costing is done for all the major components for our product and competitor product. Below chart shows the difference between the current price and the should cost for our product. The current price and should cost is plotted on Primary axis (Values are intentionally not Shown) and the percentage difference is plotted on Secondary axis.



3.3 Gerotor Motor Application

Gerotor motors are used in below application

- Aerial work platforms
- Wood Chippers
- Cotton Harvesters
- Sweepers
- Brooms on skid steer attachments
- Grapplers for forest industry

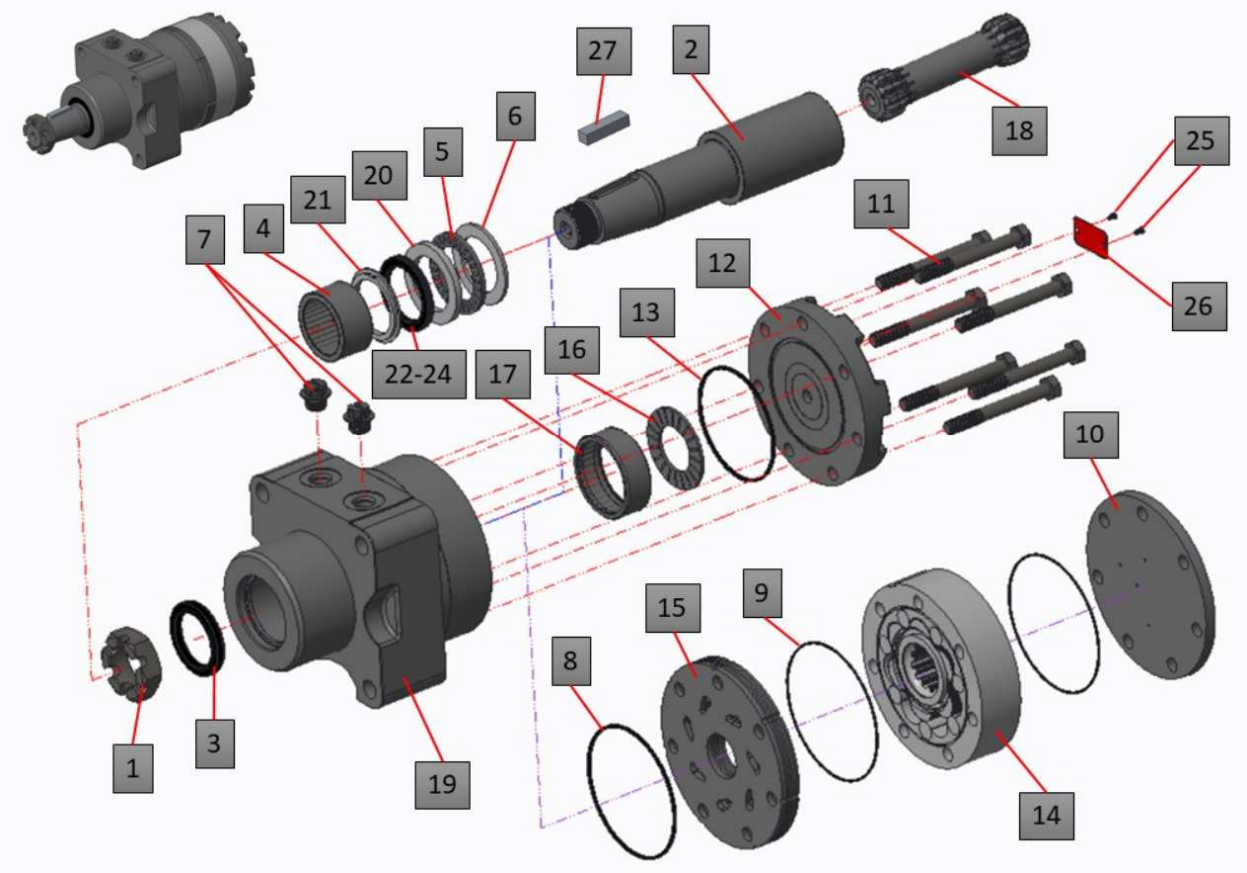
4.0 Function Phase

The objective of function phase is to describe the product in terms of functions, develop FAST diagram, relate the cost of component to the functions and to determine the functions which are being performed and those which must be performed. The tasks completed in function phase is

- Interaction Matrix
- Function listing
- Classify all functions into various types
- Develop FAST diagram
- Function cost worth (FCW) analysis
- Complete Cost/Function worksheet

4.1 Interaction Matrix

Interaction matrix is used to identify the interaction between the components of the product as well as the interaction with the external environment. In gerotor the external environments are Hydraulic fluid, wheel hub, connections and mounting bolts. Gerotor motor is fixed in the wheel hub using mounting bolt, connections are used to connect the hydraulic fluid line with the motor. Interaction matrix supports to identify the correct functions for each component. The below figure is exploded view of gerotor motor, it shows the different components used in the motor.



Exploded View of gerotor motor

Below table shows the interaction matrix for gerotor. In this all the major components and components in the external environment are listed in X-axis and Y-axis. Each component is checked for interaction with all other components, the interaction may be mechanical, electrical, thermal, chemical, electric or magnetic field. Plus (+) sign is used if the interaction is happening between the components and minus (-) sign is used if there is no interaction is happening between the components. The matrix is symmetric. If we get (+) sign between two components, then there is function exist and the team will identify the function between the components. In below table Rotor(14) which is part of gearwheel set is interacting with stator(14), Roller(14), Manifold(15), Cardan Shaft(18), Balance plate(10) and hydraulic fluid. Hence all these components are identified with (+) sign in first row. Similarly, all the components interactions are identified and marked.

INTERACTION MATRIX	Rotor	Stator	Roller	Manifold	Cardan Shaft	Housing	Output Shaft	Balance Plate	End Cover	Shaft Seal	Bolt	Wheel Hub	Connections	Hydraulic Fluid	Mounting Bolt
Rotor		+	+	+	+	-	-	+	-	-	-	-	-	+	-
Stator	+		+	+	-	-	-	+	-	-	+	-	-	+	-
Roller	+	+		+	-	-	-	+	-	-	-	-	-	+	-
Manifold	+	+	+		-	+	-	-	-	-	+	-	-	+	-
Cardan Shaft	+	-	-	-		-	+	-	-	-	-	-	-	-	-
Housing	-	-	-	+	-		+	-	-	+	+	+	+	+	-
Output Shaft	-	-	-	-	+	+		-	-	+	-	+	-	+	-
Balance Plate	+	+	+	-	-	-	-		+	-	+	-	-	+	-
End Cover	-	-	-	-	-	-	-	+		-	+	-	-	-	-
Shaft Seal	-	-	-	-	-	+	+	-	-		-	-	-	+	-
Bolt	-	+	-	+	-	+	-	+	+	-		-	-	-	-
Wheel Hub	-	-	-	-	-	+	+	-	-	-	-		-	-	+
Connections	-	-	-	-	-	+	-	-	-	-	-	-		+	-
Hydraulic Fluid	+	+	+	+	-	+	+	+	-	+	-	-	+		-
Mounting Bolt	-	-	-	-	-	-	-	-	-	-	-	+	-	-	

4.2 Random function Listing

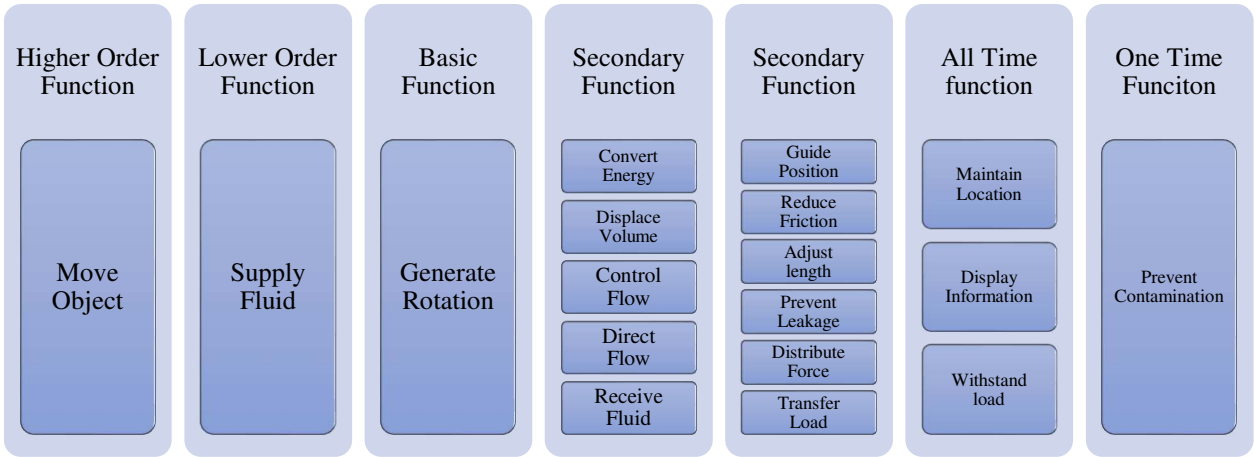
When identifying the function, the key question asked is “what does it do?” and the function is described using two words an Action Verb and Measurable Noun. The team checked all the (+) sign from the interaction matrix and identified the functions exists between the components by asking the question, what does it to? For example, in below table Rotor is doing the functions like Displace Volume, Generate Rotation, Convert Energy and Control Flow when it interacts with hydraulic fluid and cardan shaft. Rotor also interacts with other components like the stator, roller, manifold and balance plate. The functions of these interactions are listed in the respective components to differentiate which component is performing the function and which one is receiving the function. Each component is only having the list of functions which it performs on the other interacting components. Table below list the all the functions of the major components.

System or Component	Function	
	Action Verb	Measureable Noun
ROTOR (14)	DISPLACE	VOLUME
	GENERATE	ROTATION
	COVERT	ENERGY
	CONTROL	FLOW
STATOR (14)	GUIDE	POSITION
	DISPLACE	VOLUME
	MAINTAIN	LOCATION
	PREVENT	LEAKAGE
	TRANSFER	LOAD
ROLLER (14)	REDUCE	FRICTION
	DISPLACE	VOLUME
MANIFOLD (15)	CONTROL	FLOW
	PREVENT	LEAKAGE
	TRANSFER	LOAD
	DISPLACE	VOLUME
	DIRECT	FLOW
CARDAN SHAFT (18)	ADJUST	LENGTH
	GENERATE	ROTATION
HOUSING (19)	MAINTAIN	LOCATION
	RECEIVE	VOLUME
	DIRECT	FLOW

System or Component	Function	
	Action Verb	Measureable Noun
OUTPUT SHAFT (2)	GENERATE	ROTATION
	MAINTAIN	LOCATION
	DIRECT	FLOW
BALANCE PLATE (10)	DISTRIBUTE	FORCE
	DISPLACE	VOLUME
	TRANSFER	LOAD
END COVER (12)	TRANSFER	LOAD
	DISPLACE	VOLUME
	PREVENT	LEAKAGE
	MAINTAIN	LOCATION
SHAFT SEAL (22-24)	PREVENT	LEAKAGE
BOLT (11)	MAINTAIN	LOCATION
	MAINTAIN	LOCATION
	MAINTAIN	LOCATION
	TRANSFER	LOAD
	MAINTAIN	LOCATION
MOUNTING BOLT	MAINTAIN	LOCATION
CONNECTIONS	DIRECT	FLOW
	SUPPLY	VOLUME
HYDRAULIC FLUID	GENERATE	ROTATION
	REDUCE	FRICTION
	APPLY	FORCE

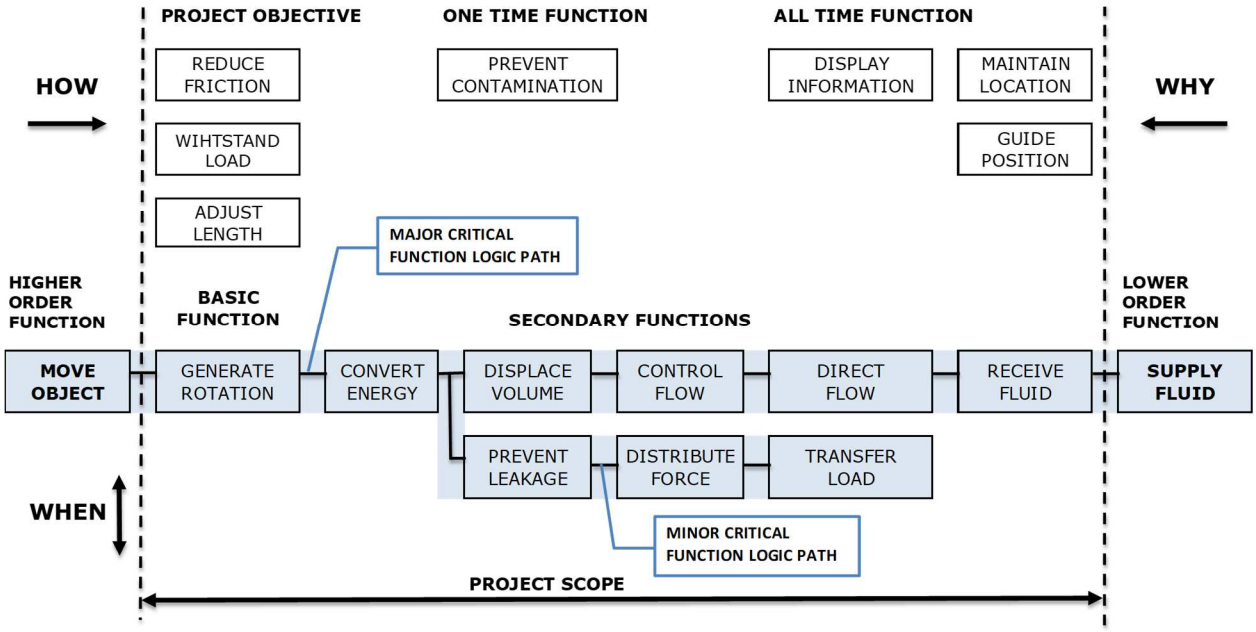
4.3 Final Function List

Functions identified in function listing is consolidated by removing all the repeating functions. The total number of final functions are Eighteen (18). All the 18 functions are classified as Higher order function, Lower order function, Basic function, Secondary function, All time function and One-time function. The basic function is identified as Generate Rotation, it is the main objective of the motor for which it exists. Higher order function is Move Object, the basic function Generate Rotation or torque created by the motor is to move the vehicle. Lower order function is supply fluid, input to the motor to start is hydraulic fluid which is supplied from the hydraulic pump. All times functions which happens all the times are Maintain location, display information and Withstand load. One-time function is identified as Prevent contamination, it is done by the protective cap Plug. Other functions are categorized as secondary function or support functions. These functions are either support basic function, support other secondary function or functions happening at the same time as another secondary function.



4.4 Technical FAST Diagram

FAST diagram is graphical representation of the dependent relationships between functions within the product. The result is a hierarchy of functions which visually shows logical Why? / How? / When? relationships and which provides a ranking of functions in order of their abstraction to achieve a critical path for any product. This 'How? -Why?' logic tests function validity. The below fig shows the FAST diagram for gerotor motor.



Basic function 'Generate Rotation' is placed right side of the left scope line, then the higher order function 'Move Object' is placed left side of the left scope line, it is arrived by asking why question to the basic function. Then how question is asked to the basic function to get the secondary function 'Convert Energy'. Next how question is asked on 'Convert Energy' to get the next secondary function 'Displace Volume' and it repeats till we get the lower order function 'Supply Fluid'. It forms the critical path. Remaining functions like Support functions happening at the same time, one time function and all time functions are placed in the FAST diagram. It also has minor critical path from 'Prevent Leakage' to 'Transfer Load'. We also have few design objectives which is mentioned on the top left corner inside the left scope line. The team finally agreed to the function model developed using FAST diagram and we verified all the function listed were captured in this diagram.

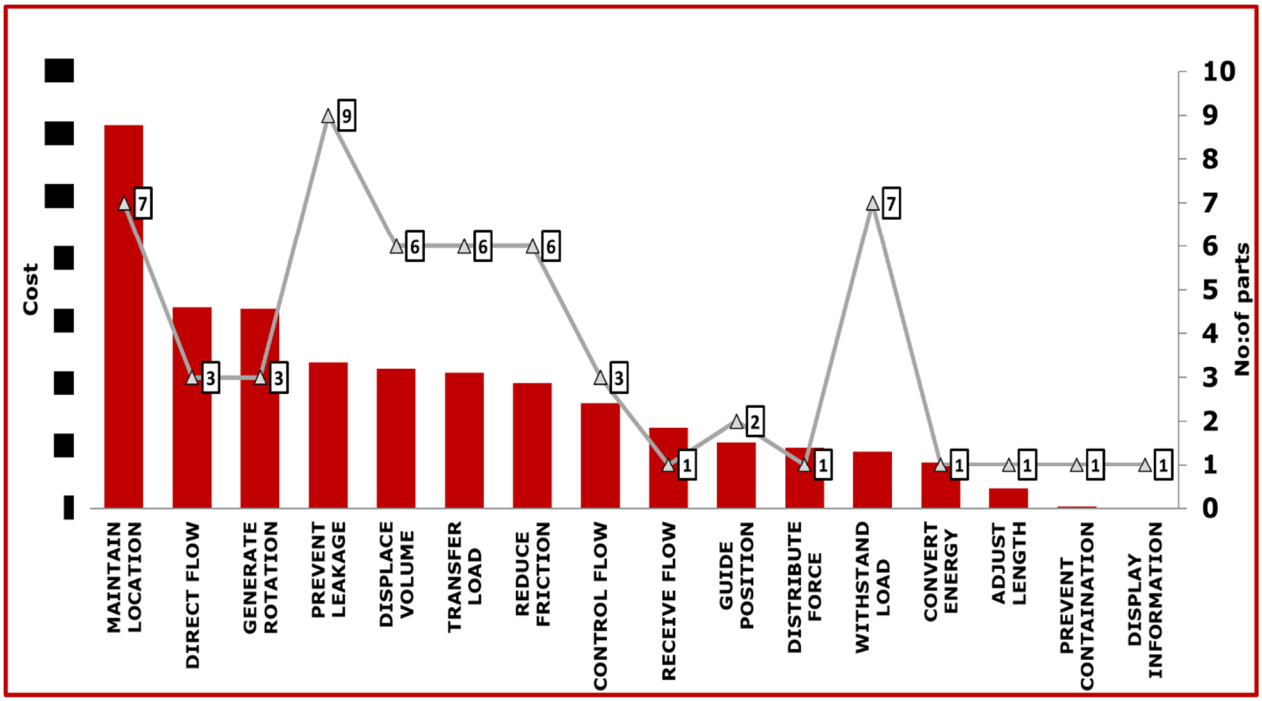
4.5 Function Resource Matrix Worksheet

The function resource matrix Worksheet is prepared to allocate the cost of the product to functions. Each component price is distributed to the functions it performs. The below table shows distribution of cost of different parts to the functions they contributed in percentage (The cost information's are intentionally not provided). For example, the housing cost is distributed to functions Maintain Location, Direct Flow and Receive Flow by 50%,30% and 20% respectively. The percentage is agreed with all the team members. Total cost of each function is given in last row as percentage of total product cost. The highest cost function is Maintain location with 21.65% of product cost.

Function Cost Worksheet																			
			No: of parts	6	3	3	2	7	9	6	6	3	1	1	1	7	1	0	1
			Pos#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
GEOROTOR MOTOR				DISPLACE VOLUME	GENERATE ROTATION	CONTROL FLOW	GUIDE POSITION	MAINTAIN LOCATION	PREVENT LEAKAGE	TRANSFER LOAD	REDUCE FRICTION	DIRECT FLOW	ADJUST LENGTH	DISTRIBUTE FORCE	RECEIVE FLOW	WITHSTAND LOAD	DISPLAY INFORMATION	PREVENT CONTAINATION	CONVERT ENERGY
Pos*	Component	BoM Units	BoM Cost per Unit (€)	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1	HOUSING	1		10%		30%		50%	20%	20%		30%			20%				
2	MANIFOLD 5"	1			60%			30%				20%							
3	SHAFT [1-1/2 TAPERED]	1		20%						30%		10%		50%					
4	BALANCE PLATE FINISHED	1		20%			30%	30%	10%	10%									30%
5	STATOR FINISHED	1		20%	40%	10%		50%	20%	20%	80%		50%						
6	ROTOR FINISHED	1		10%			10%		100%										
7	ENDCOVER CHART	1		10%	50%			80%		20%	50%					50%			
8	ROLLER FINISHED	7									50%					50%			
9	SHAFT SEAL	1									100%					100%			
10	CARDAN SHAFT	1						100%			50%					50%			
11	3/8'-24 BOLTS	7																	
12	SHAFT BEARING1	1																	
13	SHAFT BEARING2	1																	
14	THRUST WASHER1	1																	
15	HB POLYAMIDE BACK-UP	1																	
16	NUT, SLOTTED HEX	1																	
17	BACKUP RING	1																	
18	THRUST BEARING1	1																	
19	THRUST WASHER2	1																	
20	THRUST BEARING2	1																	
21	SHIM, BACKUP	1																	
22	SEAL, DUST	1																	
23	KEY	1																	
24	STICK SCREW	2																	
25	BODY SEAL	2																	
26	CAPLUG, 9/16-18 ORING	2																	
27	O-RING SEAL	1																	
28	SEAL[D2*79.8]	1																	
29	TAG STAMPING	1																	
30	BALANCE PLATE BALL	3																	
				7.88%	11.29%	5.96%	3.75%	21.65%	8.25%	7.67%	7.07%	11.36%	1.12%	3.45%	4.58%	3.21%	0.04%	0.11%	2.61%

4.6 Function Cost Waterfall

Function cost waterfall is graphical representation of function cost matrix, it is used to sort the functions based on the cost of each function from the function cost worksheet. So that high cost functions are prioritized for developing alternate ideas in creativity phase. It also shows the number of components involved to achieve each function. From the function cost water fall it is evident the maintain location is the function with highest cost contribution, it also shows the number of components contributing to this function. Total seven components are doing the function maintain location. The number of parts is used to identify ideas to eliminate or combine the components and simplify the design with less number of components



4.7 Function Cost Worth Analysis

Function cost worth analysis is done to identify the value gap and value index. Functions which are having high cost and high value index are prioritized for idea generation in creativity phase. The functions like Maintain Location, Prevent Leakage, Generate rotation, Reduce Friction and Withstand Load are prioritized from the below FCW table.

Function	Components	Cost (C)	Worth(W)	Basis of Worth	Value Gap (C-W)	Value Index (C/W)
Maintain Location	Housing Shaft [1-1/2 Tapered] Stator Finished Endcover Chart 3/8'-24 Bolts Nut, Slotted Stick Screw	XXX.XX	XXX.XX	Reduce housing Machining	XX.XX	1.26
Transfer Load	Manifold 5" Balance Plate Stator Finished Endcover Chart 3/8'-24 Bolts Key,	XX.XX	XX.XX	Manifold 7 hole reduce t 3 Hole	X.XX	1.01
Direct Flow	Housing Manifold 5" Shaft [1-1/2 Tapered]	XX.XX	XX.XX	Negotiate based on should cost	X.XX	1.05
Receive Flow	Housing	XX.XX	XX.XX	-	-	1.00
Control Flow	Manifold 5" Rotor Finished Balance Plate Ball	XX.XX	XX.XX	-	-	1.00
Prevent Leakage	Manifold 5" Stator Finished Endcover Chart Shaft Seal Backup Ring Seal, Dust Body Seal O-Ring Seal Seal	XX.XX	XX.XX	Integrate high pressure oil seal	X.XX	1.39
Displace Volume	Manifold 5" Balance Plate Stator Finished Rotor Finished Endcover Chart Roller Finished	XX.XX	XX.XX	-	-	1.00
Generate Rotation	Shaft [1-1/2 Tapered] Rotor Finished Drive Link	XX.XX	XX.XX	Outsource Machining	X.XX	1.29
Distribute Force	Balance Plate Finished	XX.XX	XX.XX	-	-	1.00
Guide Position	Stator Finished Roller Finished	XX.XX	XX.XX	-	-	1.04
Reduce Friction	Roller Finished Hb Polyamide Back-Up Shaft Bearing1 Shaft Bearing2 Thrust Bearing1 Thrust Bearing2	XX.XX	XX.XX	Localisation of bearings	X.XX	1.68
Adjust Length	Drive Link	X.XX	X.XX	-	-	1.00
Withstand Load	Shim, Backup Shaft Bearing1 Shaft Bearing2 Thrust Washer1 Thrust Bearing1 Thrust Washer2 Thrust Bearing2	XX.XX	XX.XX	Remove one thrust washer	X.XX	1.20
Prevent Containation	Caplug	0.XX	0.XX	-	-	1.00
Display Information	Tag Stamping	0.XX	0.XX	-	-	1.00

5.0 Creativity Phase

In creativity phase prioritized functions from the functions phase is discussed with cross functional team for idea generation. Brainstorming and Brainwriting technique is used for idea generation. Initially we used open idea generation session with the free-flowing ideas. Once we completed with free-flowing ideas, we used six key questions on each function to generate ideas, the six questions are,

1. Why is it being done? Is it needed?
2. What else will perform the function?
3. What other material or process could perform the same function?
4. Where else may the function be performed?
5. How else may the functions be performed?
6. Can parts (process) be combined to perform the same function

Below table shows the different ideas generated on the function Maintain Location. It is high cost function with value index 1.26. The function maintain location is contributed by seven components, all the components were listed with the unit cost and how much cost is shared for this function. Then each component brainstormed using the six questions for 'Maintain Location' function. We got five ideas against the maintain location function.

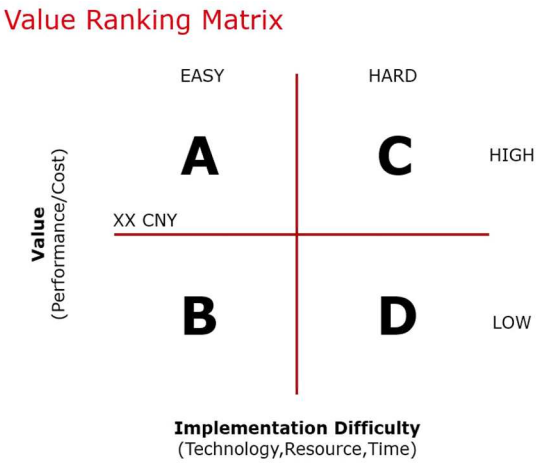
Function	Ideas
MAINTAIN LOCATION	1. Housing can be manufactured through forging process with lesser thickness 2. Web design to reduce material 3. Use end cap to maintain roller location 4. Stator can be manufactured through stock machining 5. End cap and stator can be integrated

The above process is applied to all the high value index functions, the below is the list of ideas generated on some of the high value index functions,

Function	**Ideas**
Transfer Load	1. Manifold 7 holes reduce to 3 Holes 2. Balance plate small disc inside flange end plate
Prevent Leakage	1. Integrate high pressure oil seal 2. Replace honing process by phosphorization 3. End cover roughness reduce 4. Standardize all O-rings
Generate Rotation	1. Reduce grinding area in shaft 2. Outsource shaft 3. Drive link cold forging 4. Change heat treatment process for shaft
Guide Position	1. Stator Machined from bar 2. Rotor in sintering 3. Optimize rotor cold drawing process

6.0 Evaluation Phase:

In creativity phase total 49 ideas generated. Out of 49 ideas, 18 Ideas were killed during initial screening, which are either duplicate or involve new technology or would negatively impact on our Motto of "Safety, Quality, Delivery, and Cost". Remaining 31 ideas are evaluated and categorized using the value ranking matrix. X- axis is for value (improvement in Performance and Cost) and Y-axis is for implementation difficulty (New Technology, resource, time). The table below table shows the ideas ranked as per the value ranking matrix.



Value Ranking	No of ideas	Identified Savings	% on total savings
A	5	xx.xx	18%
B	13	xx.xx	6%
C	11	xx.xx	75%
D	2	xx.xx	1%
Total	31	xx.xx	100%

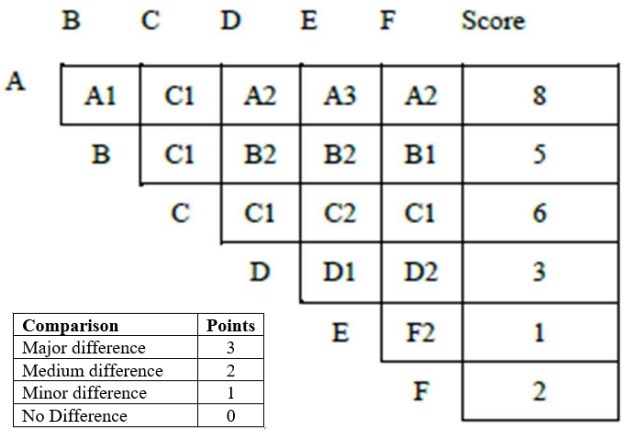
Ideas ranked A is taken as high priority for implementation since it gives more value to the product and the implementation difficulty also less. All the ideas ranked B will be tried for implementation because it is very easy to implement. The ideas ranked C is further evaluated to decide whether it can be part of this project or it can be perceived separately as technology project. The ideas ranked D is parked as of now for future use.

6.1 Paired comparison matrix

Ideas in C which are harder to implement because it requires more time and resource, but they give substantial value improvement in our product. The team selected four ideas from C to evaluate through paired comparison matrix and decision matrix. Below are the four ideas team selected for evaluation,

1. Reduce weight and machining in housing.
2. Purchase finished shaft directly from supplier.
3. Integrated high pressure oil seal.
4. Drive link maching to cold forging.

The criteria selected for paired comparison matrix was Performance, cost, Customer Acceptance, Lead time, Resources and Implementation risk. After scoring the all the criteria's in paired comparison matrix, performance is ranked as number one with highest score of eight. The we have Customer acceptance, Cost, Leadtime, implementation risk and resource in next ranking order. The scores form the paired comparison matric is used in decision matrix to evaluate all the four ideas identified by the team.



	B	C	D	E	F	Score
A	A1	C1	A2	A3	A2	8
	B	C1	B2	B2	B1	5
		C	C1	C2	C1	6
			D	D1	D2	3
				E	F2	1
					F	2

Comparison	Points
Major difference	3
Medium difference	2
Minor difference	1
No Difference	0

Identify	Criteria	Score	Rank
A	Performance	8	I
B	Cost	5	III
C	Customer Acceptance	6	II
D	Lead time	3	IV
E	Resources	1	VI
F	Implementation risk	2	V

Decision Matrix

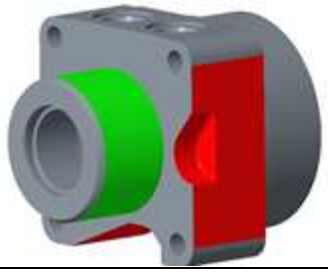
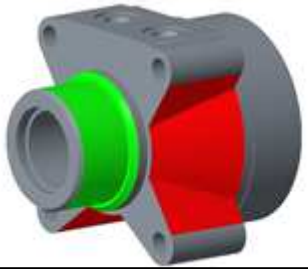
All the four ideas along with existing design is scored using the five-point sale in decision matrix. The scores are multiplied with the weightage and then all the multiplied scores are added together for getting final score for each idea. Out of 4 ideas two ideas Idea 1 and Idea 2 are scored better than existing design. Hence the team decided to go ahead with the two-top rank idea. The idea 3 and Idea 4 not taken for implementation.

Point Scale: Excellent = 5 Very Good = 4 Good = 3 Satisfactory = 2 Poor = 2		Performance	Cost	Customer Acc	Lead time	Resources	Imp. Risk	Total	Rank
Weightage		**8**	**5**	**6**	**3**	**1**	**2**		
Existing	Existing Product Design	3	2	4	4	4	4	82	3
		24	10	24	12	4	8		
Idea1	Reduce weight and machining in housing	4	4	3	2	2	3	84	2
		32	20	18	6	2	6		
Idea2	Purchase finished shaft directly from supplier	3	4	4	3	4	3	87	1
		24	20	24	9	4	6		
Idea3	Integrated high pressure oil seal	3	3	3	3	4	3	76	4
		24	15	18	9	4	6		
Idea4	Drive line maching to cold forging	3	3	3	2	2	2	69	5
		24	15	18	6	2	4		

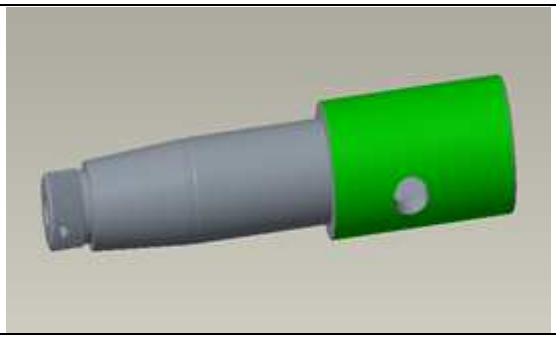
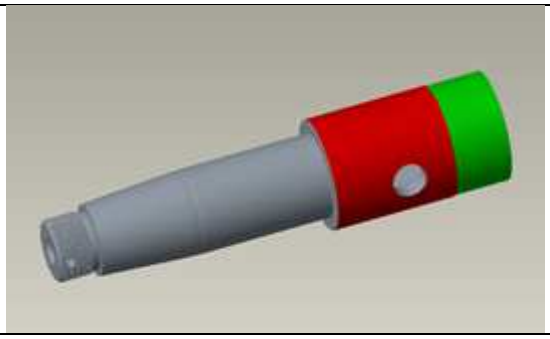
7. Development phase

In development phase business case for all the major ideas were prepared. The business case includes resource allocation, Validation plan, drawings and 3D models for new design, Saving confirmation by supplier quotation, investment and implementation time. The developed business case is presented to the management for approval. The top three ideas which is approved by the management for implementation is given below,

Idea1. Redesign housing with web design

BEFORE	AFTER
	
The green surface requires higher machining time and the surface is as cast.	Green surface is redesigned to reduce rough maching and material reduced from red surface. Weight reduction is 2Kg.

Idea2. Reduce grinding area on shaft & outsource machining

BEFORE	AFTER
	
Maching and grinding is done in highlighted green area. Grinding length 83.1mm	Grinding length is reduced to 25mm matching to the bearing length. Grinding cycle time reduced.

Idea3. Stator machined from stock instead of casting

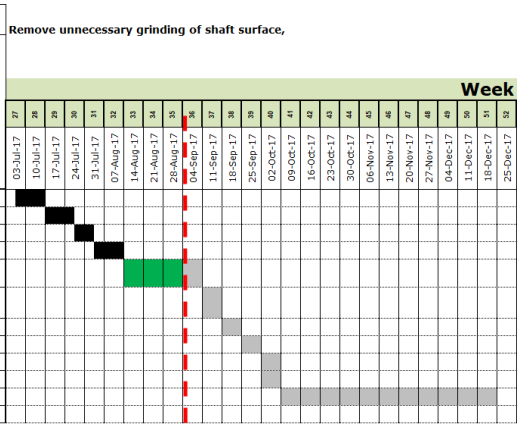
BEFORE	AFTER
	
Stator is casted first than machining is done. Casting cast is high, machining is done all the surfaces	Stator is machined directly from stock. Number of suppliers reduced from 2 to 1. Lead time for supply is improved

8. Implementation

Implementation plan is prepared for all the ideas. Total 13ideas considered for implementation. Implementation plan is prepared for all the 13 ideas which includes below steps. Sample implementation plan is also given below.

- Design Review, DFMEA
- Drawing release for Prototype parts
- Prototype fitment trial
- Initial Customer Approval
- Vehicle level validation
- Vendor PPAP
- Engineering Change Note (ECN)
- Customer acceptance
- Change implementation

Core Team		Adele Gu, Leo Zhan,Linda Li , Richard Li, Philip Ling, Vivian Liu , Jason Wang, Premkumar Chandran		
Idea Responsible		Zhang Kai (Leo)		
Objective	Work stream	Activity	Workstream Responsible	Support Resource
Idea Validation and Approval	Technology Validation	Proposal on new grinding length	Leo	
		Saving evaluation and idea profile (IL2)	Leo	
		Risk assessment	Leo	
		Change request on WF EC sharepoint (IL3)	Leo	
		Making 30 pcs PPAP sample for test (3 week + HT next Thurseday)	Leo	Wu CaiPing
		Grinding /finishing (1 week)	Leo	
		Inspection Sample & test (5 days)	Leo	
		Result & Approval on PPAP sample (3 days) (IL4)	Leo	
		Communication with Sales & PAE for customer notification process	Leo	Roger Yang
		Release EC pring	Leo	
		Mass production implementation (IL5)	Leo	



Sample implementation plan

9.0 Conclusion

The total savings achieved from this project is more than 10% of variable cost. We also reduced our product weight by 2kg. At the end of each value analysis project we also gather lot of information, which will be stored and used in future. Danfoss engineers the technologies that enable the world of tomorrow to do more with less, value methodology helping us to achieve this.

10.0 Acknowledgement

We are thankful to all the project team members who have put their concentrated effort in making this project successful.
We are also thankful to Mr. Peter Dahl, Head of DBS supply chain for encouraging us to participate in this conference.
We also thank Mr. Alok Ghosal CVS -Life for mentoring our team.