

Multidisciplinary Capstone Design: VIA Dynamic Load Simulation On A Journal Bearing Test Rig

In 2010, Dresser-Rand, a global supplier of rotating equipment, donated ESH-1 reciprocating compressor to the Rochester Institute of Technology and has continually sponsored multidisciplinary senior design (MSD) projects. Dr. Jason Kolodziej, Assistant Professor of Mechanical Engineering at Rochester Institute of Technology, commissioned the construction of a dynamic journal bearing similarity test rig. The objective of this rig is to reduce the time required to perform seed of fault research of journal bearings. The project was split into a two phase build utilizing two consecutive multidisciplinary senior design teams. While the similarity test rig will assist Dr. Kolodziej and future graduate students with research at RIT, it also served as a “real world” design and development project for 10 soon-to-be engineers.

Course Structure:

- Required for all engineering seniors
- Team-Based, Capstone Design Experience
- Two Semester Breakdown – 30 Weeks
- MSD I focus – Design phase
- MSD II – Implementation, build & Test

Concept Selection (5)

Pugh charts assist in team based concept selection, by measuring how well each option meets requirements

Criteria #	Selection Criteria	Con. Concept 1	Con. Concept 2	Electro Hydraulic	Pneumo and Spring	Pneumatic 1	Pneumatic 2	Electric Linear 1	Electric Linear 2	Pneumo Electric 1	Pneumo Electric 2	Pneumo Electric 3
1	Applied Load Achievable To 100	-	-	S	S	S	S	S	S	S	S	S
2	Applied Load Achievable To 100	S	S	S	S	S	S	S	S	S	S	S
3	Applied Load Achievable at 100lb (1)	-	-	DATUM	S	S	S	S	S	S	S	S
4	Applied Load Achievable at 100lb (1)	-	-	DATUM	S	S	S	S	S	S	S	S
5	Response Time	+	+	+	+	+	+	+	+	+	+	+
6	Adaptability to Current System	+	-	+	+	+	+	+	+	+	+	+
7	Cost	+	+	\$2000	-	-	-	-	-	-	-	-
8	Estimated Life of System	-	-	S	+	+	+	+	+	+	+	+
9	Acoustic Noise Level	S	S	S	S	S	S	S	S	S	S	S
10	Responsibility of Major Components	+	+	+	+	+	+	+	+	+	+	+
11	Ease of Journal Bearing Replacement	S	-	DATUM	-	+	+	+	+	+	+	+
12	Applied Load Accuracy	-	-	+	+	+	+	+	+	+	+	+
13	System Design Complexity	-	-	-	-	-	-	-	-	-	-	-
14	Backlash Sensitivity	+	+	S	S	S	S	S	S	S	S	S
	Sum (1)	3	5	7	6	2	2	2	2	2	2	2
	Sum (2)	3	5	7	6	2	2	2	2	2	2	2
	Sum (3)	6	8	5	5	3	3	3	3	3	3	3
	Total Sum	3	4	0	3	-2	-2	-3	-3	-4	0	-3

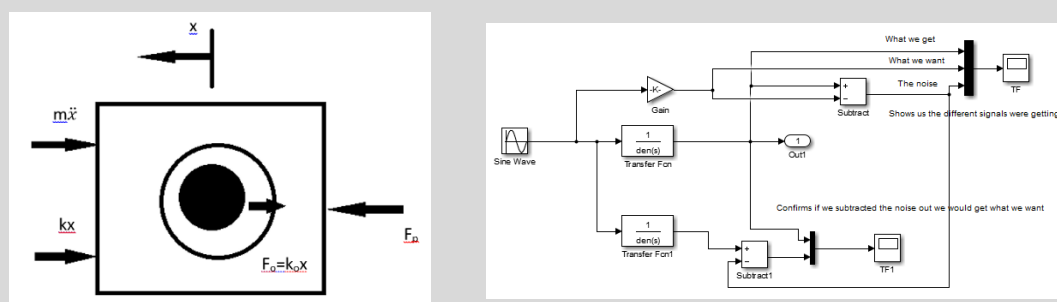
Risk Assessment (6)

Measure the likelihood and severity of the risks associated with the chosen design

Risk #	Risk Item	Impact	Severity	Probability	Control	Residual	Residual Severity	Residual Probability	Residual Impact	Residual Severity
1	Motor failure	High	High	Low	Replace motor with backup	Medium	Medium	Low	Medium	Medium
2	Electrical wiring error	Medium	Medium	Medium	Double check wiring	Low	Low	Low	Low	Low
3	Structural failure	High	High	Low	Use safety factor	Medium	Medium	Low	Medium	Medium
4	Assembly error	Medium	Medium	Medium	Use assembly manual	Low	Low	Low	Low	Low
5	Material quality	Medium	Medium	Low	Inspect materials	Low	Low	Low	Low	Low
6	Human error	Medium	Medium	Medium	Use safety protocols	Low	Low	Low	Low	Low
7	Software error	Medium	Medium	Low	Test software	Low	Low	Low	Low	Low
8	Communication	Medium	Medium	Low	Regular meetings	Low	Low	Low	Low	Low
9	Time constraints	High	High	Medium	Manage resources	Medium	Medium	Medium	Medium	Medium
10	Budget constraints	High	High	Low	Track expenses	Medium	Medium	Low	Medium	Medium
11	Equipment availability	Medium	Medium	Low	Reserve equipment	Low	Low	Low	Low	Low
12	Weather conditions	Low	Low	Low	Monitor weather	Low	Low	Low	Low	Low
13	Public relations	Medium	Medium	Low	Engage community	Low	Low	Low	Low	Low
14	Legal issues	High	High	Low	Consult lawyer	Medium	Medium	Low	Medium	Medium
15	Health and safety	High	High	Low	Follow safety rules	Medium	Medium	Low	Medium	Medium
16	Environmental	Medium	Medium	Low	Reduce waste	Low	Low	Low	Low	Low
17	Energy consumption	Medium	Medium	Low	Optimize energy	Low	Low	Low	Low	Low
18	Water usage	Medium	Medium	Low	Conserve water	Low	Low	Low	Low	Low
19	Waste management	Medium	Medium	Low	Recycle materials	Low	Low	Low	Low	Low
20	Community impact	Medium	Medium	Low	Engage neighbors	Low	Low	Low	Low	Low

Theoretical Analysis (7)

Can the concept be proved?
Theoretically? By software?

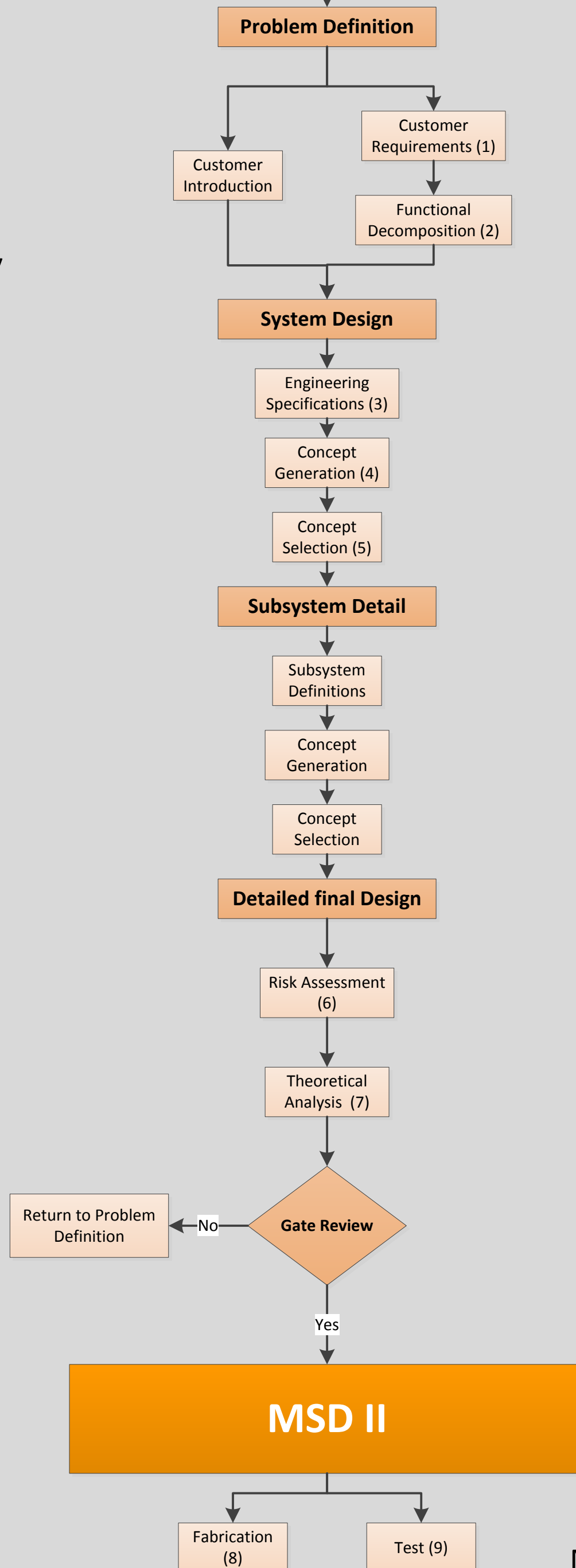


Fabrication (8)

Students working hand and hand with RIT machine shop faculty to build design to specifications



MSD II



Test (9)

Test plans consisting of detailed steps which will, if passed, ultimately lead to system verification.

Test #	Test Description	Pass/Fail	Notes
1	Visual inspection of components	Pass	
2	Dimensional check of critical parts	Pass	
3	Functional test of motor and sensors	Pass	
4	Load test at 100lb	Pass	
5	Temperature measurement	Pass	
6	Vibration measurement	Pass	
7	Oil pressure measurement	Pass	
8	Oil flow rate measurement	Pass	
9	Oil temperature measurement	Pass	
10	Oil level measurement	Pass	
11	Oil viscosity measurement	Pass	
12	Oil pressure sensor calibration	Pass	
13	Oil flow rate sensor calibration	Pass	
14	Oil temperature sensor calibration	Pass	
15	Oil level sensor calibration	Pass	
16	Oil viscosity sensor calibration	Pass	
17	Oil pressure sensor accuracy test	Pass	
18	Oil flow rate sensor accuracy test	Pass	
19	Oil temperature sensor accuracy test	Pass	
20	Oil level sensor accuracy test	Pass	
21	Oil viscosity sensor accuracy test	Pass	

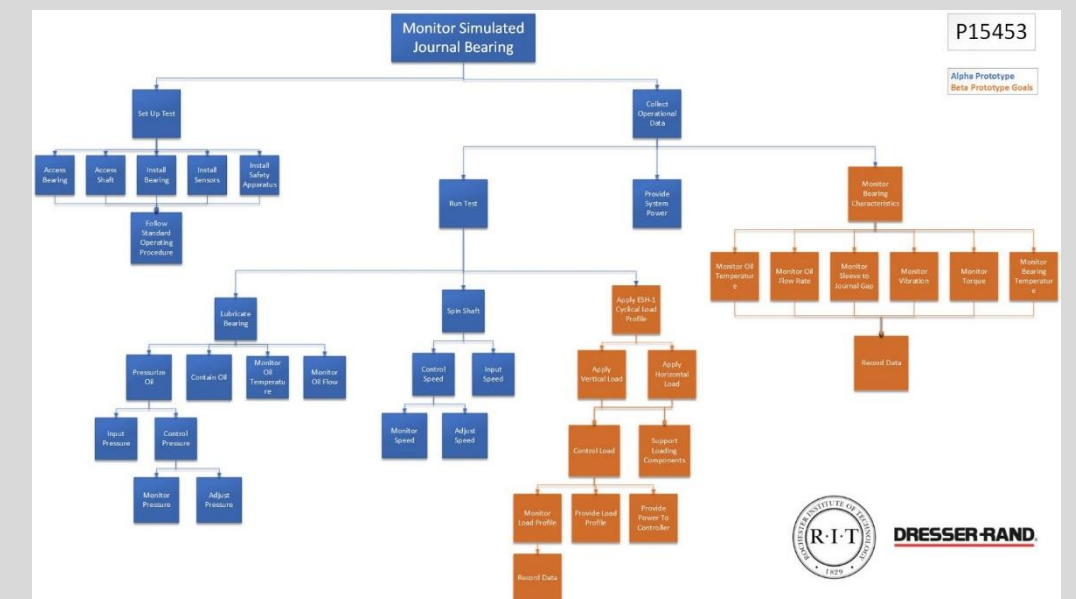
Customer Needs (1)

The key requirements the customer expects from the finished product

P15453 Customer Requirements				
Revision Letter	Type	Importance	Description	
	Cost	CR 1.1	9	Fits within budget
	Functionality Properties	CR 2.1	9	Replicates load profile of ESH-1 Compressor
		CR 2.2	9	Rapid Bearing replacement
		CR 2.3	9	Measures Load
		CR 2.4	9	Measures Oil Return Temperature
		CR 2.5	9	Measures Bearing Temperature
		CR 2.6	9	Measures Oil Pan Temperature
		CR 2.7	9	Measures Vibration
		CR 2.8	3	Measure Gap Between Journal & Sleeve
		CR 2.9	3	Modify Oil Flow Rate In/Out Measurement
		CR 2.10	3	Able to isolate bearing vibration from oil system vibration
		CR 2.11	1	Measures Bearing Wear
	Safety	CR 3.1	9	Guarded Rotating Assembly
		CR 3.2	9	Add E-Stop
		CR 3.3	3	Low noise
	Usability	CR 4.1	9	Records test data
		CR 4.2	9	Compatible with existing D50 equipment

Functional Decomposition (2)

Small, easily definable steps, taken to achieve customer requirements



Engineering Requirements (3)

A set of requirements that coincide with customer requirements but have technical values of measure.

P15453 Engineering Requirements						
Reqmt. #	Importance	Source	Function	Engr. Requirement (metrics)	Unit of Measure	Ideal Value (ENGR)
ER 1	9	CR 1.1	Meet Financial Constraints	Yes/No	\$	\$1,000.00
ER 2	9	CR 2.1	Dynamic Load Actuating Rapid Bearing	Apply cyclical load profile	LMF / Hz	1950 / 6
ER 3	9	CR 2.2	Measure Load	Does not exceed an hour	Min	45 min
ER 4	9	CR 2.3	Measure Oil Return Temperature	Measure load at a bit rate of 10 Hz	LMF	0 - 2000
ER 5	9	CR 2.4	Measure Bearing Temperature	Measures Oil Return temperature at a bit rate of 10 Hz	°F	0 - 150
ER 6	9	CR 2.5	Measure Oil Pan Temperature	Measures Bearing temperature at a bit rate of 10 Hz	°F	0 - 150
ER 7	9	CR 2.6	Measure Bearing Vibration	Measures Oil Pan temperature at a bit rate of 10 Hz	in/s	0 - 150
ER 8	9	CR 2.7	Measure Bearing Vibration	Accelerometer measures vibration	Hz	0 - 50
ER 9	3	CR 2.8	Measure Gap Between Journal and Sleeve	Measures gap distance at a bit rate of 10 Hz	in/s	0 - 1570
ER 10	3	CR 2.9	Modify Oil Flow Rate In/Out Measurement	Measures Oil Flow Rate for entire range of bearing load cycle at a bit rate of 10 Hz	in/s	0 - 5
ER 11	3	CR 2.10	Isolate Oil Pump Vibration	10% less vibration than current system produces without isolation	Hz	0
ER 12	1	CR 2.11	Measure Bearing Wear	Measures bearing wear at a bit rate of 10 Hz	Binary	yes
ER 13	9	CR 3.1	Guarded Rotating Assembly	Rotated assembly is to safety specifications	Binary	yes
ER 14	9	CR 3.2	Add E-Stop	E-stop is present and functioning	Binary	yes
ER 15	3	CR 3.3	Low noise	Meets manufacturing decibel requirements or lower than current state	Decibel	90
ER 16	9	CR 4.1	Records test data	Follows instrumentation properly & records data within current system	bit / s	12
ER 17	9	CR 4.2	Compatible with existing D50 equipment	No extra programs are required to monitor data	Binary	Yes

Concept Generation (4)

Morphological charts provide a platform to brainstorm concept ideas based on system or function.

TEAM INFO



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