ASSE 4311: Learning Outcome Assessment III/Eng

Mechanical Engineering Department

جامعة الأمير محمد بن فهد الأهلية

PRINCE MOHAMMAD BIN FAHD UNIVERSITY

Section# 101

Prepared for

Dr. Emad Tanbour

Prepared by

Jamal J. Al-Saeed	ID# 200600177
Abdullah J. Al-Dossary	ID#200600188
Ali S. Al-Bayat	ID#200600246

Statement of Purpose

- Our project is mainly focusing on the amount of sand in KSA by scooping it from the roads through the basic concepts of snow blowers.
- By that we will design a **Sand Scoop** for that purpose by using computer-aided design (CAD) program.

Outline

- Introduction
  - Snow Blowers.
  - Components of a Snow Blower.
- Scope of Project.
- Analogy between Two-Stage Snow & Sand Scooper.
- Computation to determine volume, weight & torque
- Bearings Selections & Calculations.
- SolidWorks® CAD - Prototype.
- Conclusion.

Introduction

- The snow blower was invented in 1925 by Arthur Sicard.
- Snow Blowers has came a long way since then around the globe and its basic principles remain the same.
- In comparison, a Sand Scooper is a machine that is designed for the purposes of **sand clearing.**

Scope of Project

- Designing a Sand Scooper

  Speed: 60 rpm

  Capacity: 1.6 m wide x 0.6 m high scoop

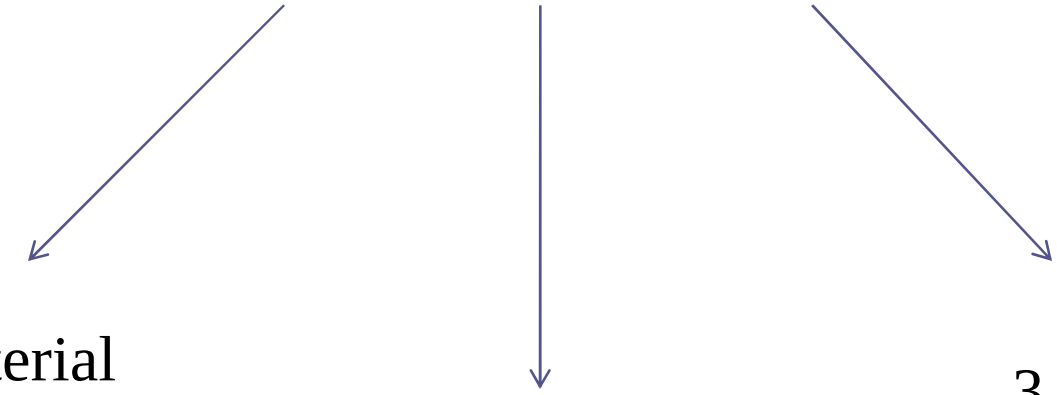
  - Deferential.
  - Bearings.
  - Shafts.
  - Material Selection.

- Making of Digital Prototype.

Design Approach

- ✓ Group Brainstorming.
- ✓ Gathering Literatures review from different sources.
- ✓ Conceptualization Design.
- ✓ Identification of Critical Components.
- ✓ Sizing and Bearing Calculations.
- ✓ Prototyping using CAD SolidWorks®

Pillars of Design



1. Material

2. Load (function)

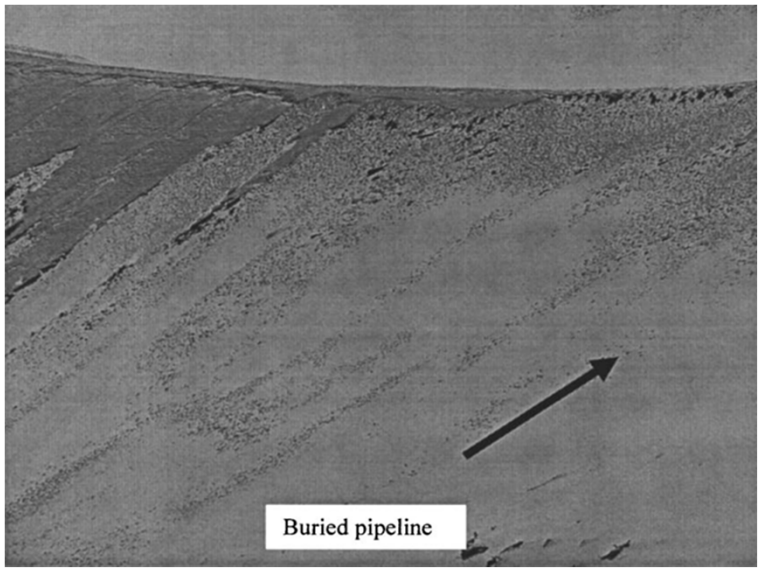
3. Geometry (shape form)

- Knowing 2 of the 3 will allow us to determine the 3rd.

Problem Statement

- About $^{1}/_{3}$ of Saudi Arabia is covered in sand.
- Sand dunes form by sand drifts and occasional sand storms.
- In the Eastern Province of Saudi Arabia drift rates reach 30 m^3/m width annually and dunes up to 25 m in height.
- An average rate of movement of dune of nearly 15 m per annum.
- **Problem:** sand buries pipelines, blocks roads, erodes and surrounds utility foundations.

Example Problems



Previous Solutions to Problem

- Most solutions involved controlling the flow of the sand rather than removing or relocating it.
- **Ditching:** digging a cut perpendicular to sand drift direction (a very expensive solution).
- **Trenching:** dune destruction using bulldozers.
- **Fencing:** depositing sands in their vicinity by installing fences perpendicular to the wind direction.

Drawing Sketches

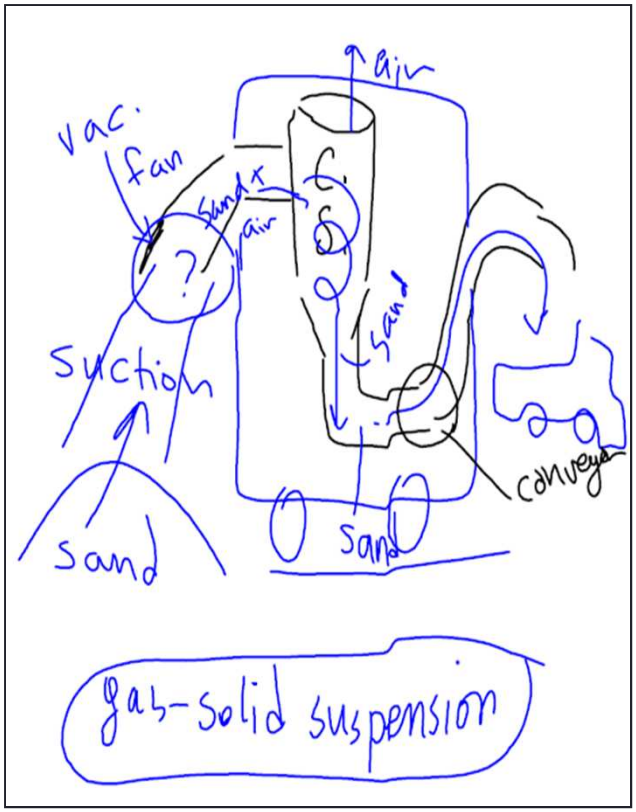


Figure 1: Gas-Solid Suspension

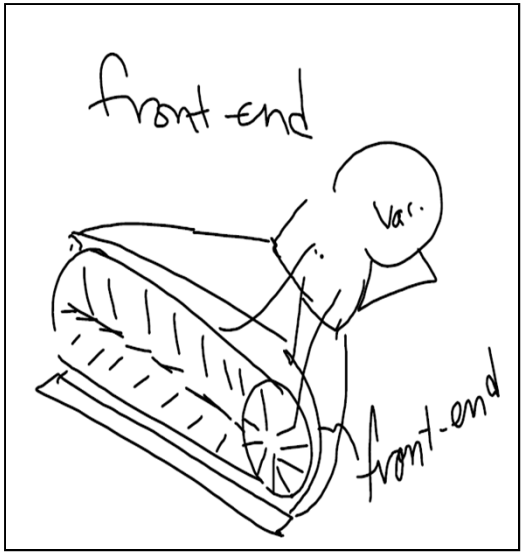


Figure 2: Front-end

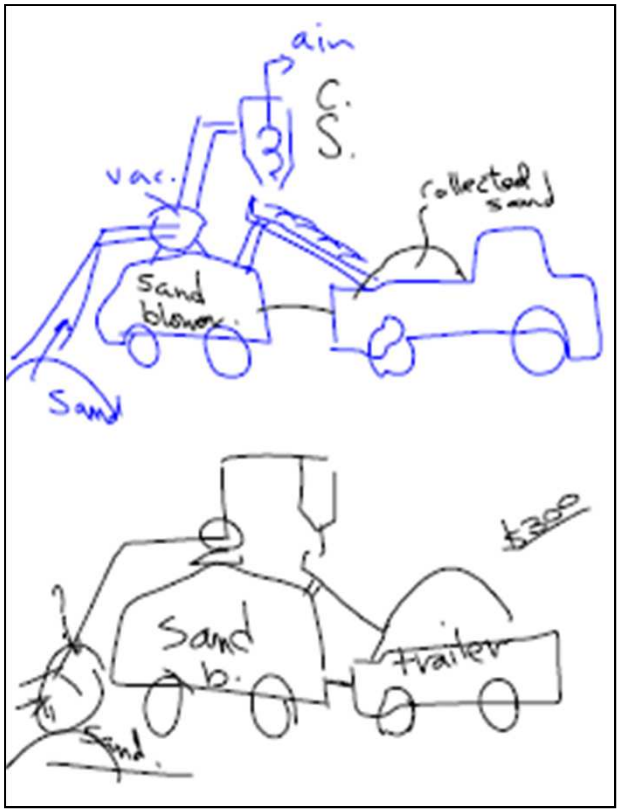


Figure 3: Overall Process

Hand Drawing Sketches

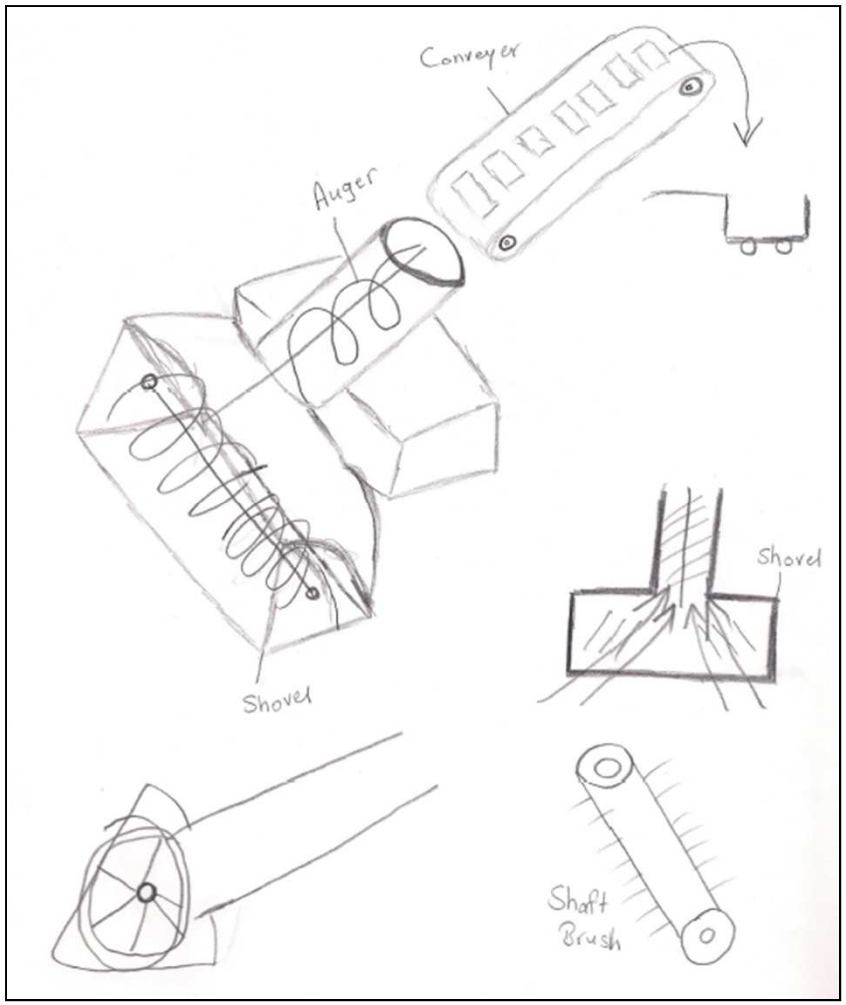


Figure 4: Overall View of Shovel

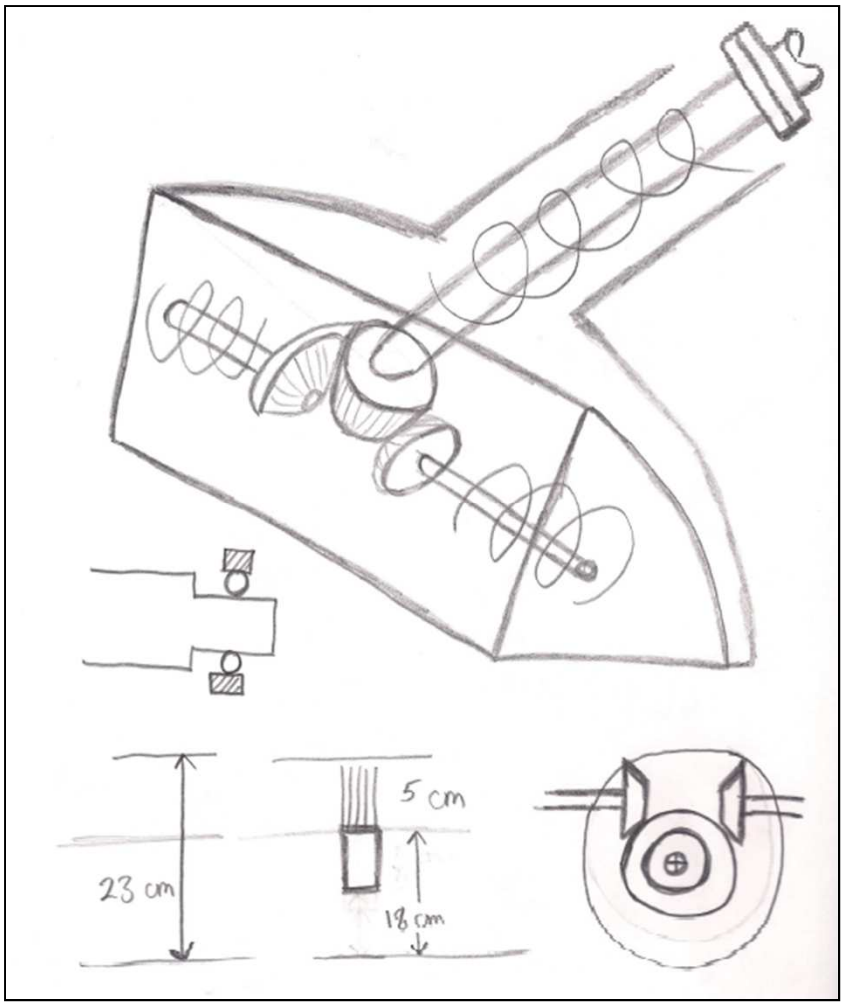


Figure 5: Close up view of Shovel & dimensions

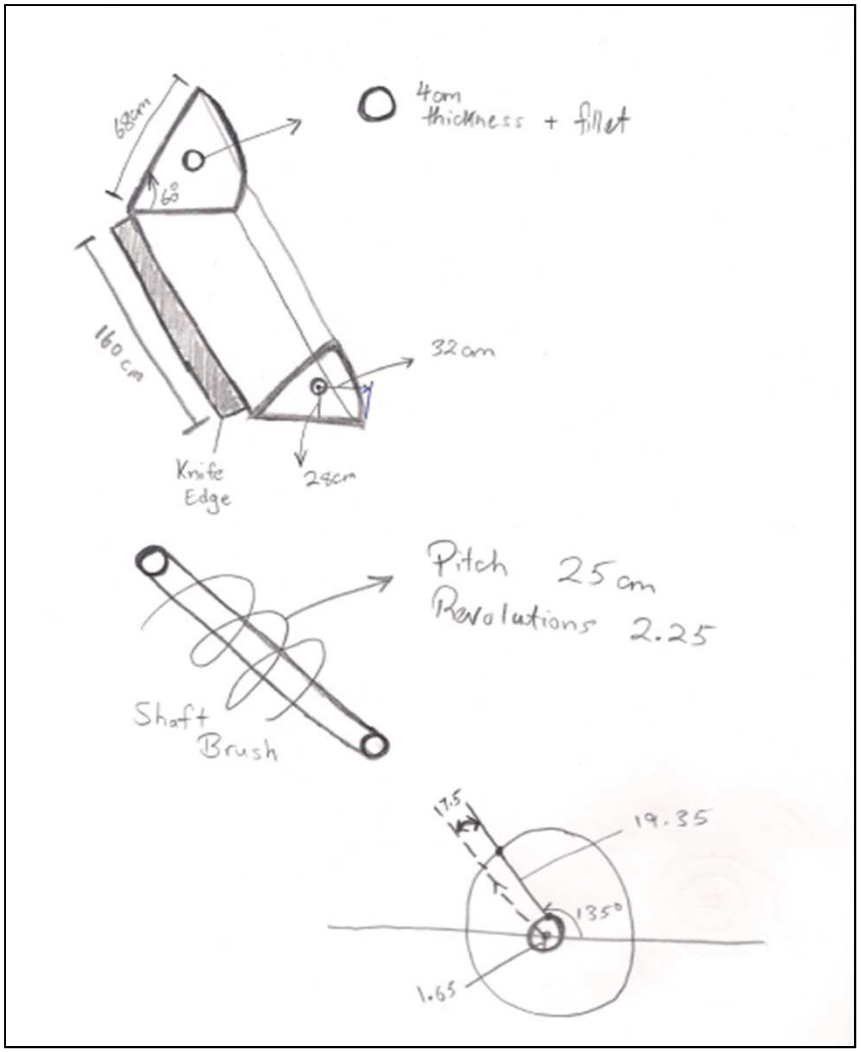


Figure 6: Shaft Brush

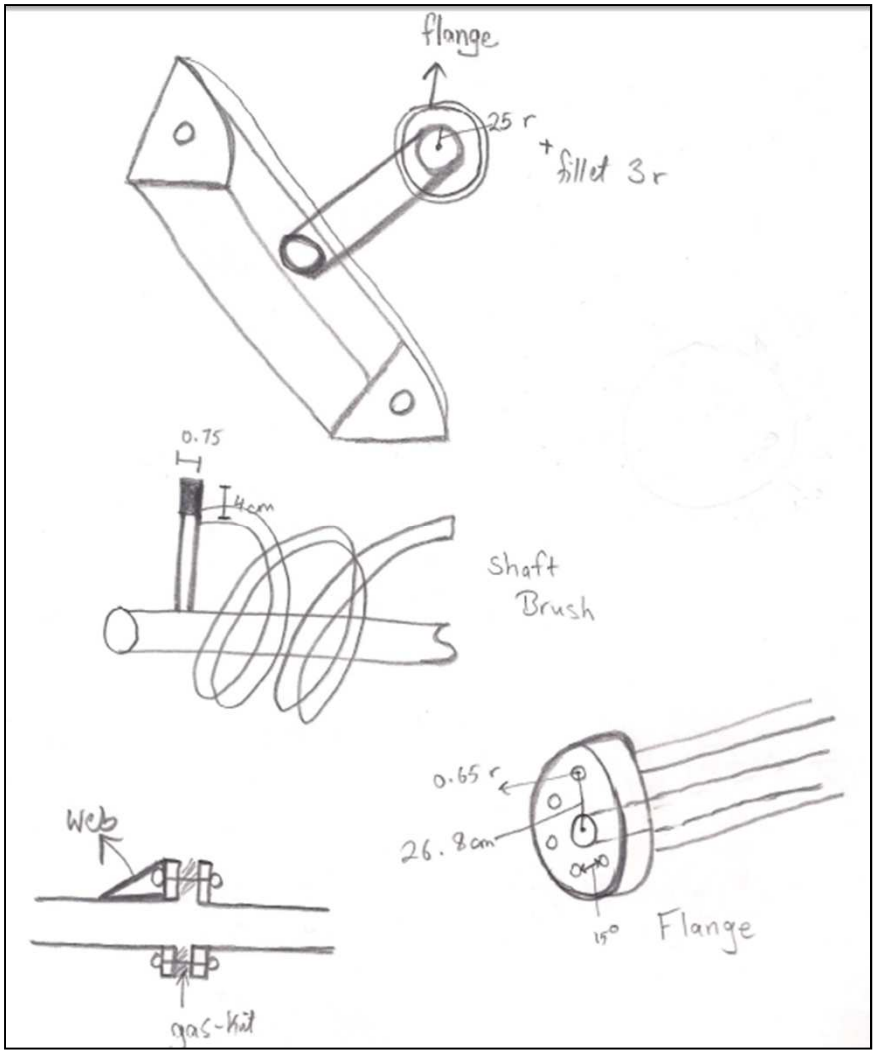


Figure 7: Brush & Shaft dimensions

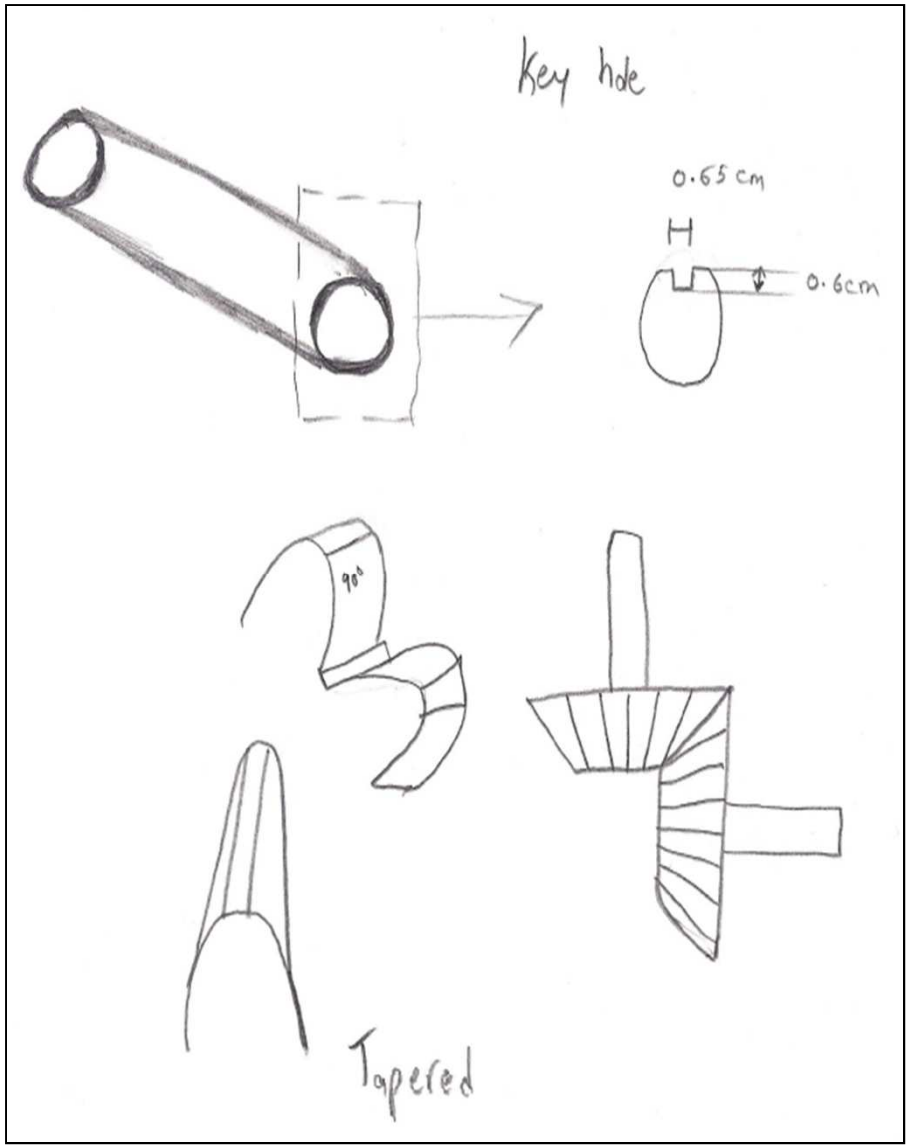


Figure 8: Key Hole

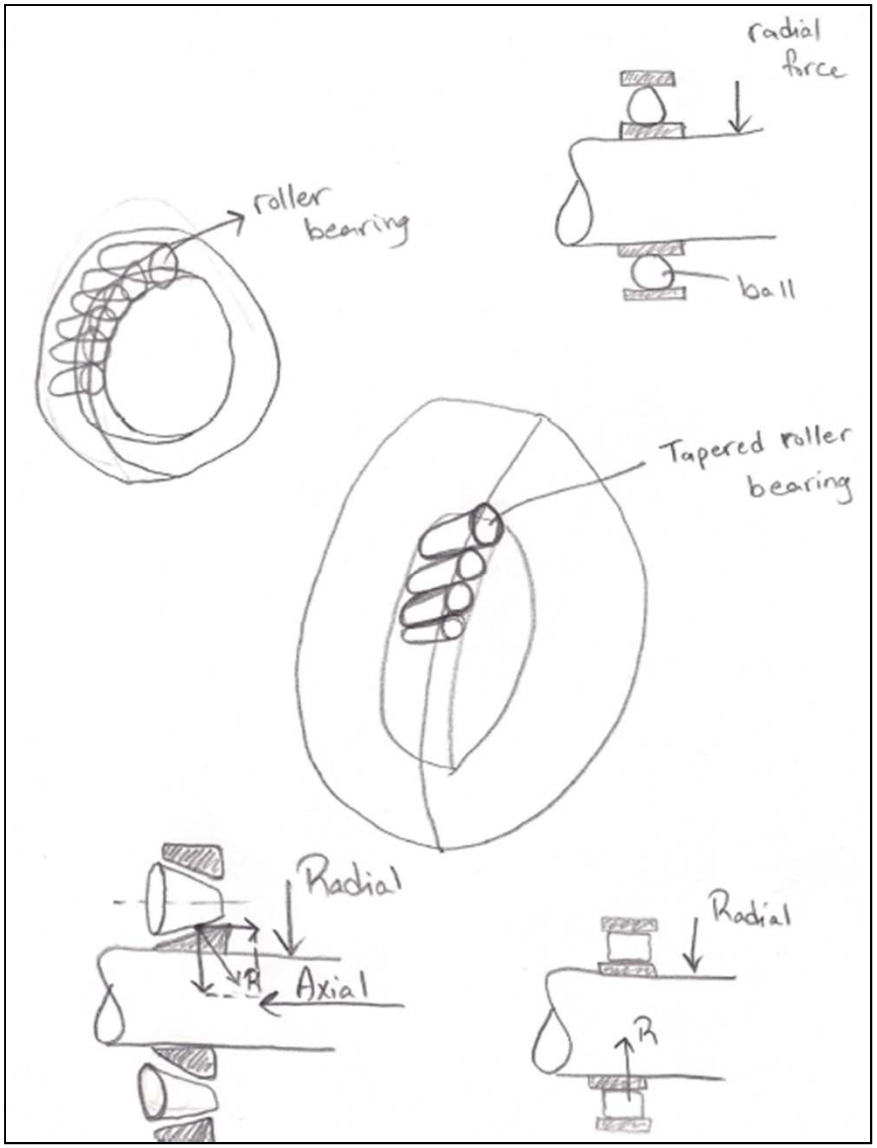


Figure 9: Tapered Roller Bearing

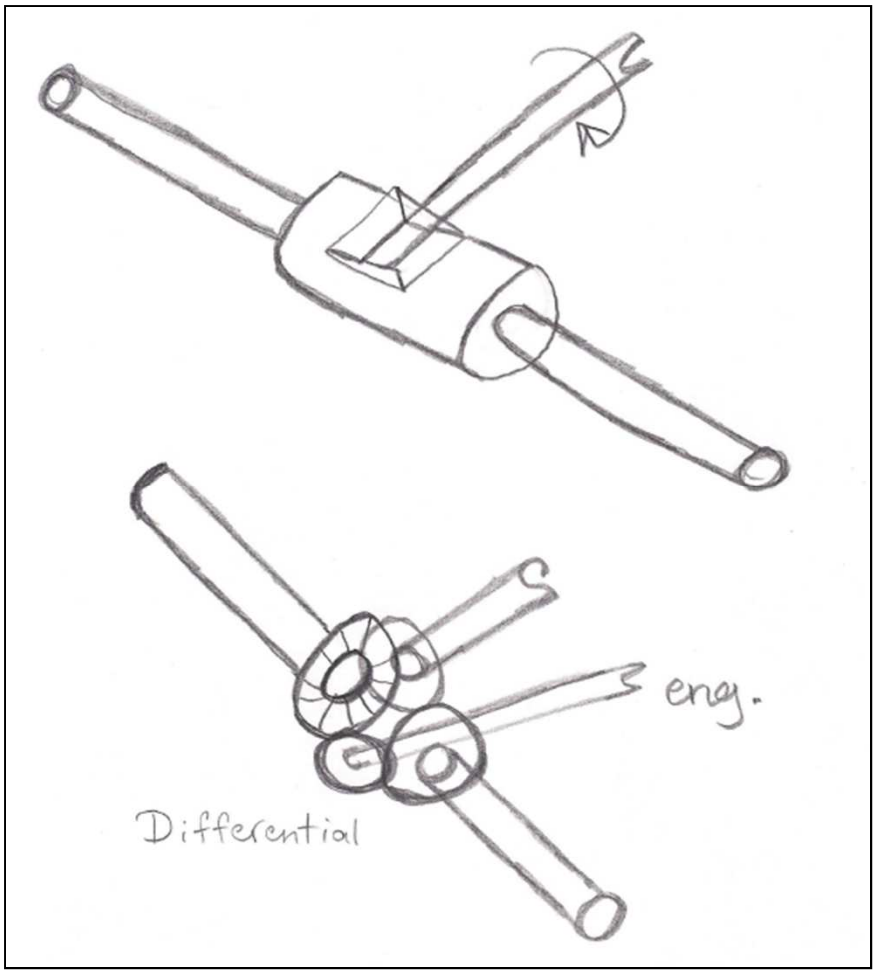


Figure 10: Differential Gear

Background on Snow Blowers

Snow Blower Types:

- There are 2 different types of Snow Blowers:
  - Single-stage: Just uses an impeller to force the snow out a chute.
  - Two-stage: Breaks up the snow with metal augers, then uses an impeller to force the snow out a chute.

Snow Blower Components

- A Snow Blower consists of:
  1. Frame
  2. Motor
  3. Impeller
  4. Chute

- In a two-stage blower, there are also metal augers.
- They spin and break up the snow before it hits the impeller.

1. Frame

- The frame of a snow blower contains all the components and has a handle to push the blower.

2. Impeller

- The snow blower engine moves the impeller. The impeller is at the front of the blower, it is the first thing the snow hits.
- The impeller is formed so that when it spins, the snow will go out a chute.

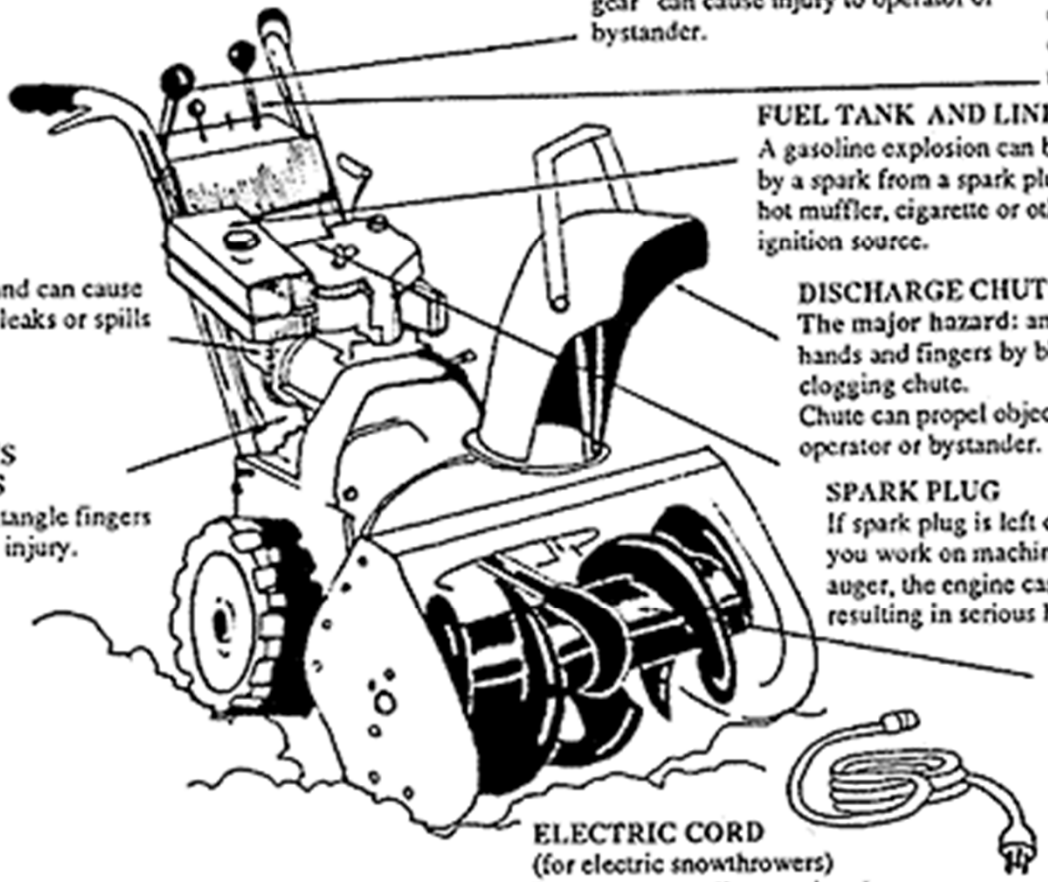
3. Chute

- The chute is attached to the front of the snow blower in direct contact with the impeller. All the snow is pushed through this chute.
- In most push snow blowers, you can point the chute in different directions.

4. Motor

- The motor is what drives the impeller. It is attached to the impeller with a belt to make it spin.

Snow Blower Components



TRANSMISSION CLUTCH
Accidental startup of machine "in gear" can cause injury to operator or bystander.

ATTACHMENT CLUTCH
Accidental engaging of clutch can cause sudden blade startup — while operator is unclogging machine, making adjustments or repairs.

FUEL TANK AND LINES
A gasoline explosion can be set off by a spark from a spark plug, or a hot muffler, cigarette or other ignition source.

EXHAUST
The exhaust gets hot and can cause burns on contact. Gas leaks or spills can lead to explosion.

DISCHARGE CHUTE
The major hazard: amputation of hands and fingers by blade while unclogging chute.
Chute can propel objects — injuring operator or bystander.

EXPOSED CHAINS AND SPROCKETS
Moving parts can entangle fingers and clothes, causing injury.

SPARK PLUG
If spark plug is left connected while you work on machine or move the auger, the engine can restart, resulting in serious hand injury.

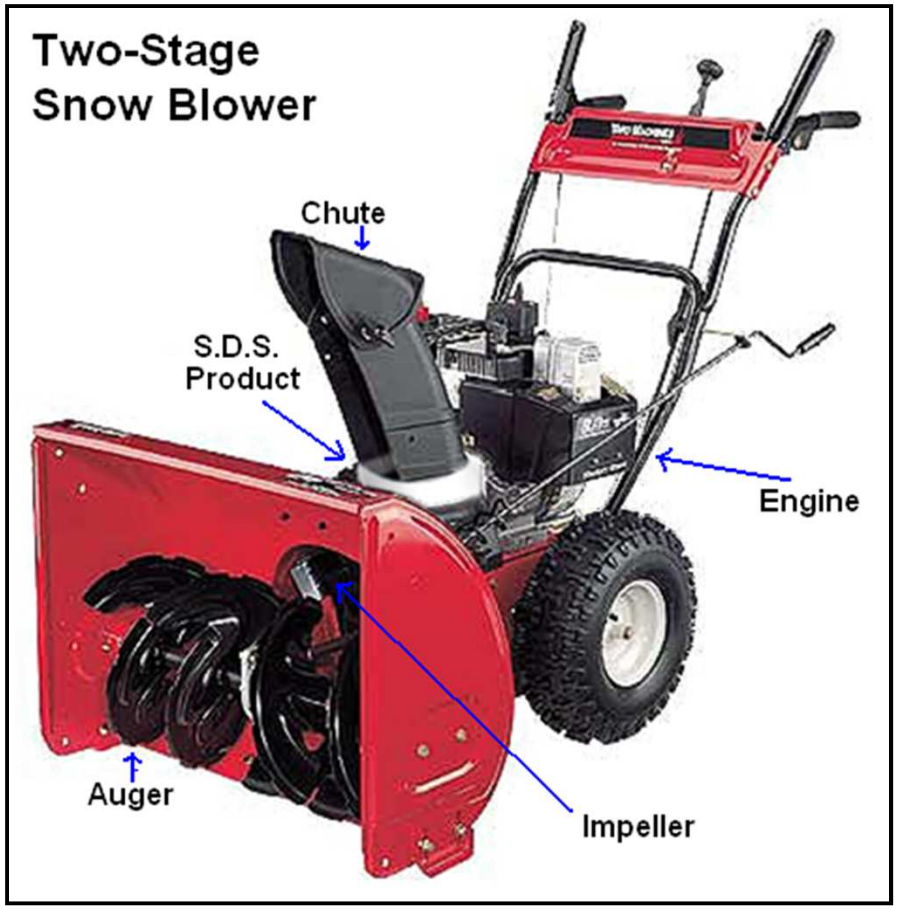
AUGER AND IMPELLER
Presents hazards to hands because of clogging. Sometimes stalled blade suddenly restarts on being freed or has enough residual energy to mash hand or finger.

ELECTRIC CORD
(for electric snowthrowers)
Improper grounding, cutting the cord, frayed cords and extensions can be deadly hazards.

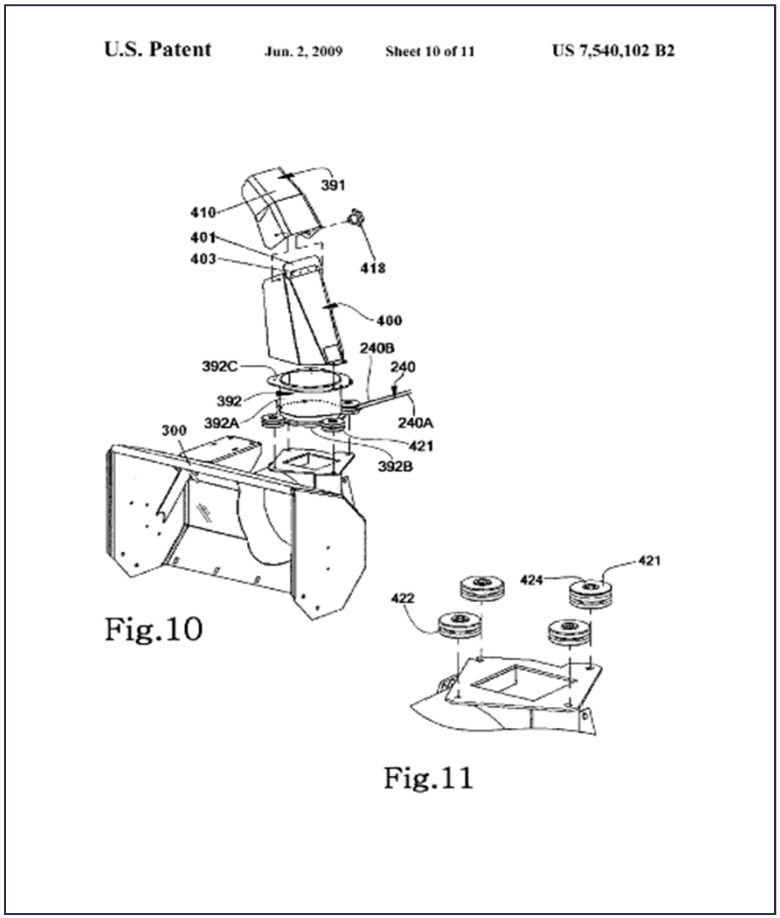
Criteria

- Efficiency (to maximize sand removal outcome).
- Quality and reliability of operation.
- Power (off-road operation i.e. diesel engine power).
- Resistance (to function in extreme conditions).
- Safety of user and bystander.

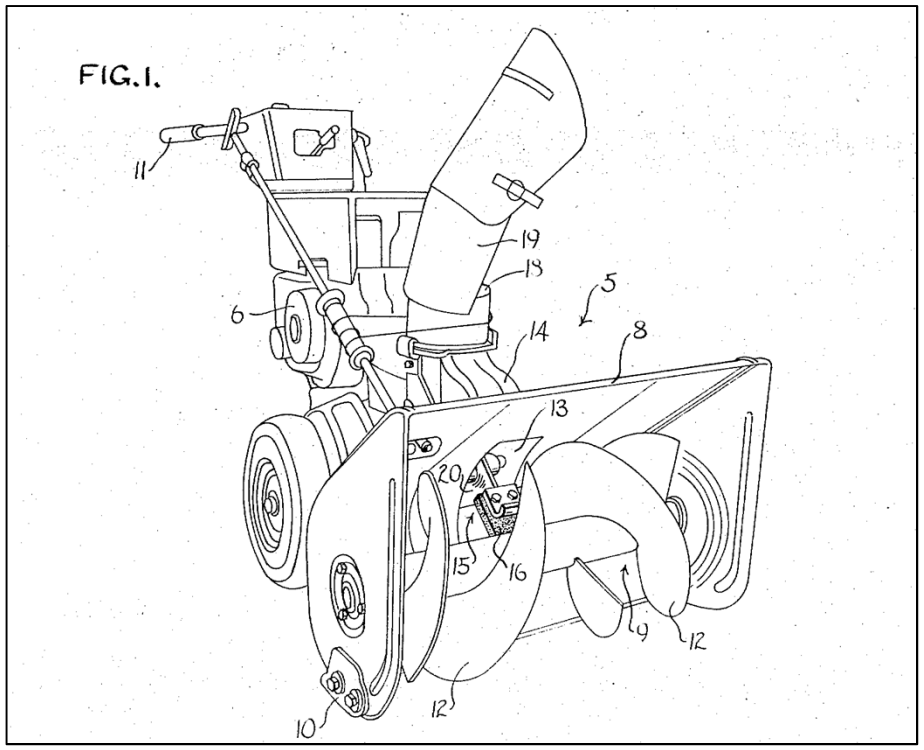
Analogy Between Two-stage Snow & Sand Blower



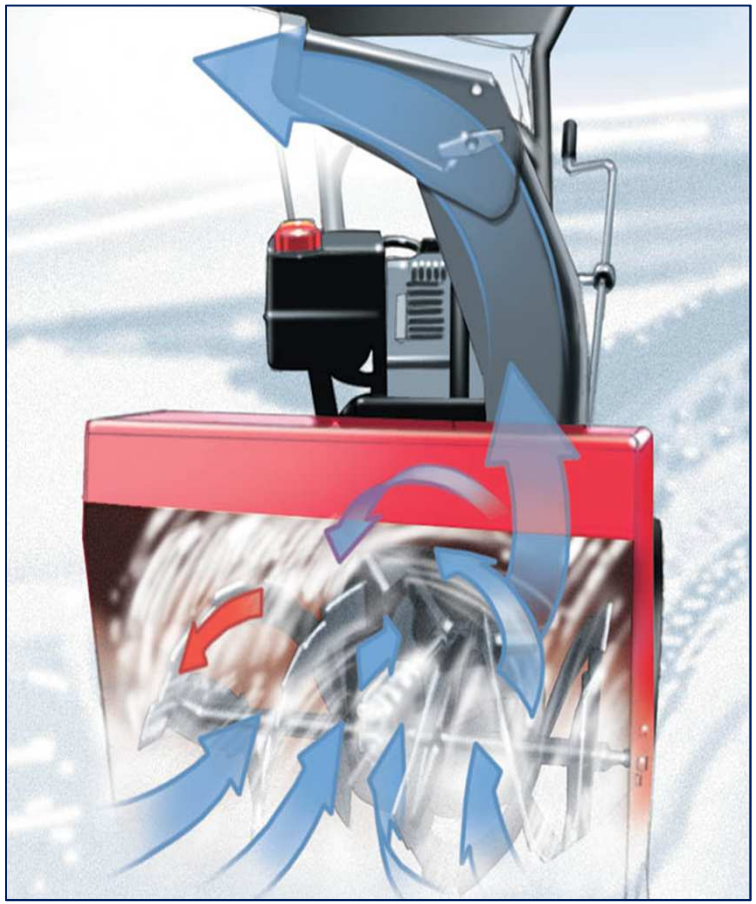
Analogy Between Two-stage Snow & Sand Blower

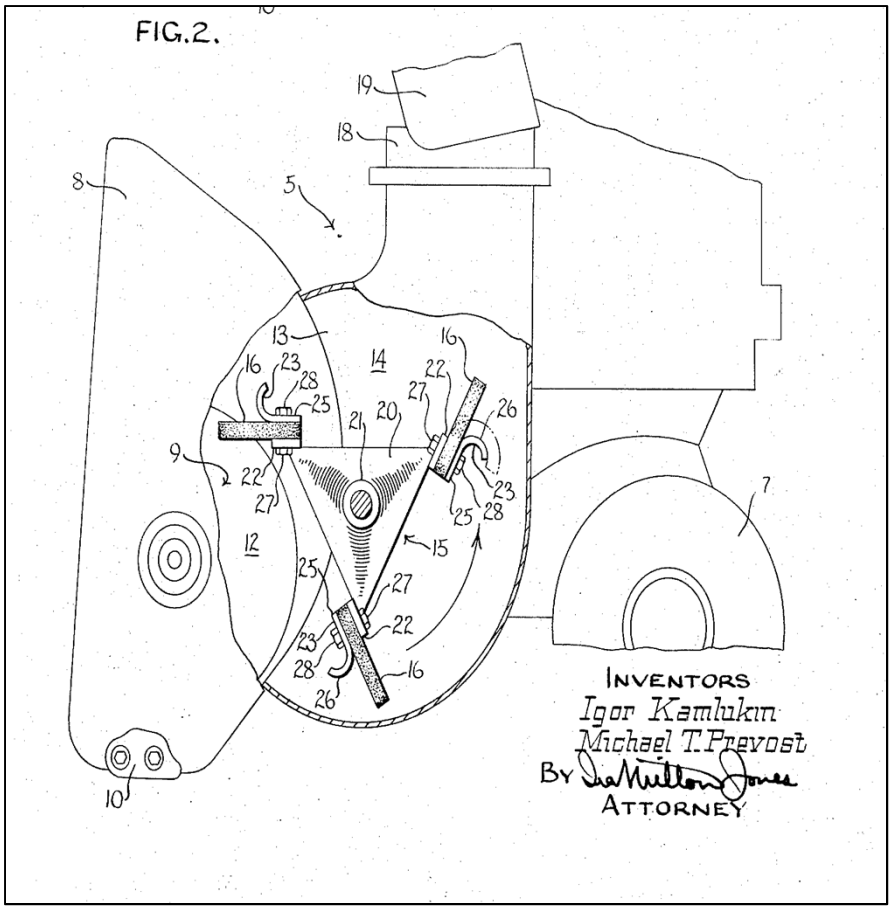


Analogy Between Two-stage Snow & Sand Blower



Analogy Between Two-stage Snow & Sand Blower





Calculations to determine Volume, Weight & Torque

- **Volume = ½ * h * b * l**

  = ½ * 0.6 * 0.65 * 1.6 = 0.312 m^3

- ρ_{sand} = 1922 kg/m^3
- **Mass = ρ_{sand} * V**

  = 1922 * 0.312 = 599.64 ≈ 600 Kg

- **Weight = m * g**

  = 600 * 9.81 = 5886 ≈ 6000 N

- **Torque = w * r**

  = 6000 * 0.25 = 1500 N.m

- Assuming worse scenario, harsh environment,
  - Factor of Safety = 3
- Load = 3 * 6000
- = 18000 N = 18 kN
- Therefore, **Torque = w * r** = 18000 * 0.25 = 4500 N.m
- $\mathbf{J = \pi C^4 / 2}$

  $= \pi (0.02)^4 / 2 = 2.5 \times 10^{-7}$
- $\boldsymbol{\tau = T c / J}$

  $= 4500 * 0.02 / 2.5 \times 10^{-7} = 3.6 \times 10^{-6}$ N/m^2 = 360 MPa

SolidWorks® CAD - Prototype

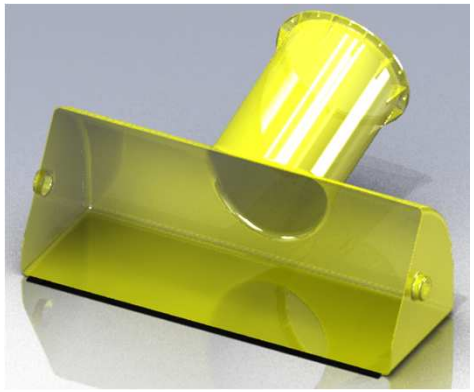


Figure 11: Shovel

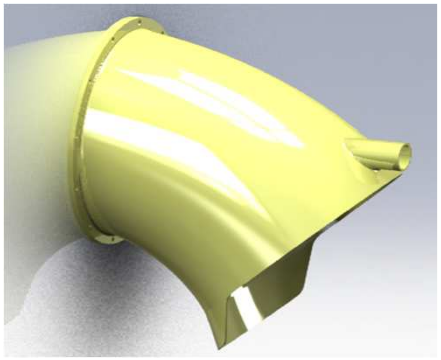


Figure 12: Spree

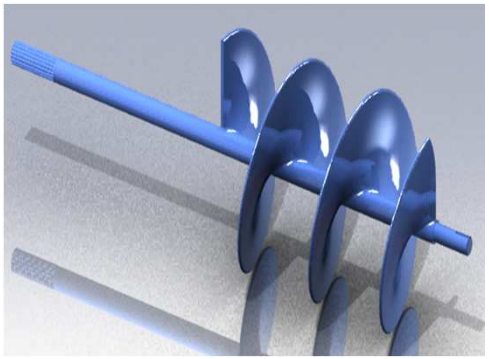


Figure 13: Auger

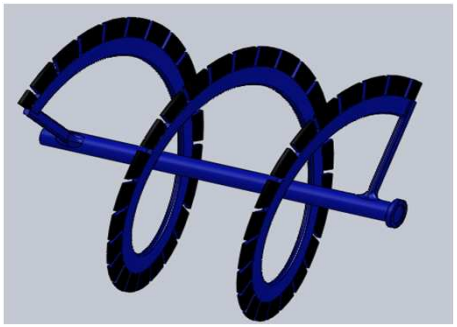


Figure 14: Left Brush

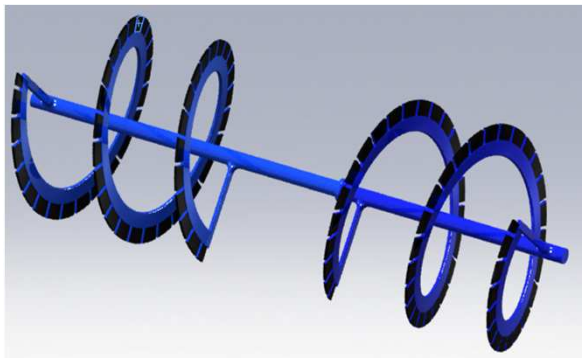


Figure 15: Whole Brush

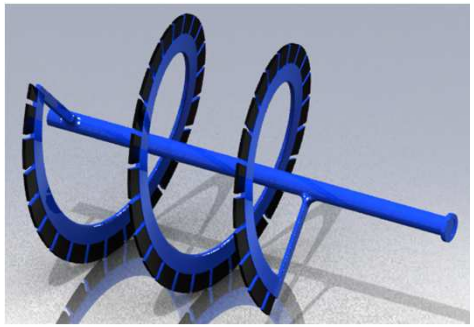


Figure 16: Right Brush

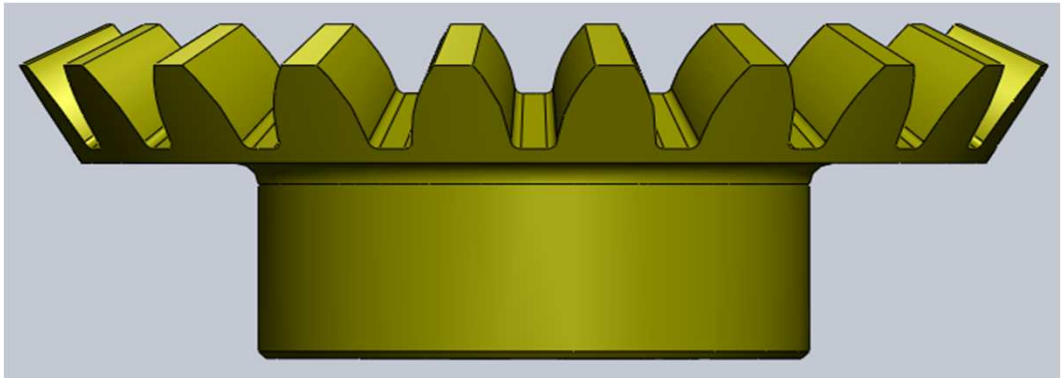
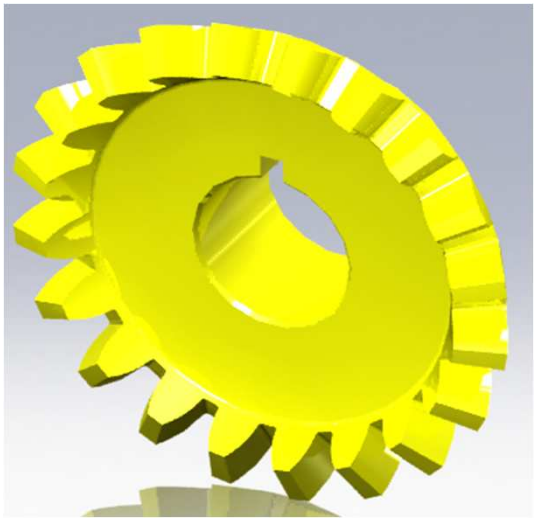


Figure 17: Bevel Gear Side View



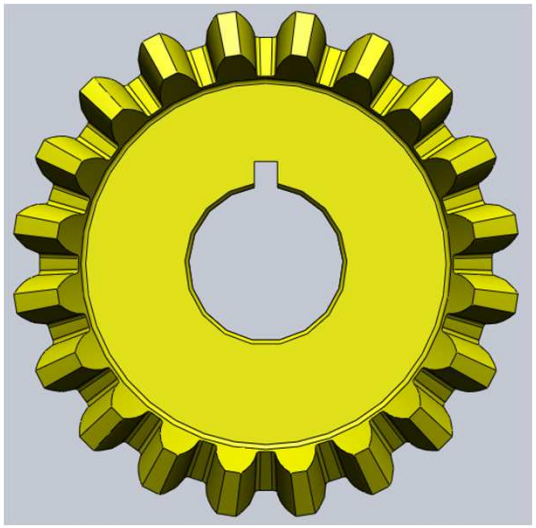


Figure 19: Bevel Gear Front View

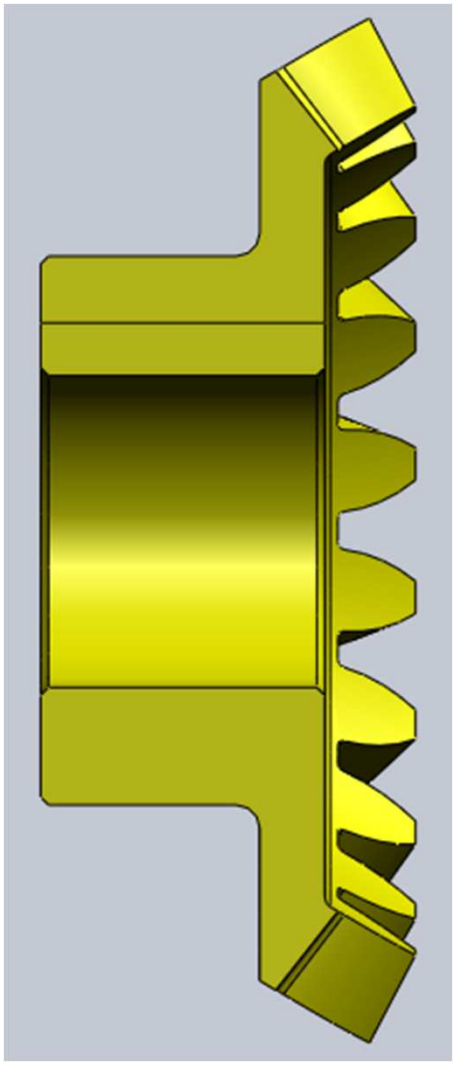


Figure 18: Bevel Gear Cross-section

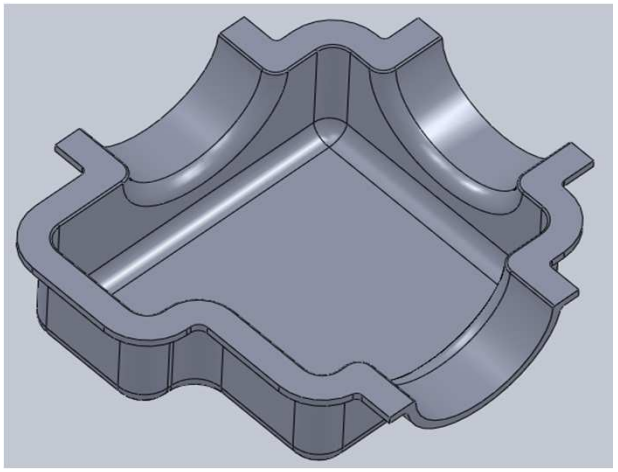


Figure 20: Gear Box - Bottom

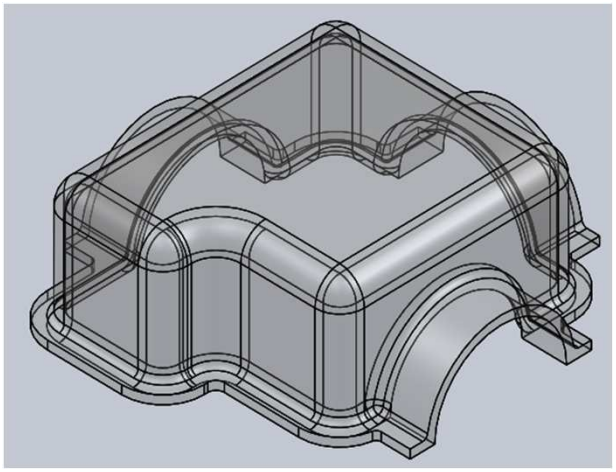


Figure 21: Gear Box - Top

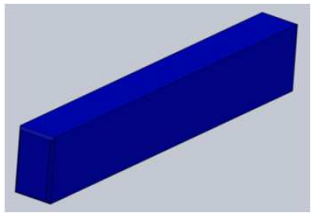


Figure 22: Key Hole

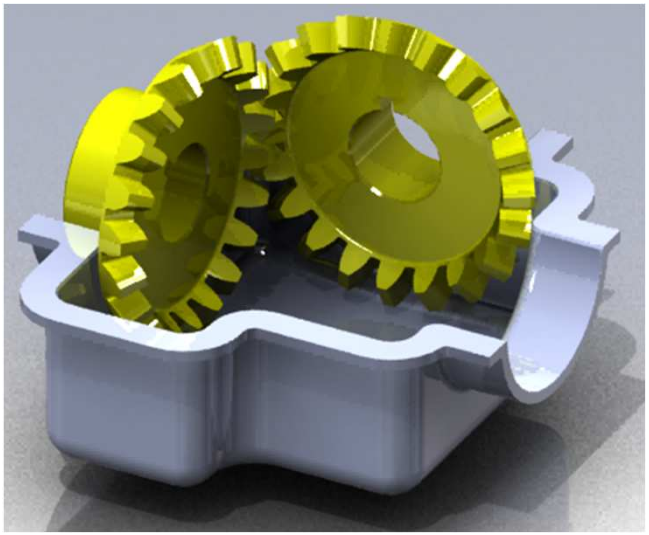


Figure 23: Complete Gear Box

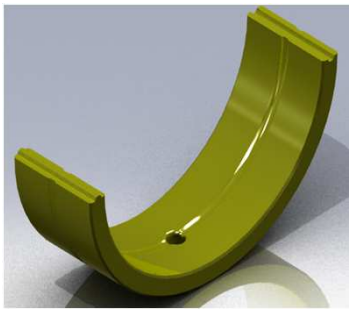
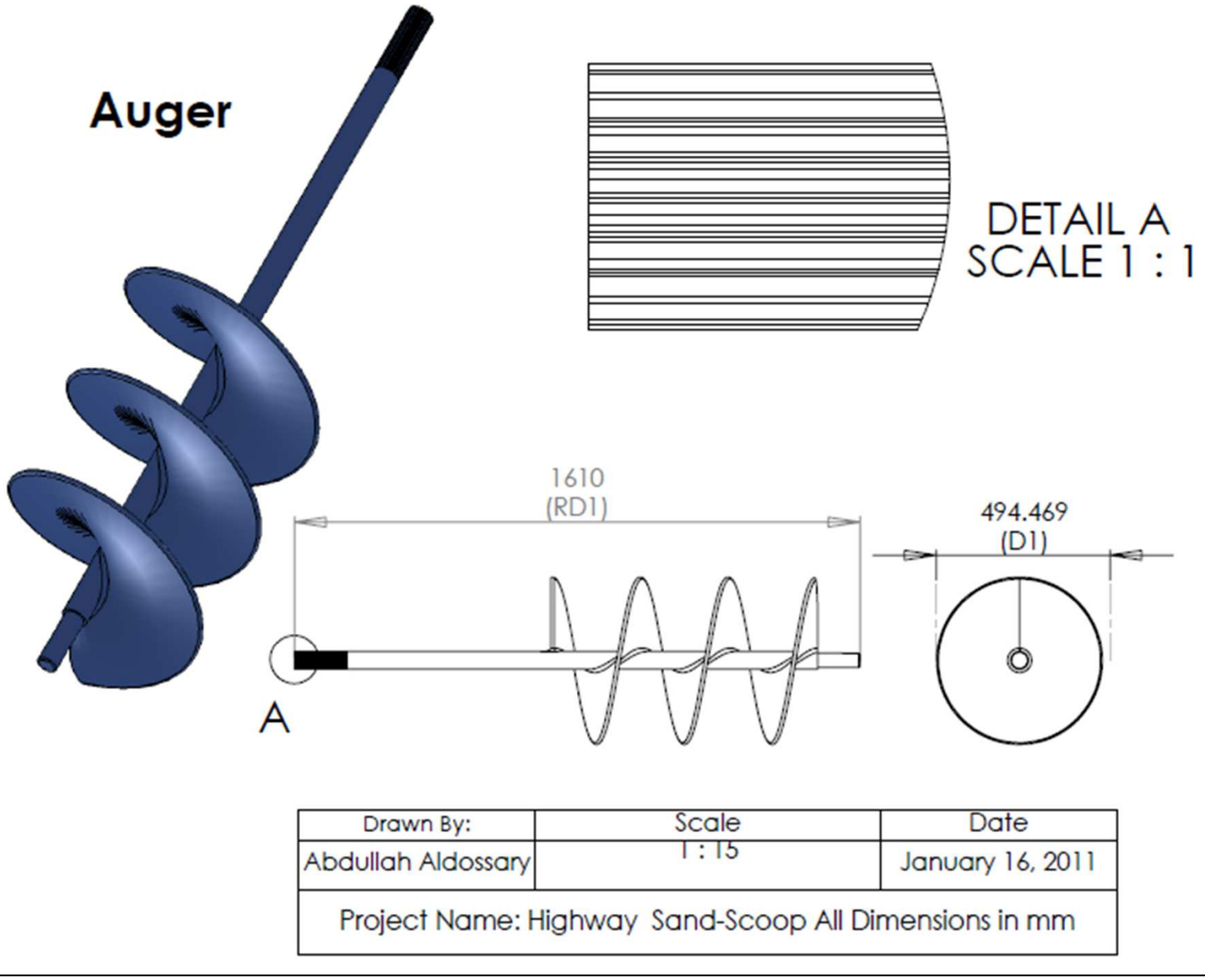
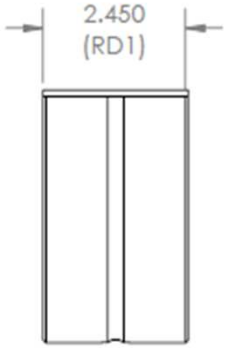
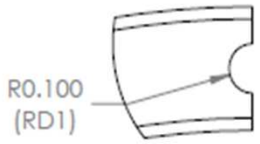


Figure 18: Journal Bearing


Auger
DETAIL A
SCALE 1 : 1
1610
(RD1)
494.469
(D1)
A
Drawn By:
Abdullah Aldossary
Scale
1 : 15
Date
January 16, 2011
Project Name: Highway Sand-Scoop All Dimensions in mm

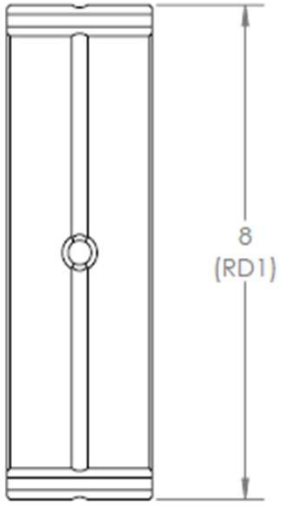
Journal Bearing

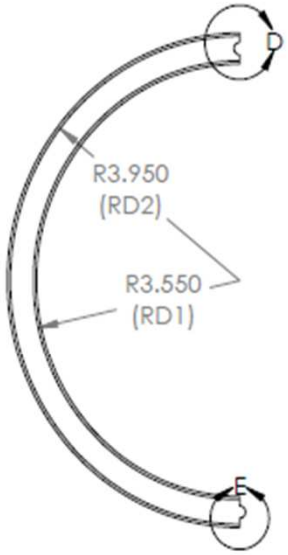


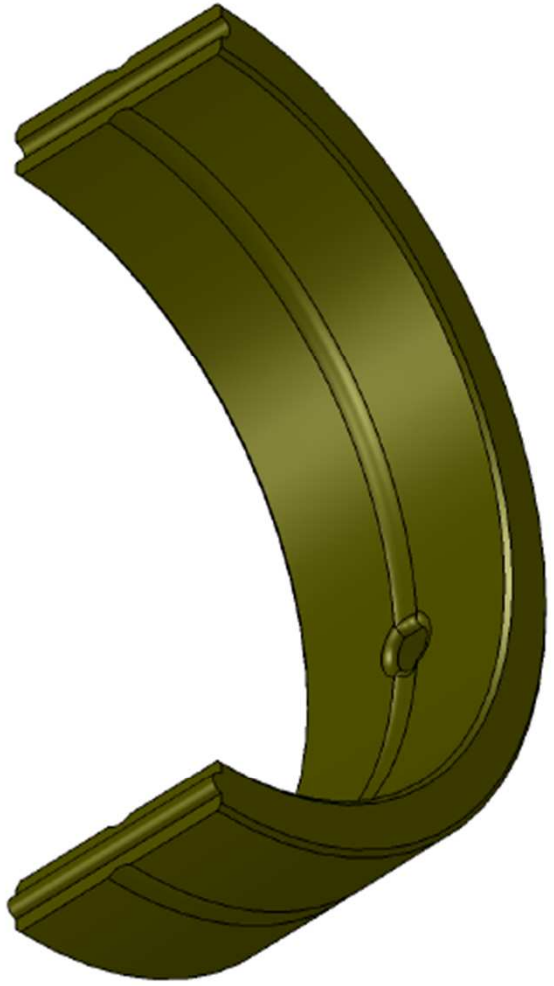


DETAIL D
SCALE 4 : 1

DETAIL E
SCALE 4 : 1

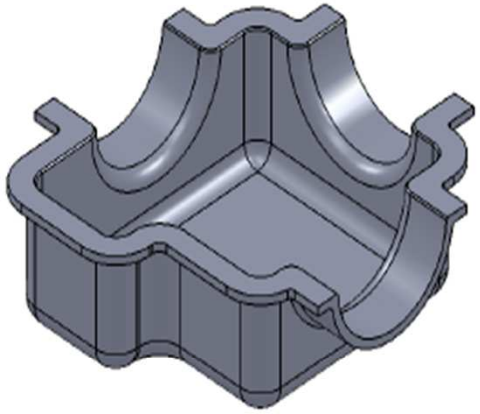


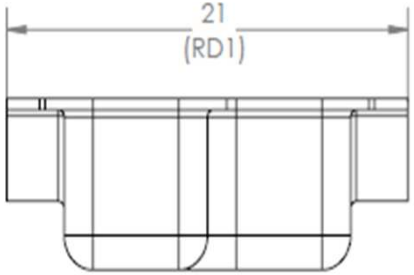


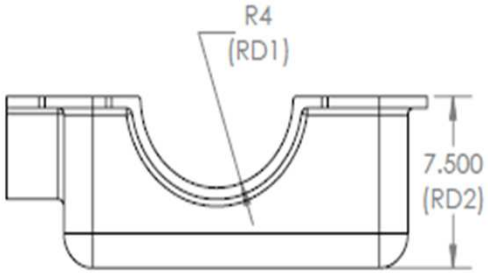


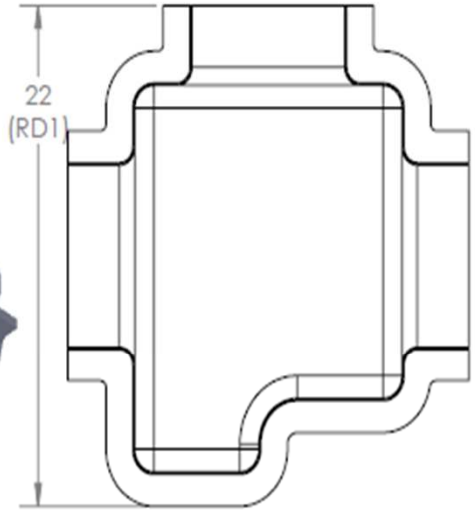
Drawn By:	Scale	Date
Abdullah Aldossary	1 : 1	January 16, 2011
Project Name: Highway Sand-Scoop		

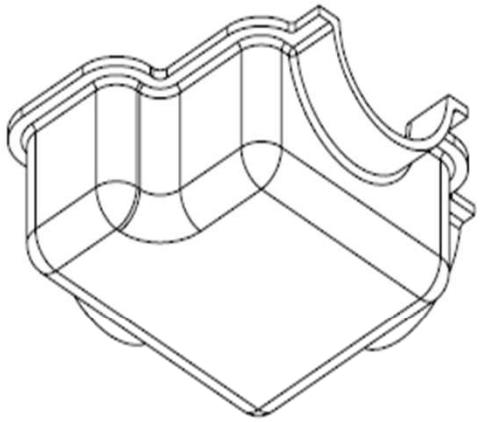
Gear Box



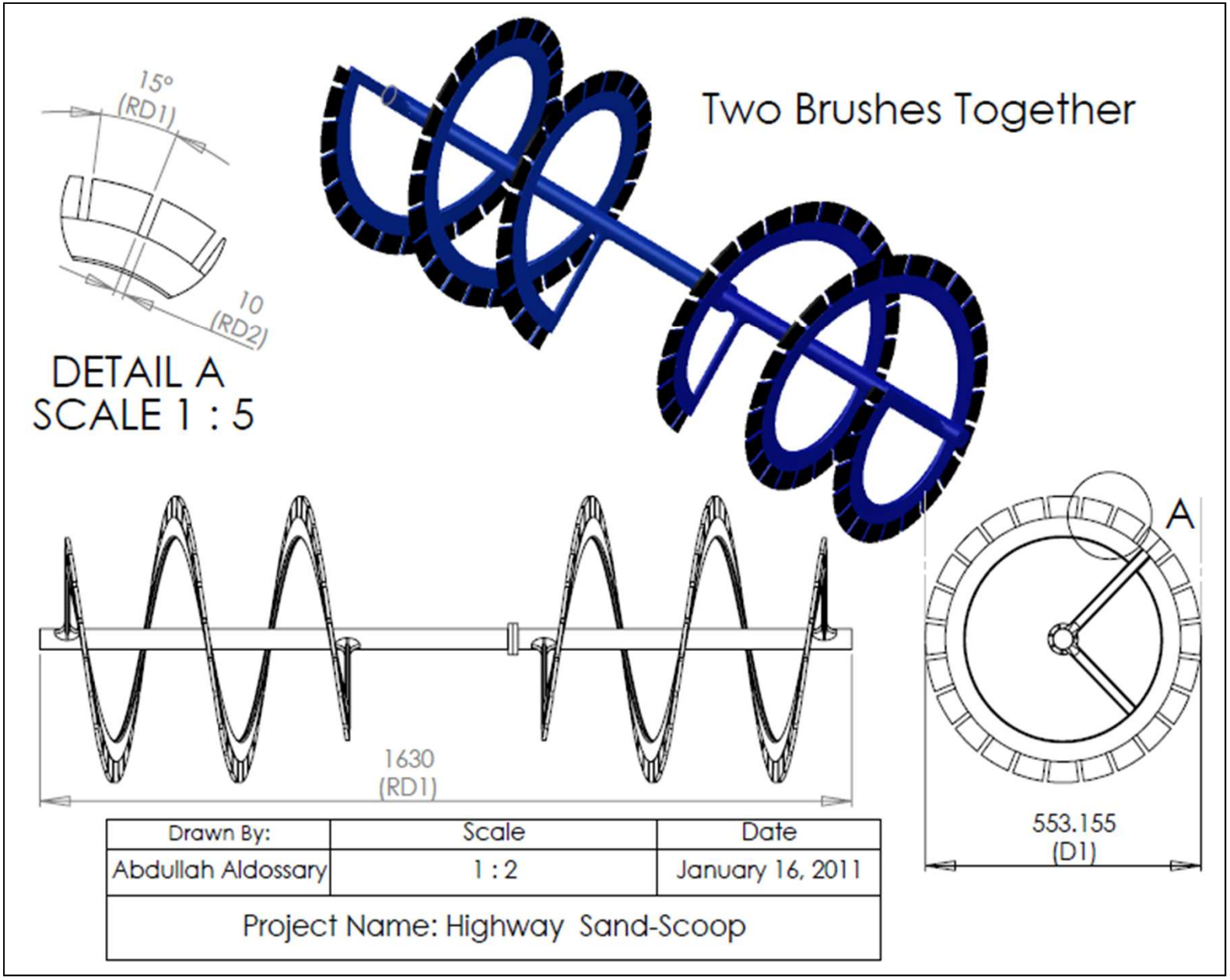




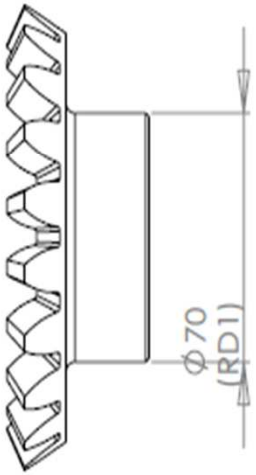


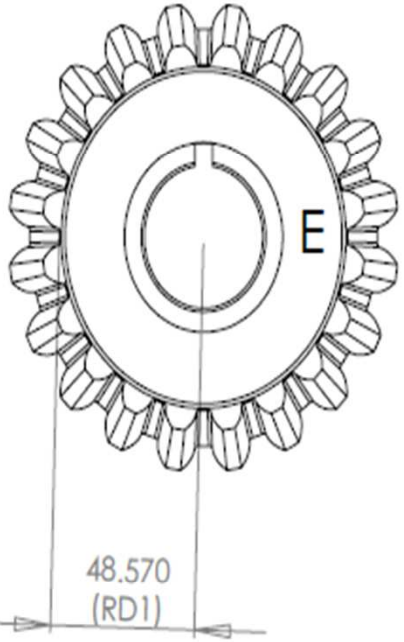


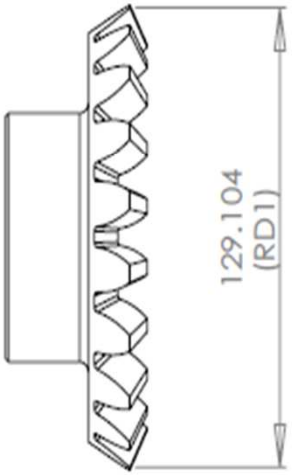
Drawn By:	Scale	Date
Abdullah Aldossary	1 : 4	January 16, 2011
Project Name: Highway Sand-Scoop		

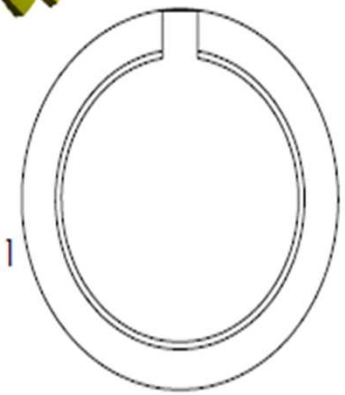

15°
(RD1)
10
(RD2)
DETAIL A
SCALE 1 : 5
Two Brushes Together
A
1630
(RD1)
553.155
(D1)
Drawn By:
Abdullah Aldossary
Scale
1 : 2
Date
January 16, 2011
Project Name: Highway Sand-Scoop

Bevel Gear





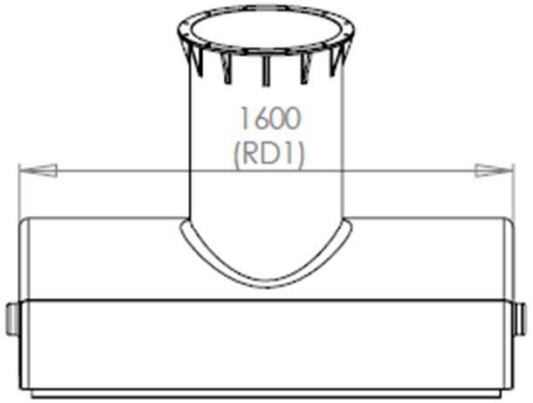


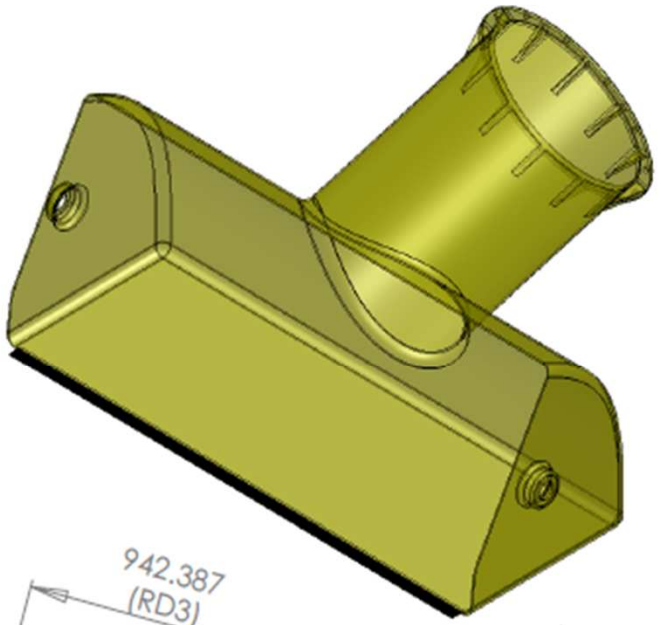


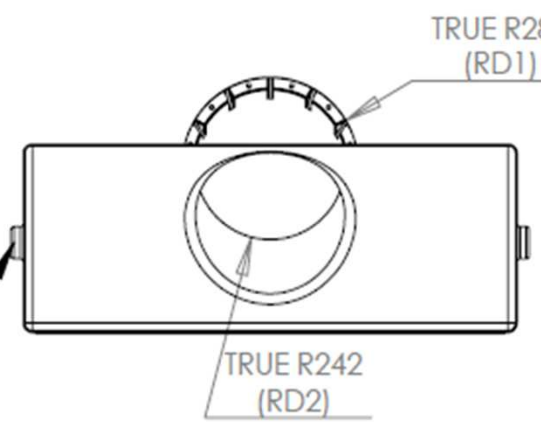
DETAIL E
SCALE 1 : 1

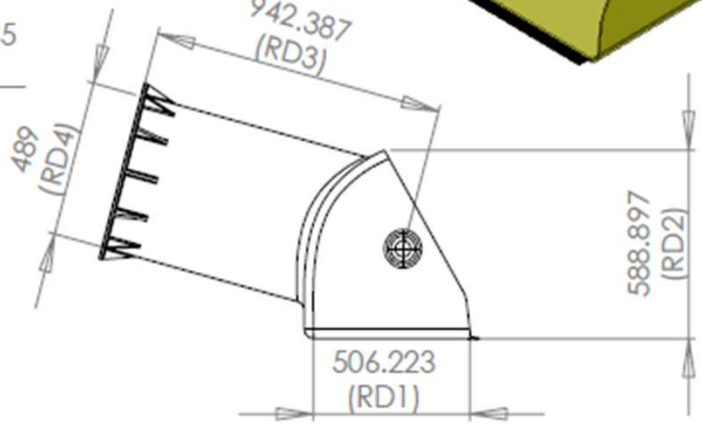
Drawn By:	Scale	Date
Abdullah Aldossary	1 : 2	January 16, 2011
Project Name: Highway Sand-Scoop all Dimensions in mm		

SHOVEL





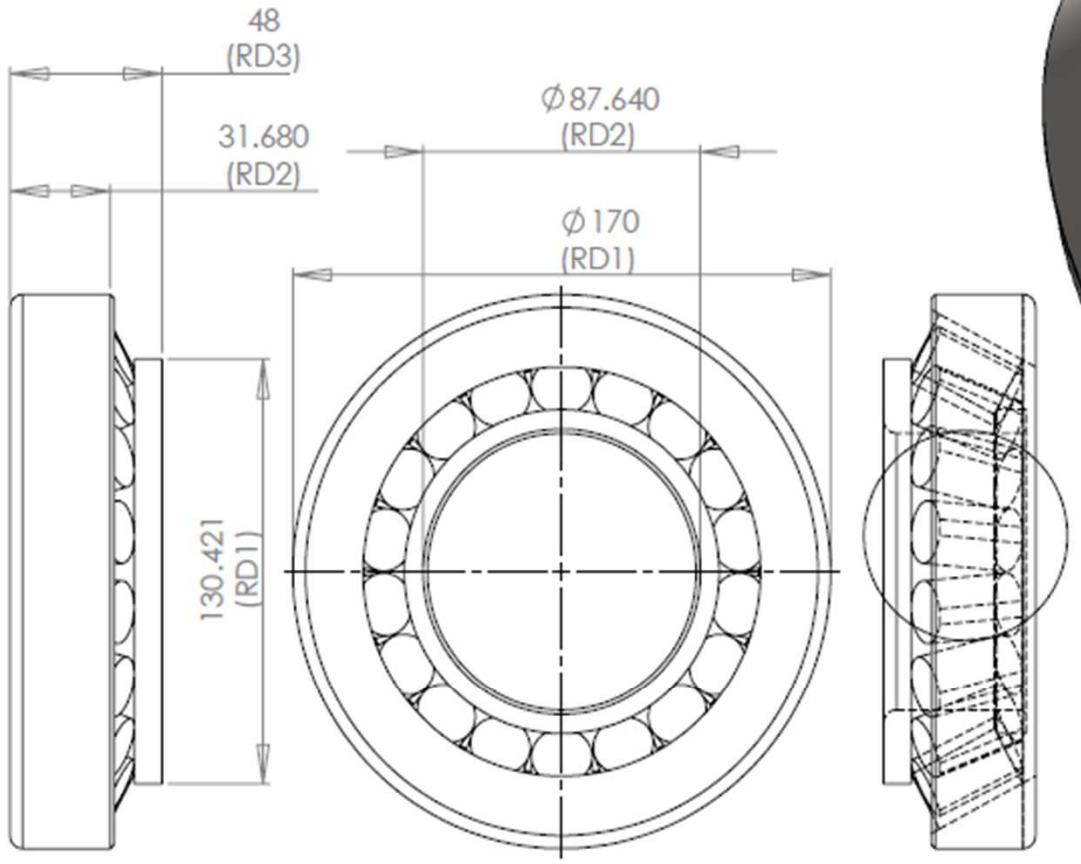


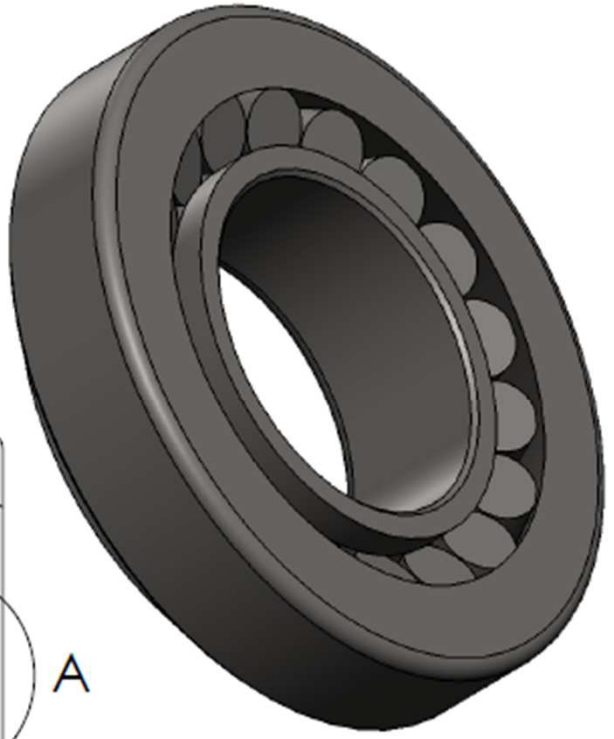


HOUSING FOR THE BEARING

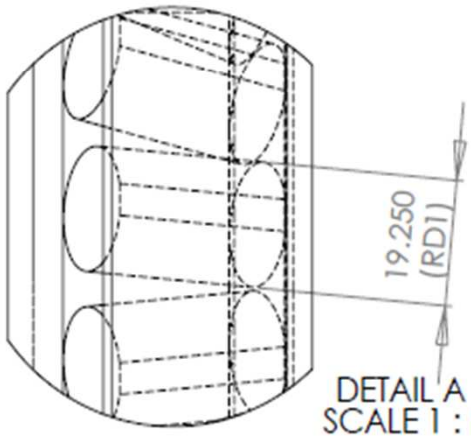
Drawn By:	Scale	Date
Abdullah Aldossary	1 : 2	January 16, 2011
Project Name: Highway Sand-Scoop		

TAPER BEARING





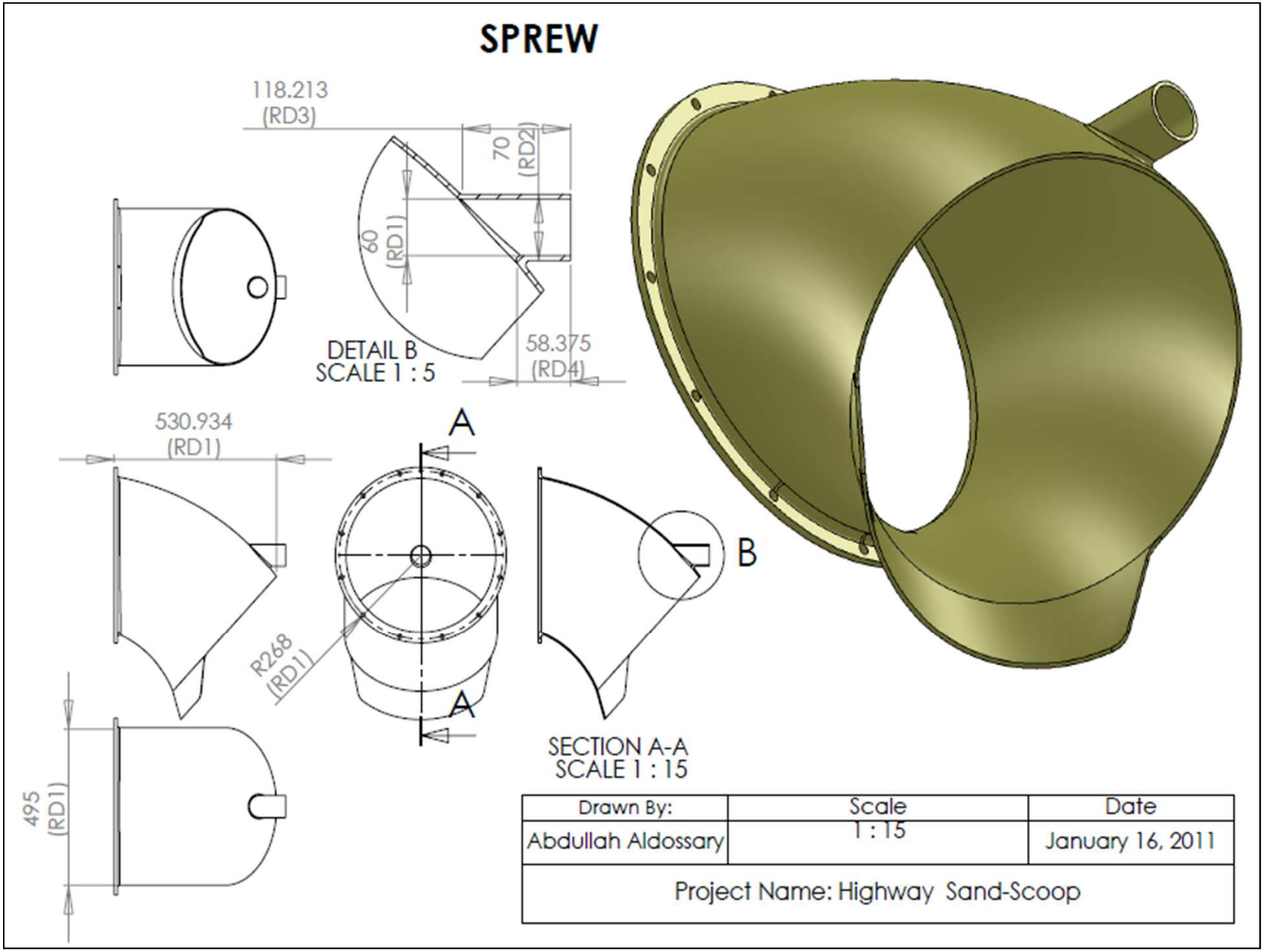
A



DETAIL A
SCALE 1 : 1

Drawn By:	Scale	Date
Abdullah Aldossary	1 : 2	January 16, 2011
Project Name: Highway Sand-Scoop		

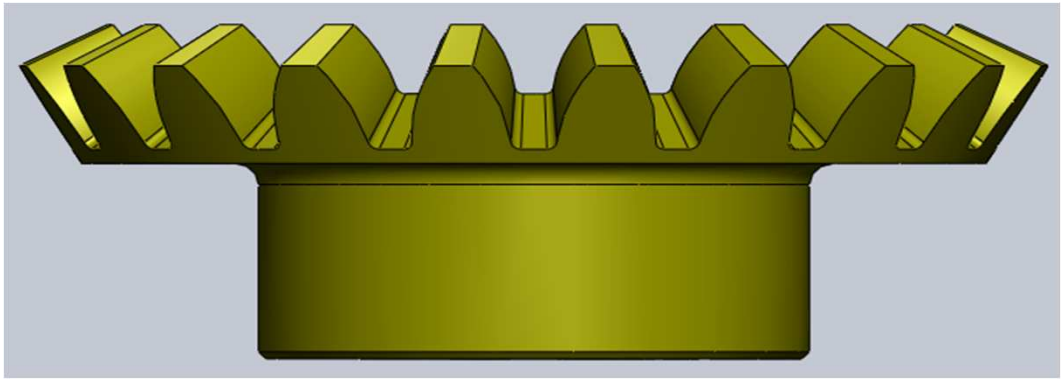
SPREW

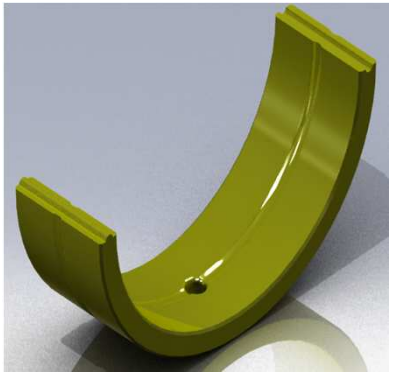


Drawn By:	Scale	Date
Abdullah Aldossary	1 : 15	January 16, 2011
Project Name: Highway Sand-Scoop		

Journal Bearing

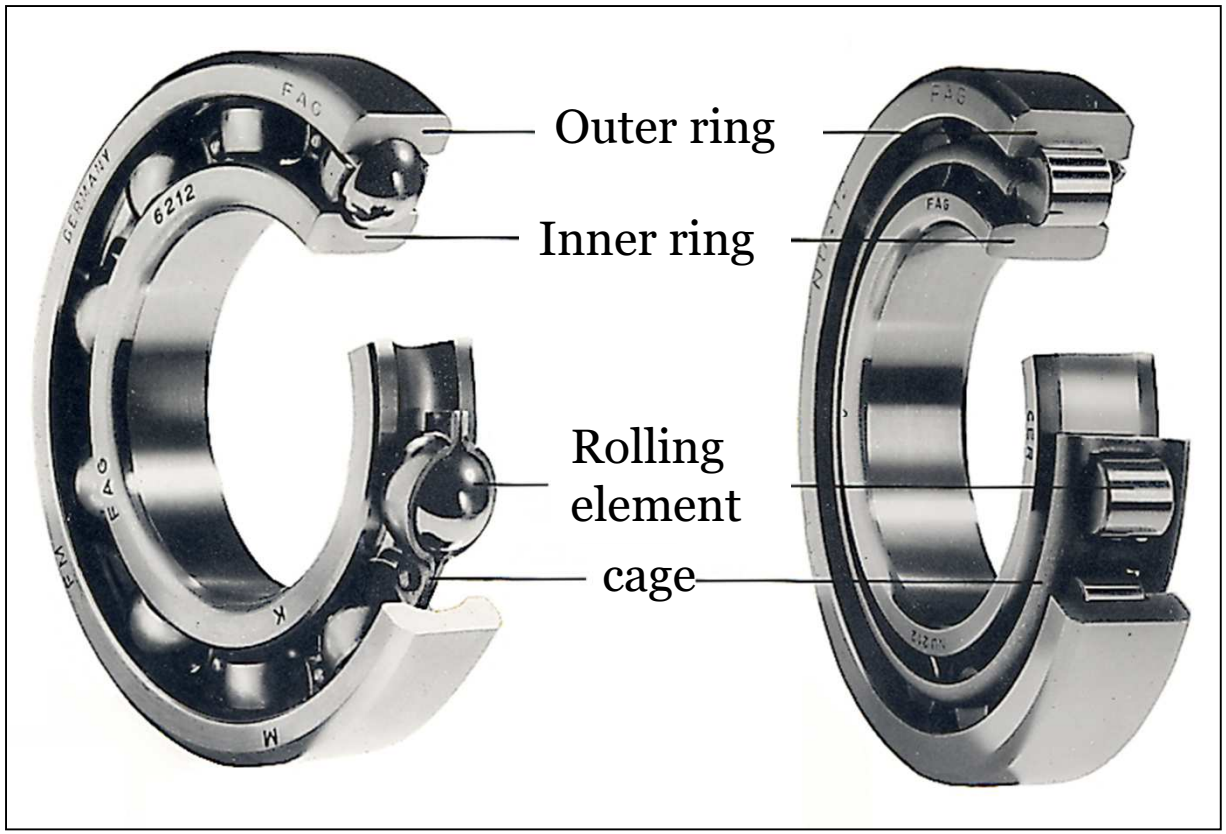
- A journal bearing, simply stated, is a cylinder which surrounds the shaft and is filled with some form of fluid lubricant.
- Journal bearings are considered to be sliding bearings as opposed to rolling bearings such as ball bearings.





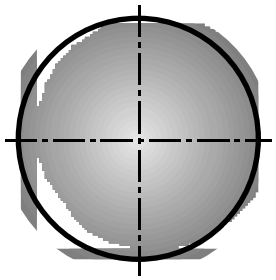
How to Select A Bearing?

Key Components

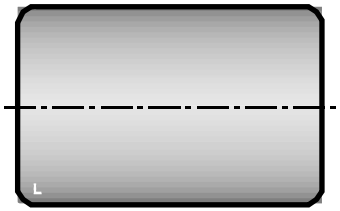


By changing these and their combination a rolling bearing can be **optimized** for almost every application.

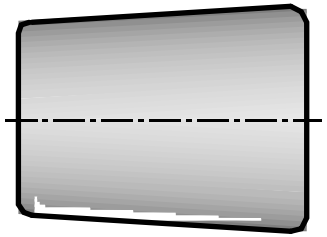
Types of Bearings?



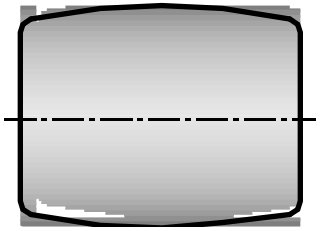
Ball



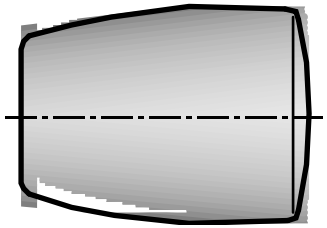
Cylindrical roller



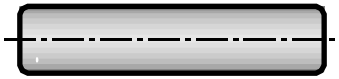
Tapered Roller



Symmetrical
Barrel Roller

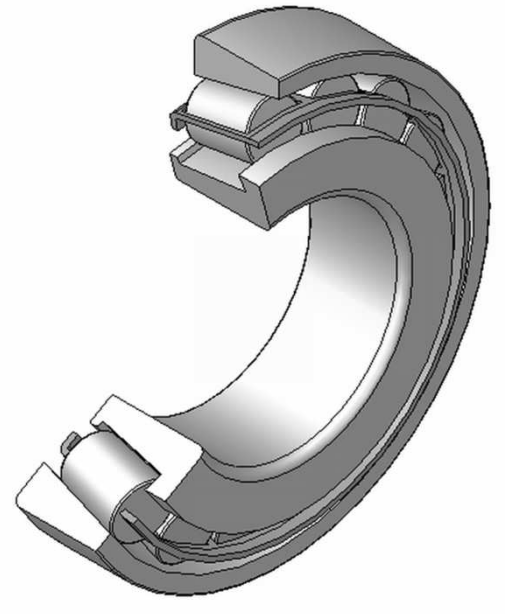


Asymmetrical
Barrel Roller

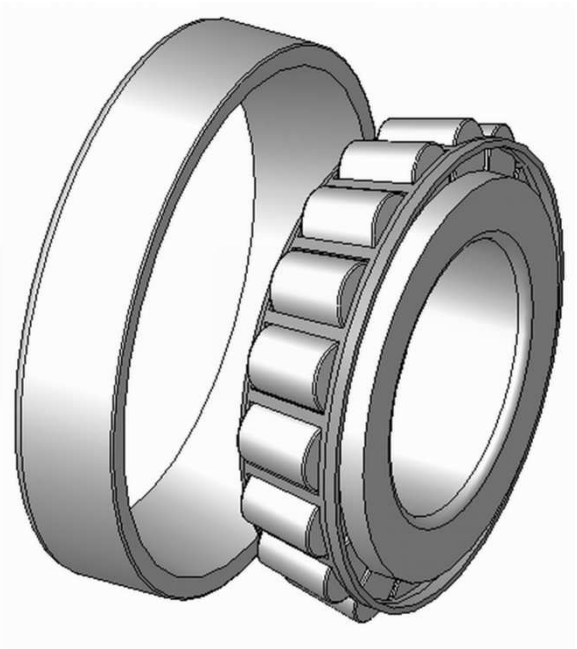


Needle Roller

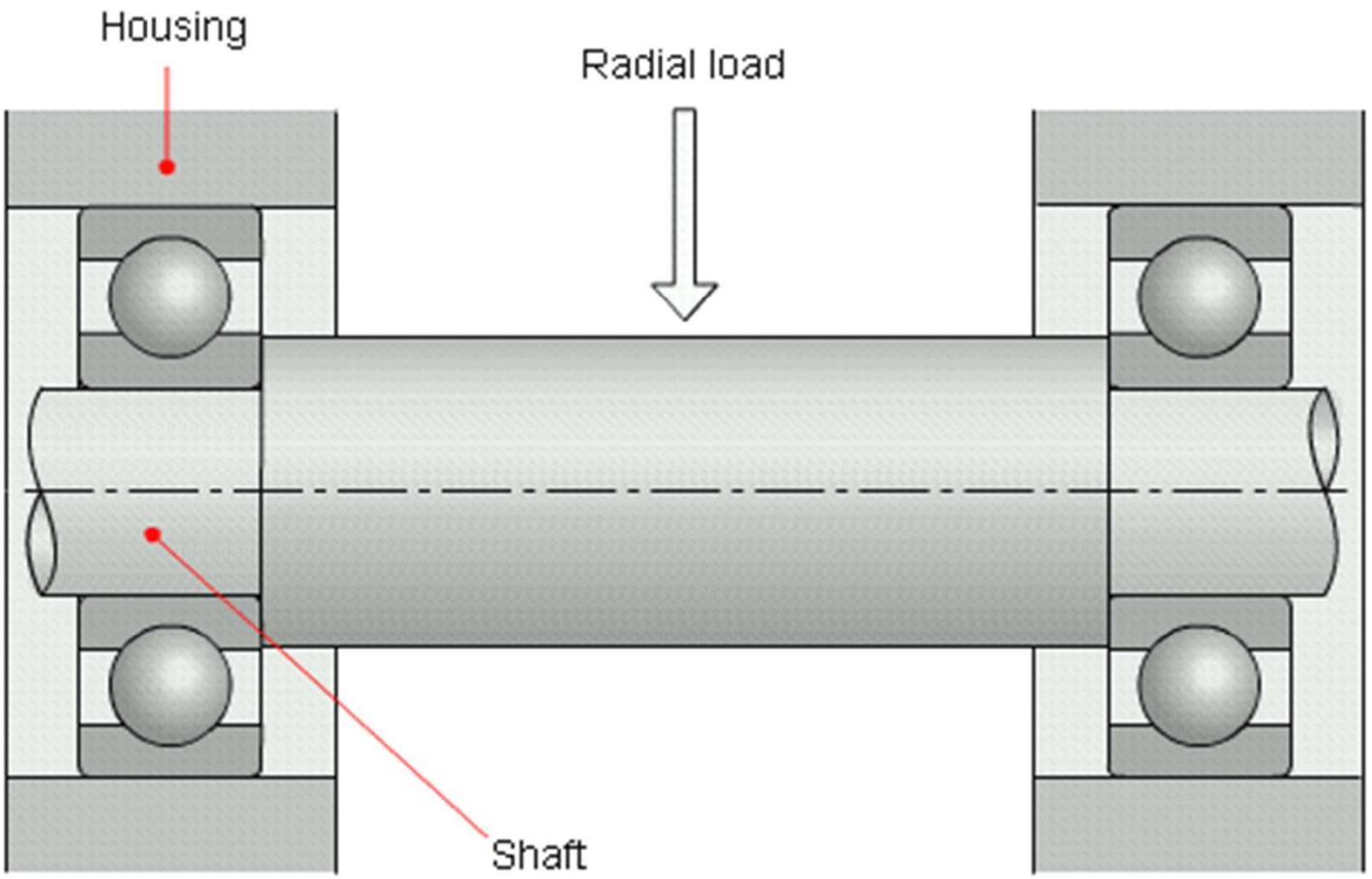
Main stress factors that require spezialized bearings for different applications:



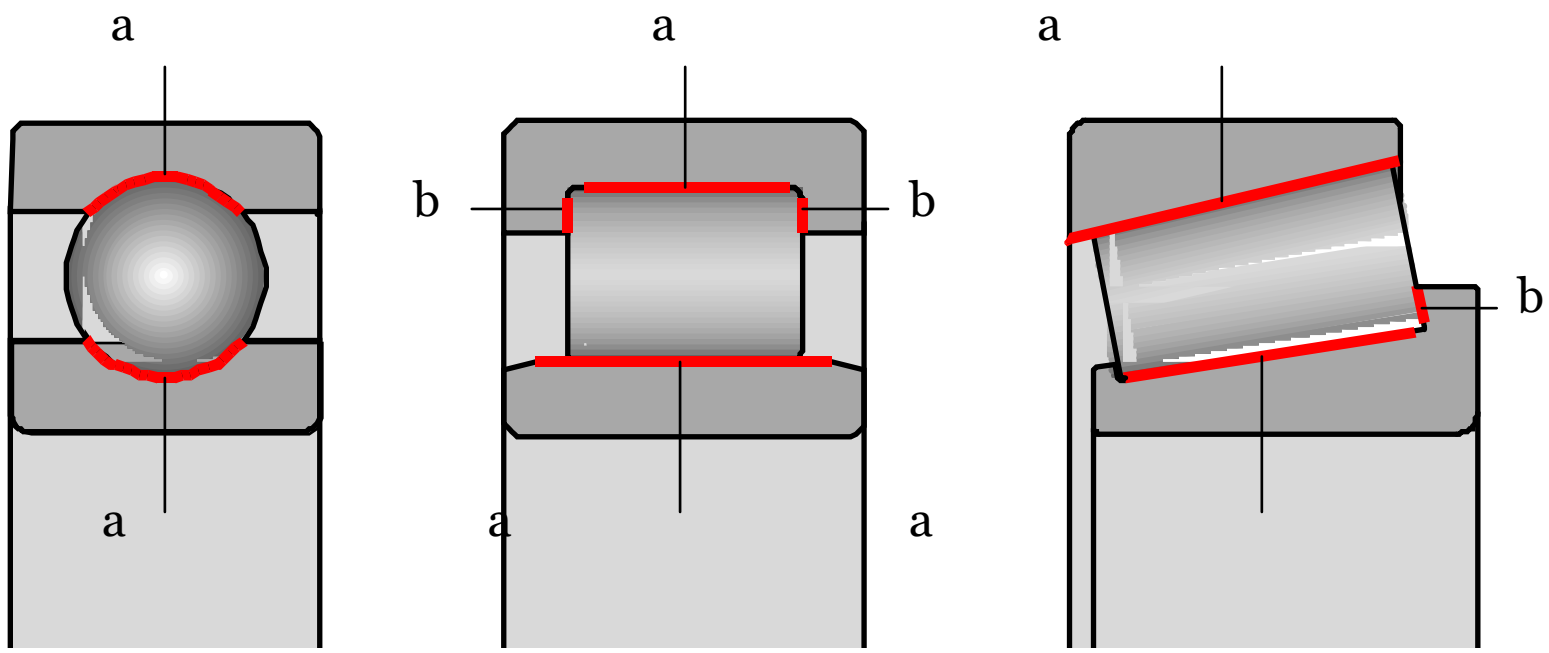
- Radial load
- Axial load
- Speed
- Misalignment
- Temperature



Radial Load



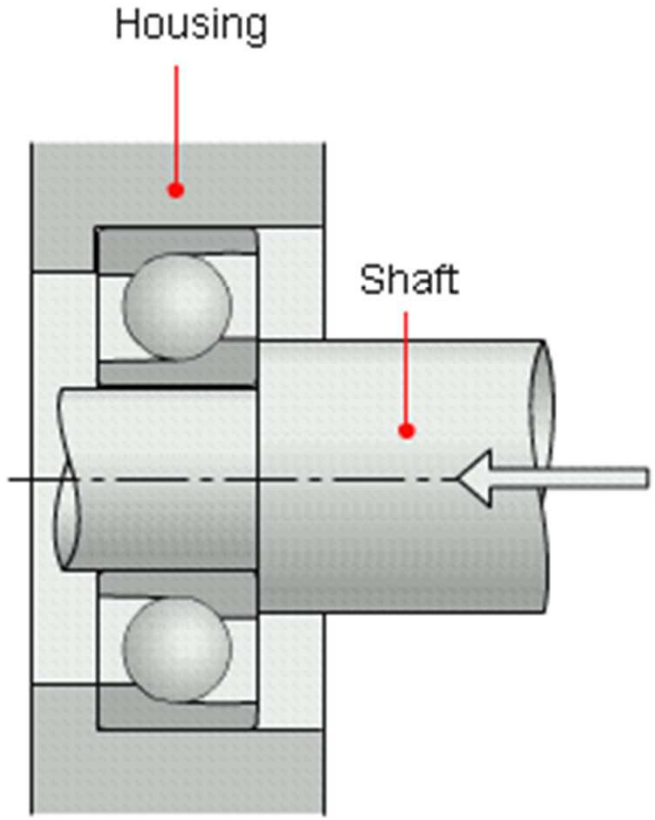
When the brush starts to shovel the sand inside the shovel will have a radial force due to the sand and while it’s pushing the sand towards the augur using the spiral shape the shaft will experience an axial load.



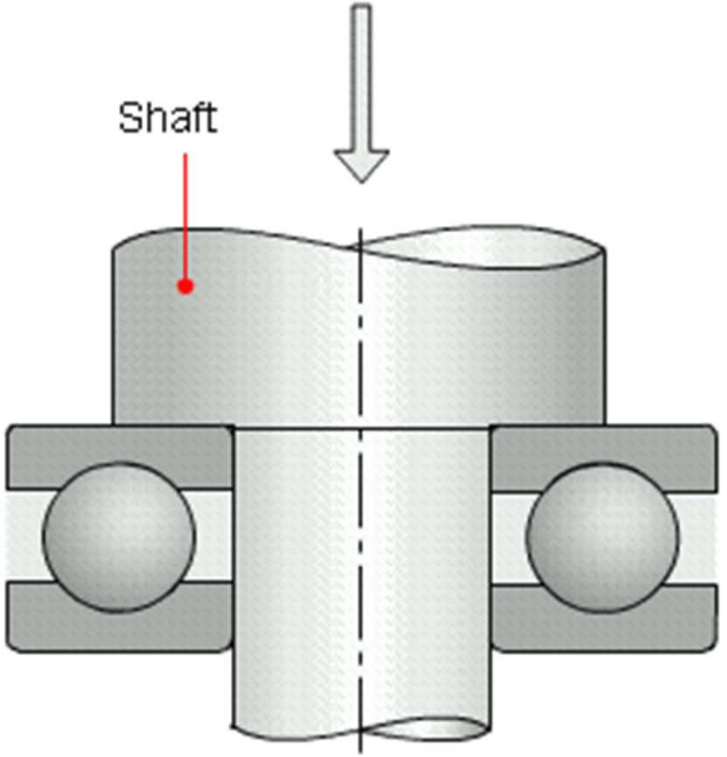
a: Raceway **b: Lip**

The radial load bearing capacity of a rolling bearing depends on the length of the contact line between rolling element and ring.

Axial Load

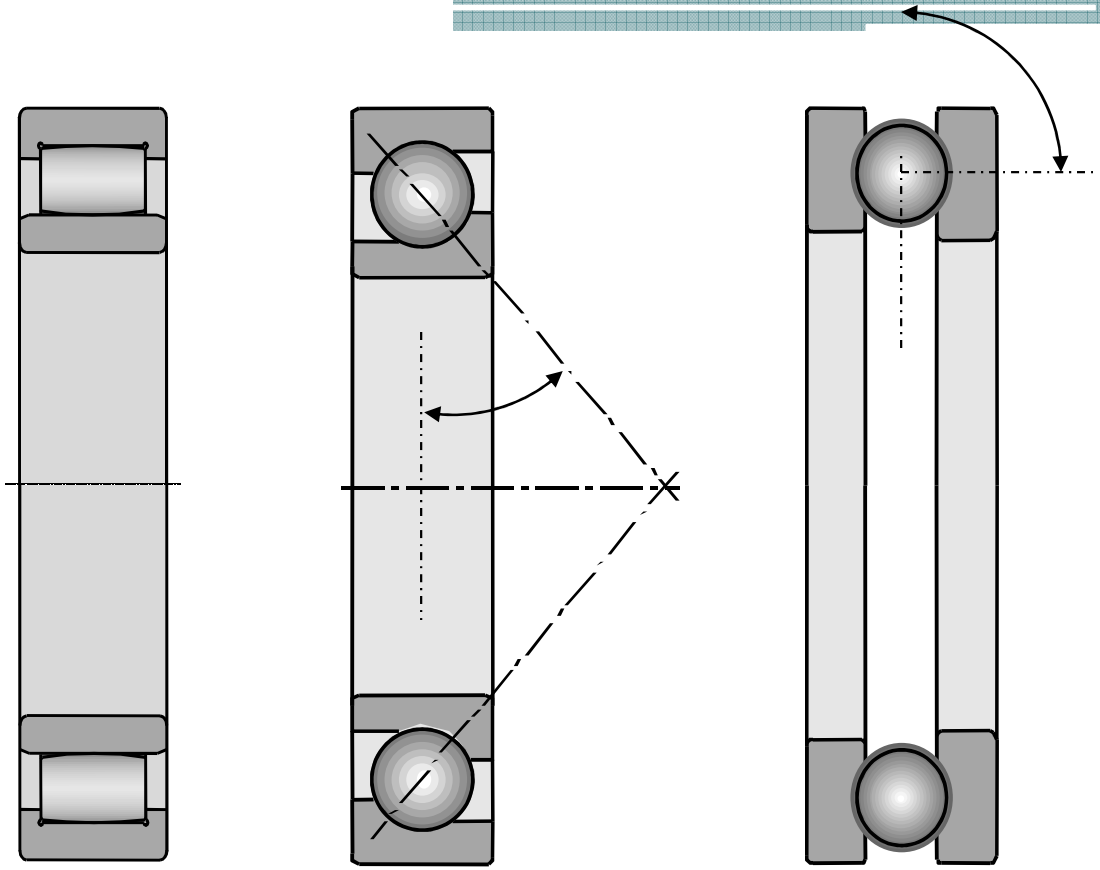


Horizontal axial load



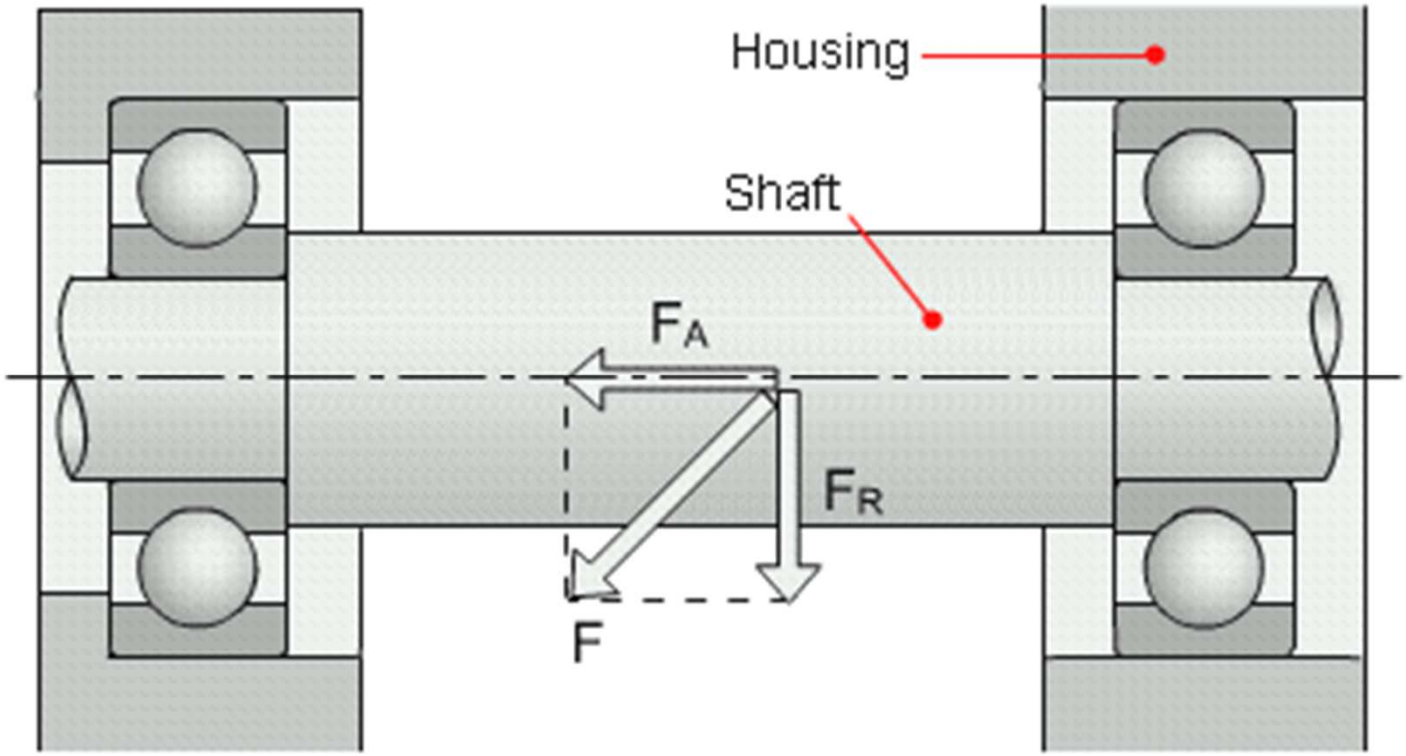
Vertical axial load

The axial load bearing capacity of a rolling bearing can be judged from its contact angle.



The axial load is largely determined by the contact angle α; the larger α, the higher the axial load carrying capacity.

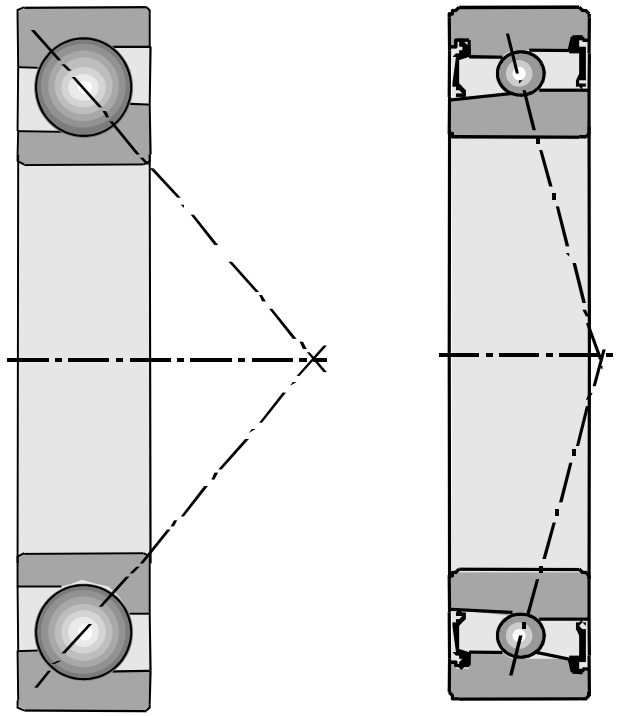
Inclined Load



An inclined load may be split into two components: Radial load F_R and Axial load F_A . A tapered roller bearing is more suitable or combined axial and radial loading

Speed

The larger the rolling elements and the higher the speed of the bearing the higher is the centrifugal force pressing the rolling elements against the outer ring raceway.



High Speed Effects

- The speed limitations of tapered roller bearings are dependent upon the permissible operating temperatures of the application and the capability of the lubrication system to effectively remove enough heat throughout its life.
- Other effects such as moments and centrifugal forces can reduce fatigue life at high speeds but are not taken into account in the basic rating life.

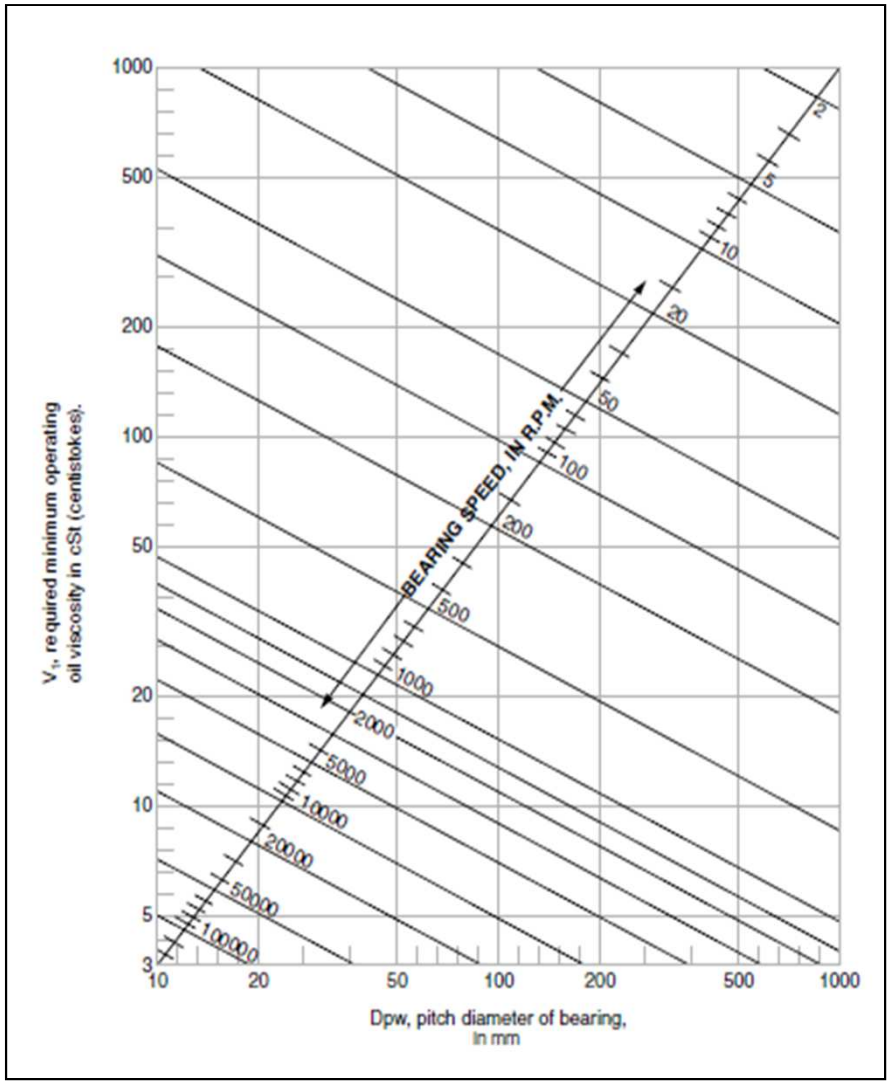
Alignment

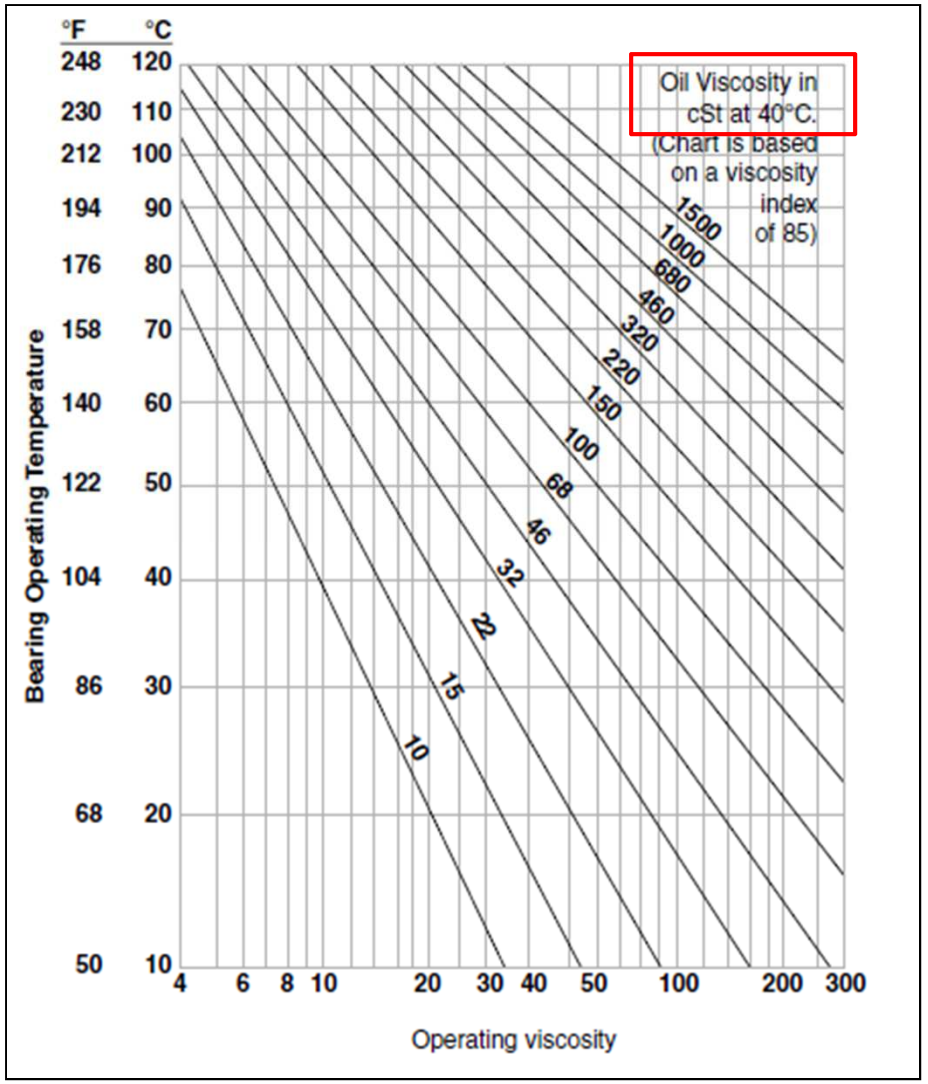
- A perfectly aligned bearing is ideal for maximum life and performance.
- The angle of misalignment for a tapered roller bearing is the difference between the axis of rotation of the cone assembly and the cup axis.

Lubrication

- The proper lubricant reduces friction and prevents wear by providing a particular thickness of film, which separates the bearing surfaces during operation.
- The required operating viscosity of the lubricant to be used is determined based on the pitch diameter and the rotational speed of the bearing.

Operating Viscosity of the Lubricant





Rolling Element Bearing

- **Description:** Ball or rollers are used to prevent or minimize rubbing.
- **Friction:** Rolling coefficient of friction with steel can be ~0.005.
- **Stiffness:** Good, but some slack is usually present.
- **Speed:** Moderate to high (often requires cooling).
- **Life:** Moderate to high (depends on lubrication, often requires maintenance).
- **Notes:** Used for higher moment loads than plain bearings with lower friction.

Bearing Selection

Tapered roller bearings, single row

Product information

Tolerances , see also text
Recommended fits
Shaft and housing tolerances

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	T	C	C_0	P_u				* – SKF Explorer bearing
mm			kN		kN	r/min		kg	-
38,1	79,375	29,37	91,3	110	12,5	6700	9500	0,67	3490/3420/QCL7CVQ492
38,1	82,55	29,37	85,5	118	13,4	6000	8500	0,77	HM 801346 X/2/310/QVQ523
38,1	82,55	29,37	85,5	118	13,4	6000	8500	0,78	HM 801346/310/Q
38,1	88,5	26,988	101	114	13,2	6300	9000	0,83	418/414/Q
39,688	73,025	25,654	66	86,5	9,3	6700	10000	0,45	M 2010447/011/Q
40	68	19	52,8	71	7,65	7000	9500	0,27	32008 X/Q
40	68	19	52,8	71	7,65	7000	9500	0,27	32008 XR/QVA621
40	68	19	52,8	71	7,65	7000	9500	0,27	32008 XTN9/Q
40	75	26	79,2	104	11,4	6700	9000	0,51	33108/Q
40	80	19,75	61,6	68	7,65	6300	8500	0,42	30208 J2/Q
40	80	19,75	61,6	68	7,65	6300	8500	0,42	30208 RJ2/Q
40	80	24,75	74,8	86,5	9,8	6300	8500	0,53	32208 J2/Q
40	80	32	105	132	15	5600	8500	0,77	33208/QCL7C
40	85	33	121	150	17,3	6000	9000	0,90	T2EE 040/QVB134
40	90	25,25	85,8	95	10,8	6000	8000	0,72	30308 J2/Q
40	90	25,25	85	81,5	9,5	5600	7500	0,72	31308 J2/QCL7C *
40	90	35,25	117	140	16	5300	8000	1,00	32308 J2/Q
40,988	67,975	17,5	44	58,5	6,3	7000	10000	0,24	LM 300849/811/Q
41,275	73,025	16,667	46,8	56	6,2	6700	10000	0,27	18590/18520/Q
41,275	73,431	19,558	55	68	7,65	6700	10000	0,33	LM 501349/2/310/2/QCL7C
41,275	73,431	19,558	55	68	7,65	6700	10000	0,33	LM 501349/310/Q
41,275	73,431	21,43	55	68	7,65	6700	10000	0,35	LM 501349/314/Q
41,275	76,2	18,009	45,7	56	6,1	6700	9500	0,34	11162/11300/Q
41,275	76,2	18,009	45,7	56	6,1	6700	9500	0,34	11163/11300/Q
41,275	76,2	22,225	68,2	86,5	9,65	6700	9500	0,43	24780/24720/Q

- http://www.skf.com/skf/productcatalogue/jsp/viewers/productTableViewer.jsp?&action=cad&lang=en&newlink=first&tableName=1_14_1&presentationType=3&startnum=5

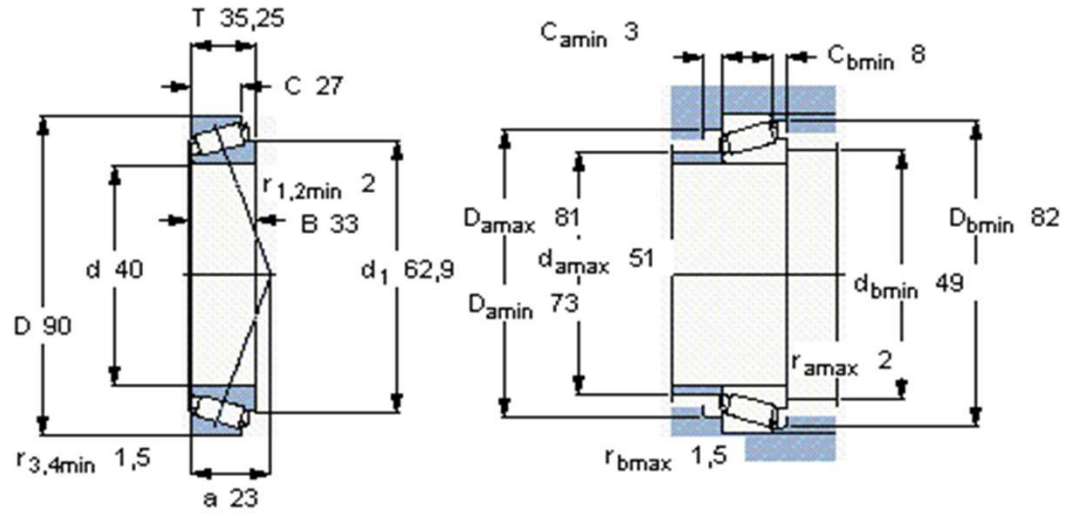
Details Dimensions

Tapered roller bearings, single row

Product information

Tolerances , see also text
Recommended fits
Shaft and housing tolerances

Principal dimensions			Basic load ratings		Fatigue load limit	Speed ratings		Mass	Designation
			dynamic	static		Reference speed	Limiting speed		
d	D	T	C	C_0	P_u				
mm			kN		kN	r/min		kg	-
40	90	35,25	117	140	16	5300	8000	1,00	**32308 J/Q**



Calculation factors

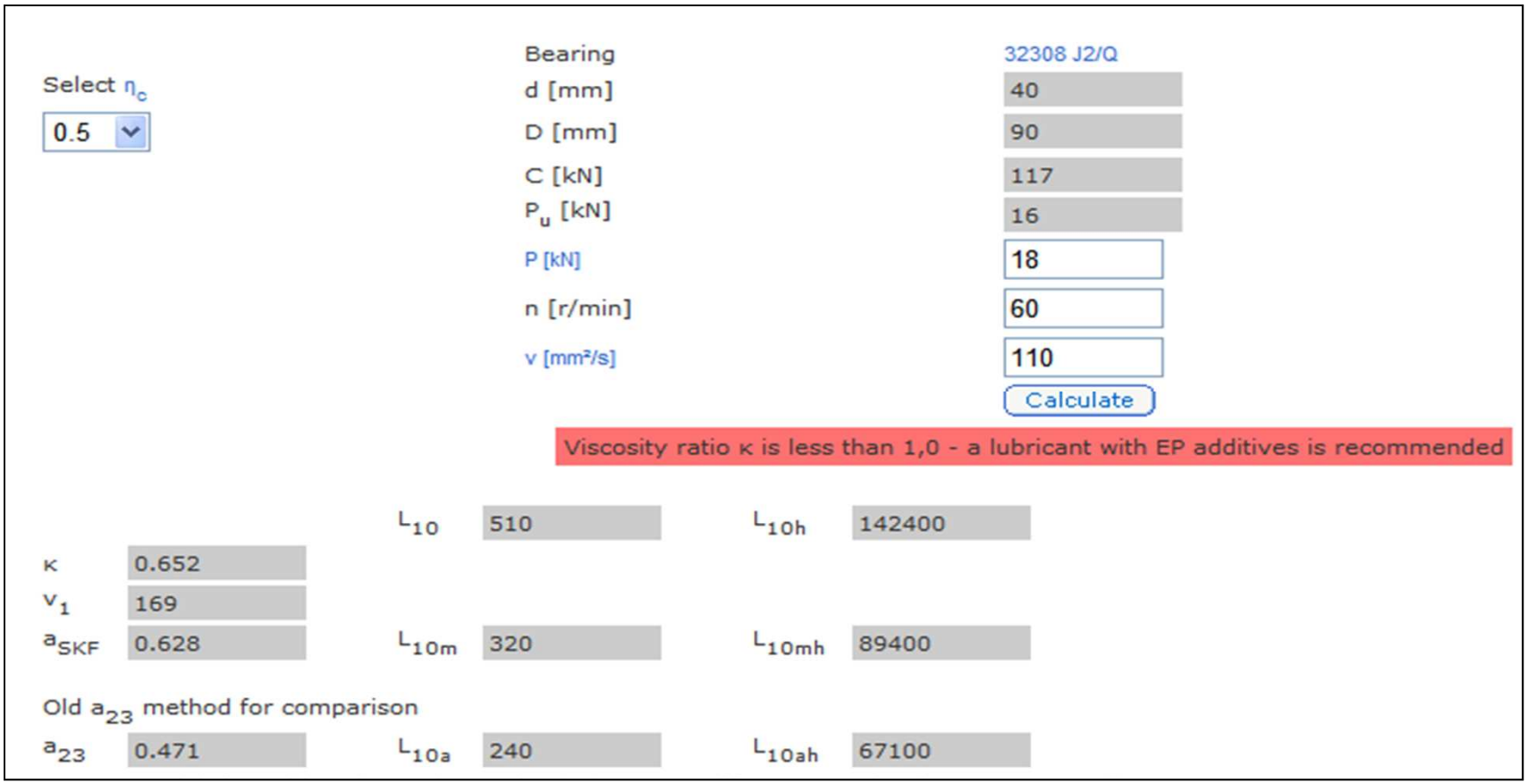
e 0,35
Y 1,7
Y_0 0,9

Table 1: SKF greases - technical specifications and characteristics

Part 1: Technical specifications

Designation	Description	NLGI class	Thickener/base oil	Base oil viscosity at 40 °C	Base oil viscosity at 100 °C	Temperature limits LTL[1]	Temperature limits HTPL[2]
-	-	-	-	mm^2/s		°C	
LGMT 2	All purpose industrial and automotive	2	Lithium soap/mineral oil	110	11	-30	+120
LGMT 3	All purpose industrial and automotive	3	Lithium soap/mineral oil	120	12	-30	+120
LGEP 2	Extreme pressure, heavy load	2	Lithium soap/mineral oil	200	16	-20	+110
LGLT 2	Light load and low temperature, high speed	2	Lithium soap/PAO	18	4,5	-50	+110
LGHP 2	High performance and high temperature	2-3	Di-urea/mineral oil	96	10,5	-40	+150
LGFP 2	Food compatible	2	Aluminium complex/ medical white oil	130	7,3	-20	+110
LGGB 2	Biodegradable and low toxicity	2	Lithium-calcium soap/ ester oil	110	13	-40	+120
LGWA 2	Wide temperature range	2	Lithium complex soap/ mineral oil	185	15	-30	+140 peaks:+220
LGHB 2	High viscosity and high temperature	2	Calcium sulphonate complex/mineral oil	450	26,5	-20	+150 peaks:+200
LGET 2	Extreme temperature	2	PTFE/synthetic/ fluorinated polyether	400	38	-40	+260
LGEM 2	High viscosity with solid lubricants	2	Lithium soap/mineral oil	500	32	-20	+120

Calculations for Bearings Life



Select η_c: 0.5

Bearing	32308 J2/Q
d [mm]	40
D [mm]	90
C [kN]	117
P_u [kN]	16
P [kN]	18
n [r/min]	60
v [mm²/s]	110

Calculate

Viscosity ratio κ is less than 1,0 - a lubricant with EP additives is recommended

		L_{10}	510	L_{10h}	142400
κ	0.652				
v_1	169				
a_{SKF}	0.628	L_{10m}	320	L_{10mh}	89400

Old a_{23} method for comparison

a_{23}	0.471	L_{10a}	240	L_{10ah}	67100

- Every care has been taken to ensure the accuracy of this calculation but no liability can be accepted for any loss or damage whether direct, indirect or consequential arising out of the use of the calculation.
- http://www.skf.com/skf/productcatalogue/calculationsFilter?lang=en&newlink=&prodid=&action=Calc1

Bearing Life Equation

- Bearing life equation is:

$$L_{10} = (C / P)10/3 \times (B / n) \times a$$

  L_{10} in hours

- Where:

  C = radial rating of the bearing in lbf or N

  P = radial load in lbf or N.

  B = factor dependent on the method; B = 1.5 × 106 for the Timken method (3000 hours at 500 rev/min) and 106 /60 for the ISO method

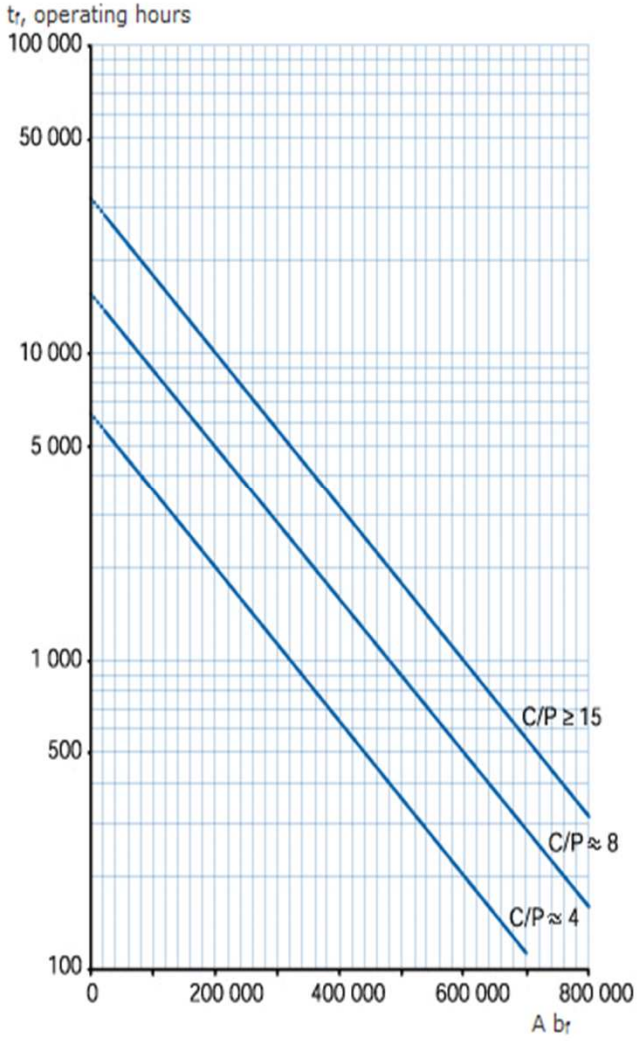
  a = life adjustment factor; a = 1, when environmental conditions are not considered ;

  n = rotational speed in rev/min.

Table 2: Bearing factors and recommended limits for speed factor A

Bearing type[1]	Bearing factor b_f	Recommended limits for speed factor A for load ratio C/P ≥ 15	C/P ≈ 8	C/P ≈ 4
-	-	mm/min		
Deep groove ball bearings	1	500 000	400 000	300 000
Angular contact ball bearings	1	500 000	400 000	300 000
Self-aligning ball bearings	1	500 000	400 000	300 000
Cylindrical roller bearings				
- non-locating bearing	1,5	450 000	300 000	150 000
- locating bearing, without external axial loads or with light but alternating axial loads	2	300 000	200 000	100 000
- locating bearing, with constantly acting light axial load	4	200 000	120 000	60 000
- without cage, full complement[2]	4	NA[3]	NA[3]	20 000
Needle roller bearings	3	350 000	200 000	100 000
Taper roller bearings	2	350 000	300 000	200 000
Spherical roller bearings				
-when load ratio $F_a/F_r \leq e$ and $d_m \leq 800$ mm				
series 213, 222, 238, 239	2	350 000	200 000	100 000
series 223, 230, 231, 232, 240, 248, 249	2	250 000	150 000	80 000
series 241	2	150 000	80 000[4]	50 000[4]
-when load ratio $F_a/F_r \leq e$ and $d_m > 800$ mm				
series 238, 239	2	230 000	130 000	65 000
series 230, 231, 232, 240, 248, 249	2	170 000	100 000	50 000
series 241	2	100 000	50 000[4]	30 000[4]
-when load ratio $F_a/F_r > e$				
all series	6	150 000	50 000[4]	30 000[4]
CARB toroidal roller bearings				
- with cage	2	350 000	200 000	100 000
- without cage, full complement[2]	4	NA[3]	NA[3]	20 000
Thrust ball bearings	2	200 000	150 000	100 000

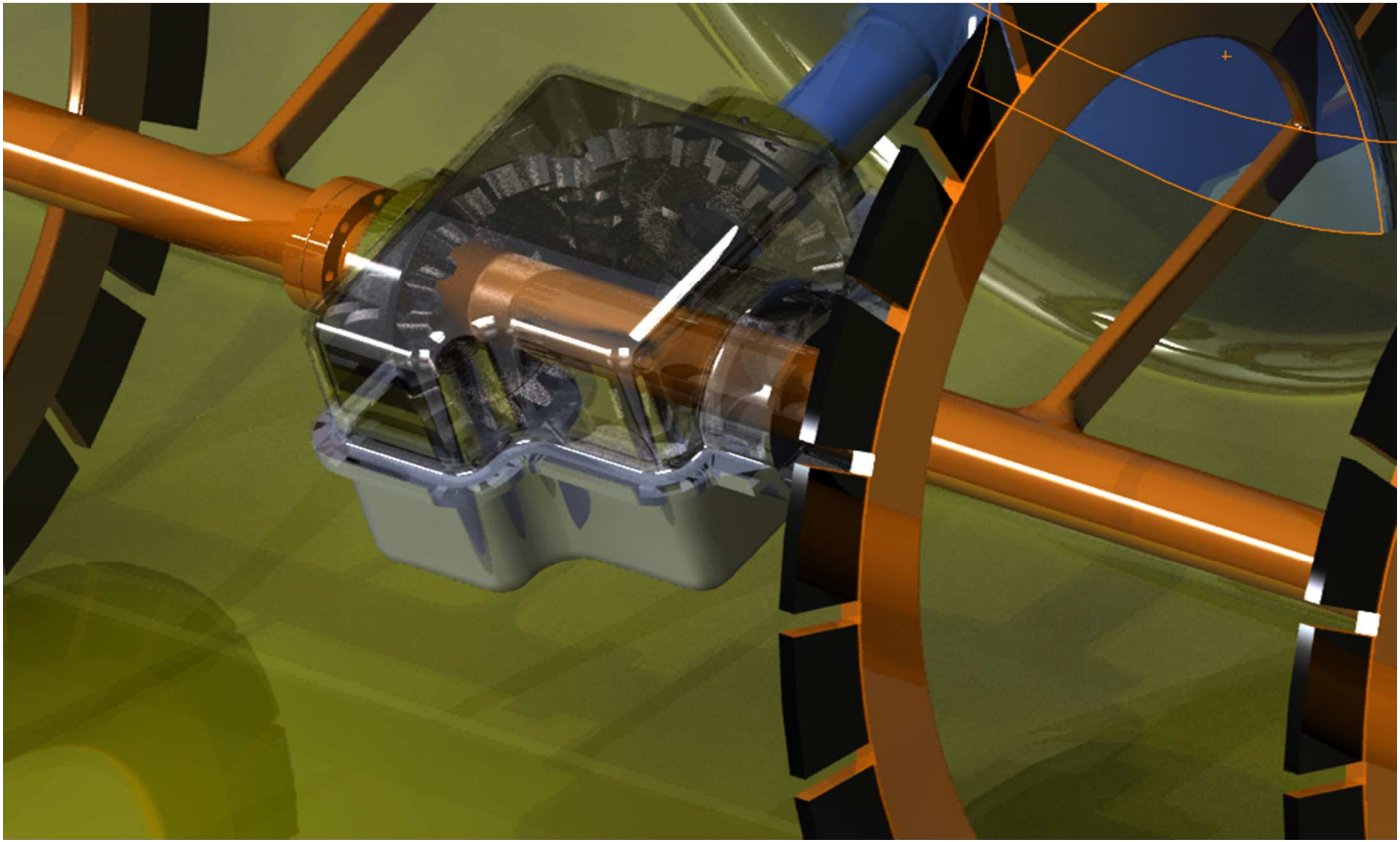
Diagram 4: Relubrication intervals at operating temperatures of 70 °C

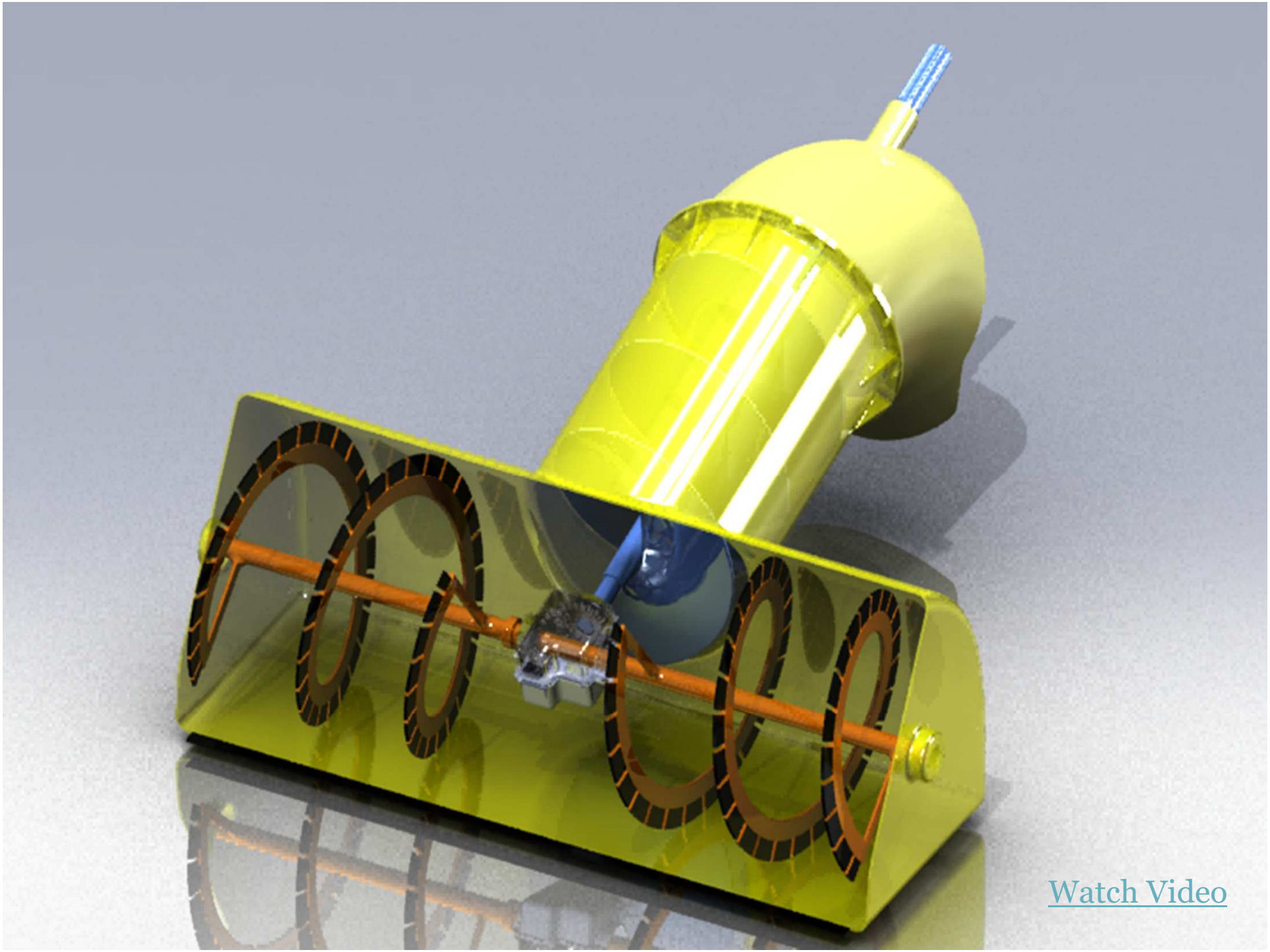


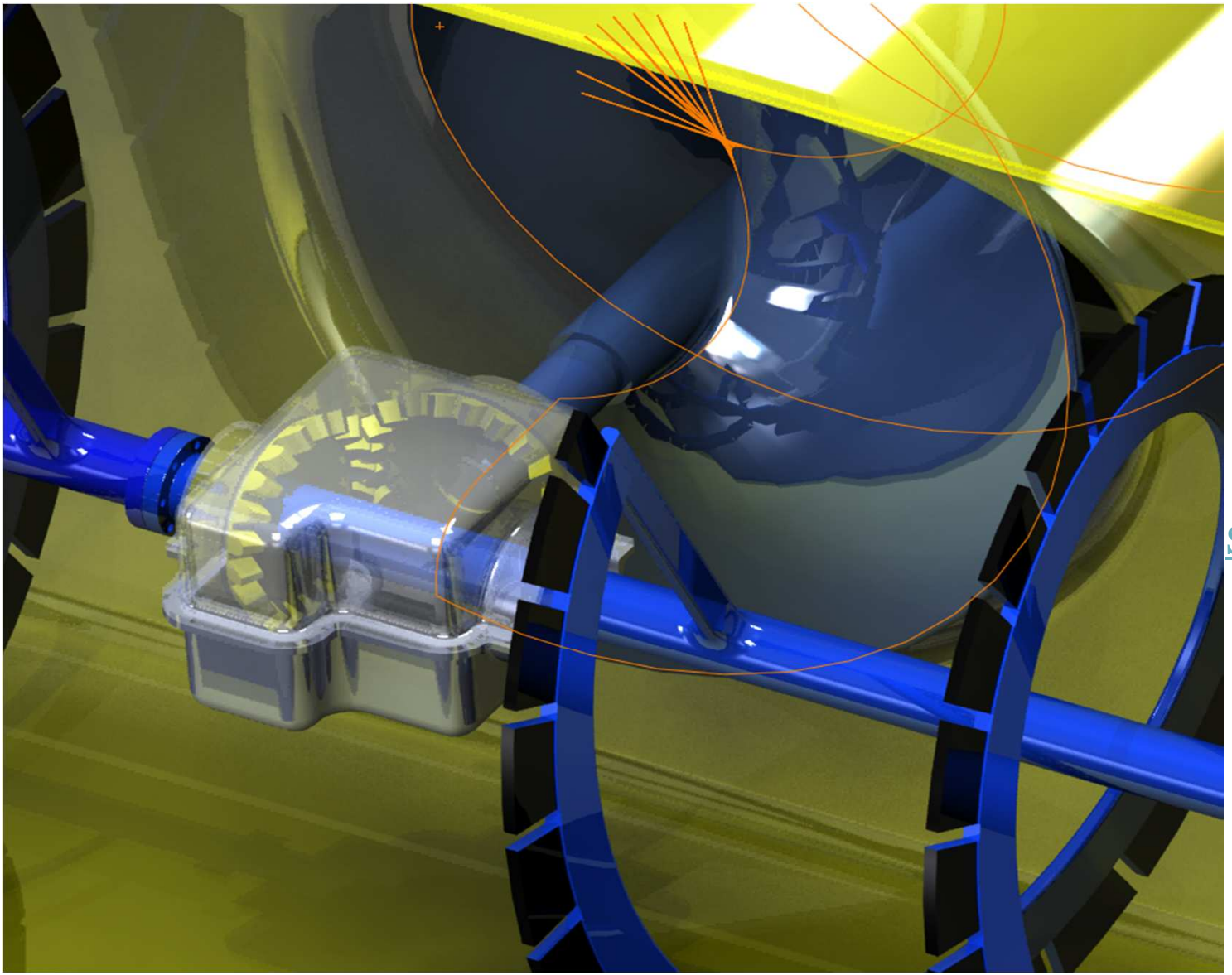
Conclusion

- Doubling load reduces life to one tenth.
  - Reducing load by one half increases life by ten,
- Doubling speed reduces life by one half.
  - Reducing speed by one half doubles life.

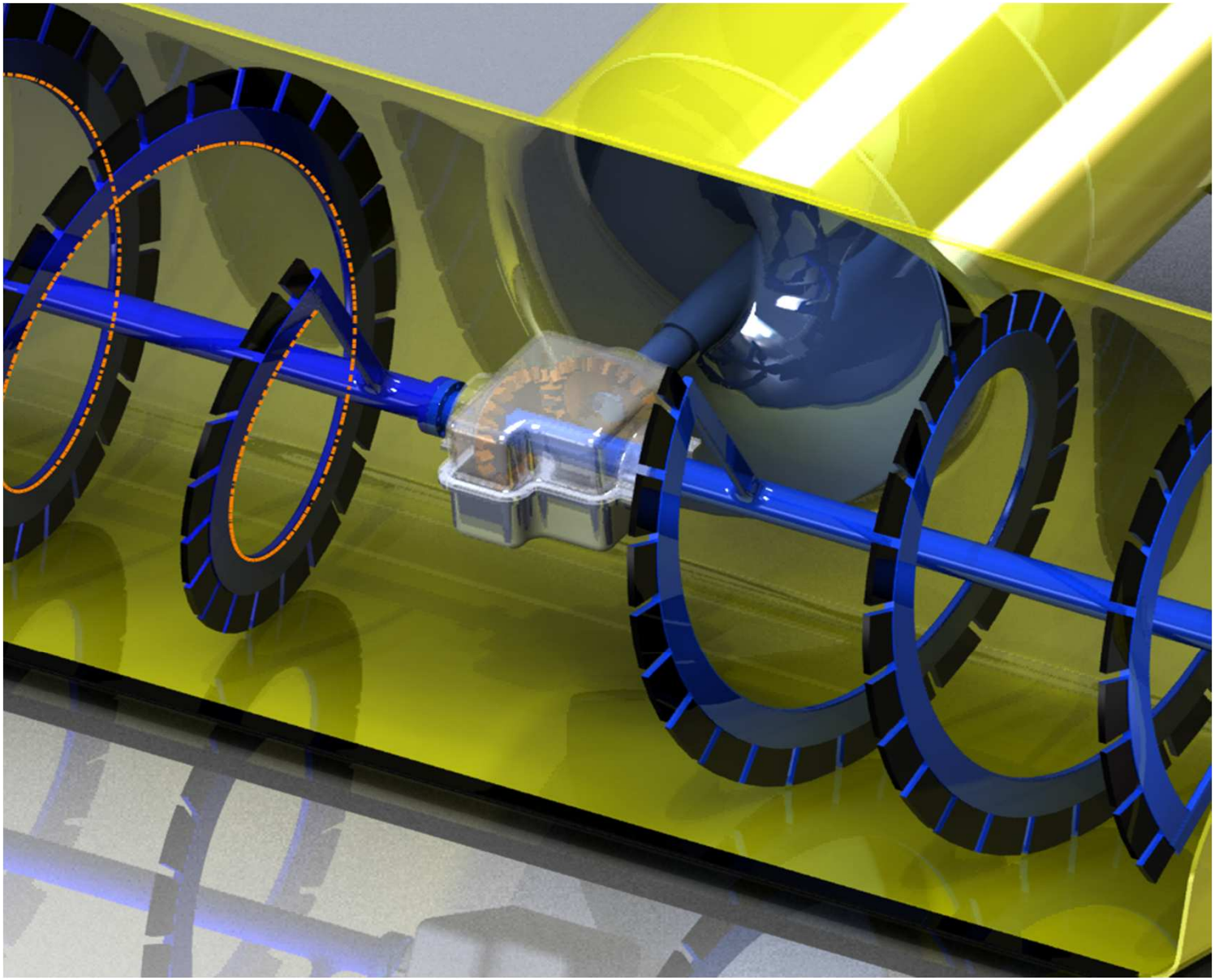
Design Outcome

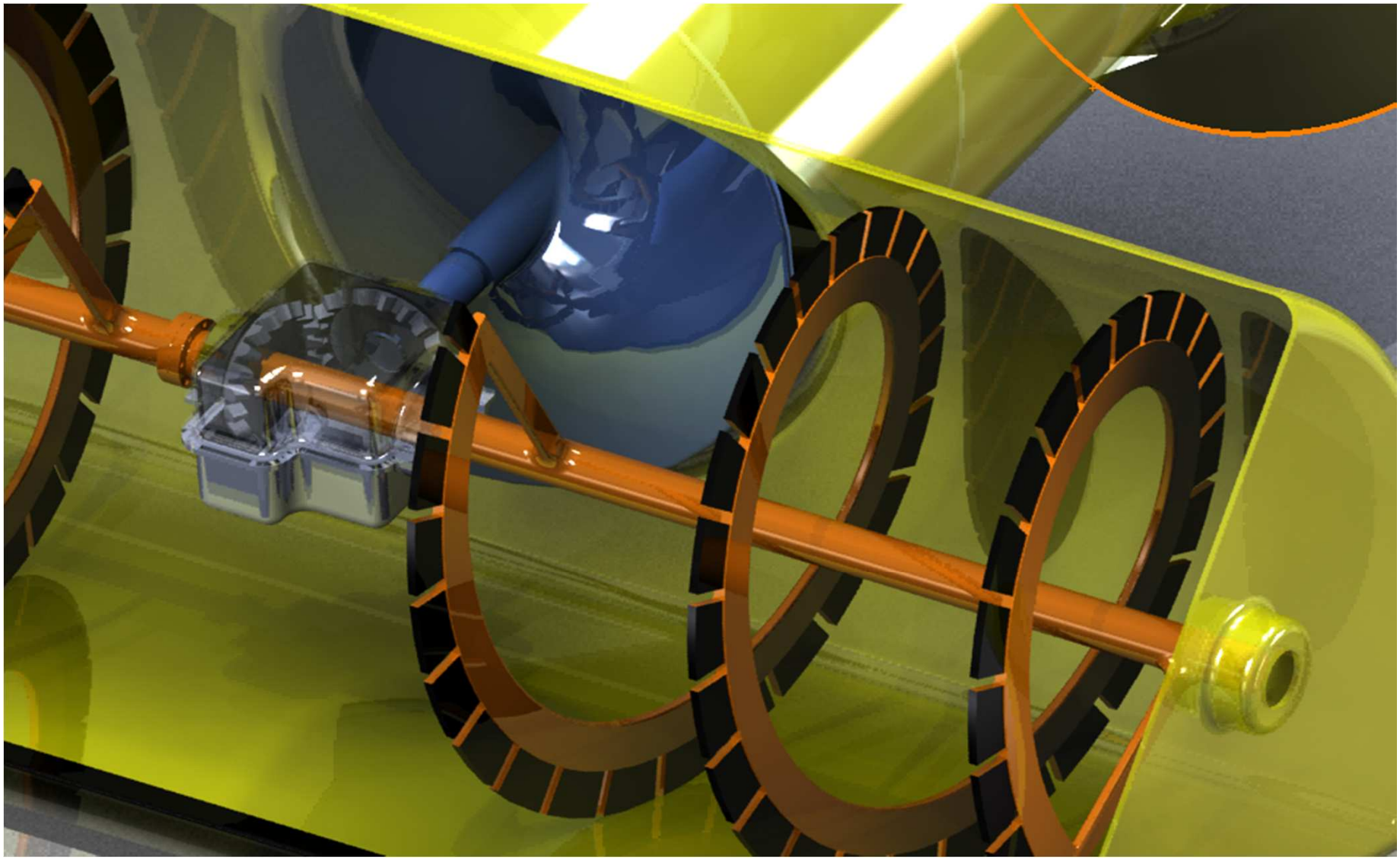


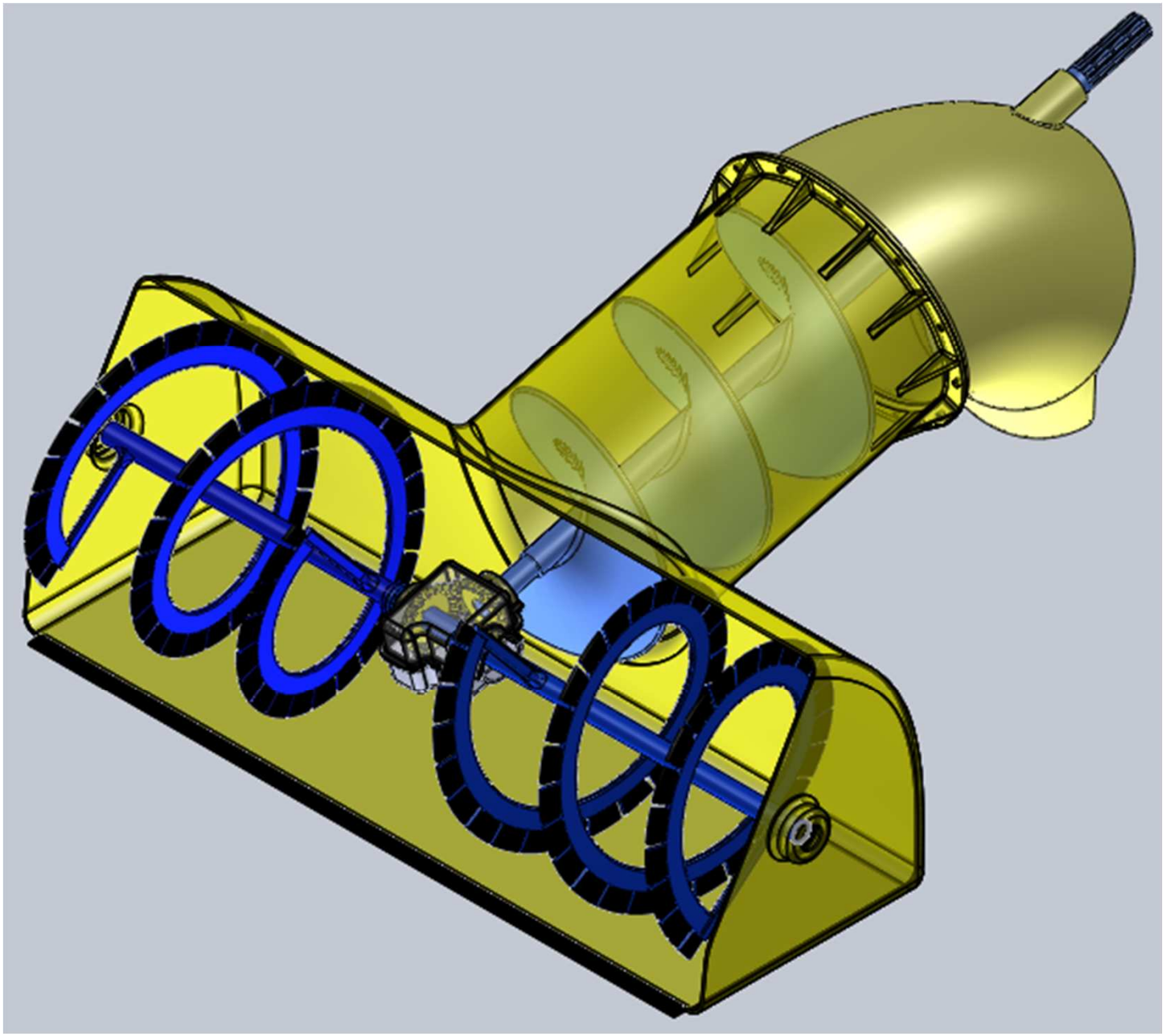

Watch Video



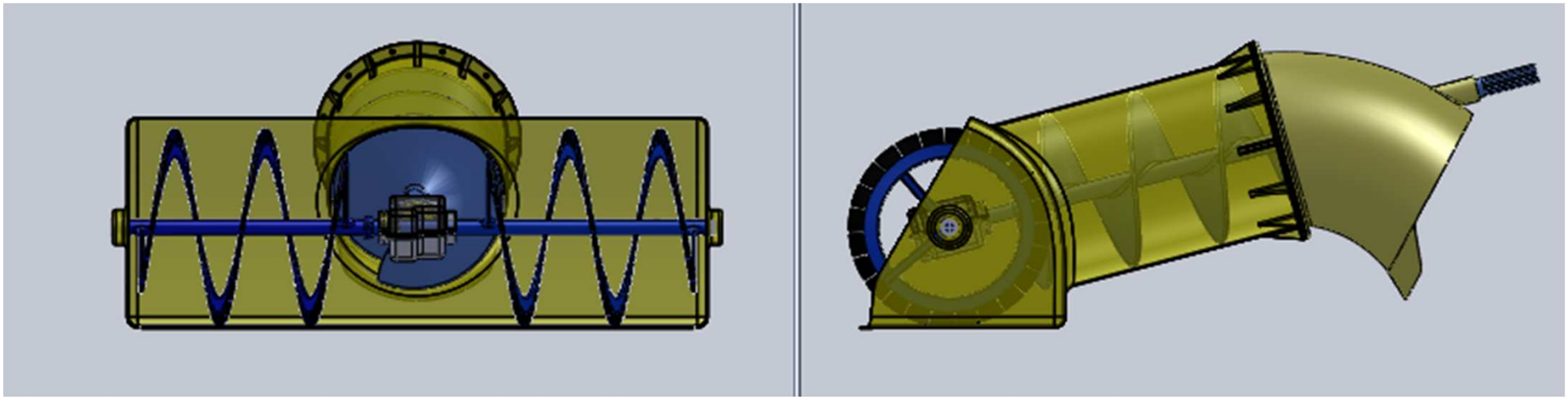
See Video



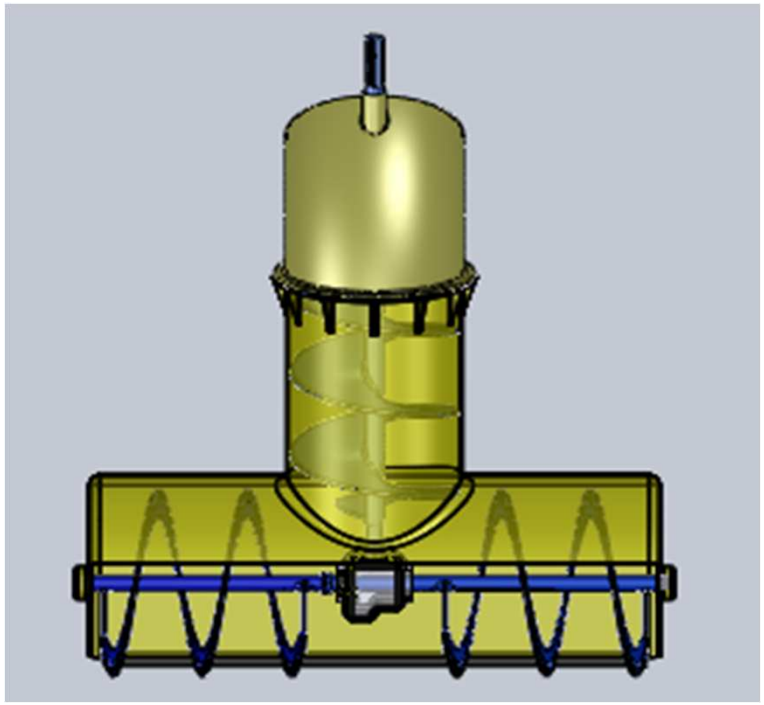


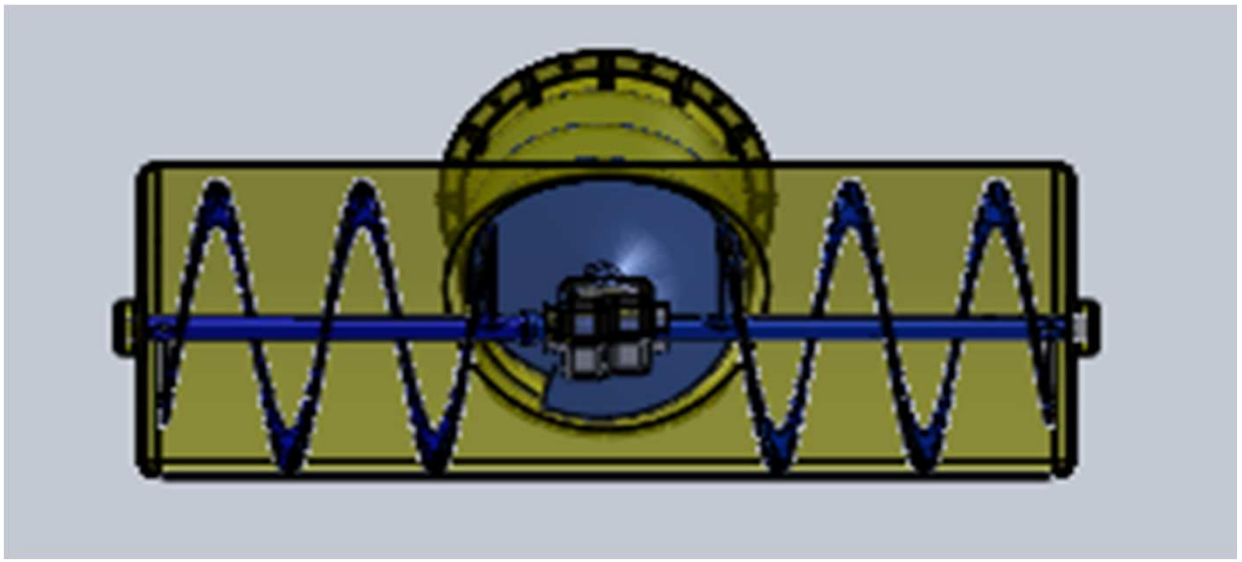


Two View - Vertical

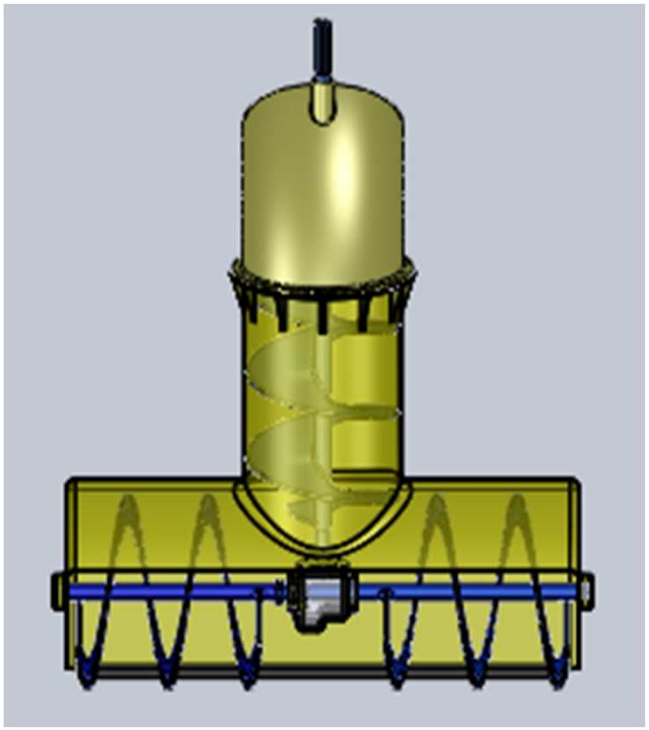


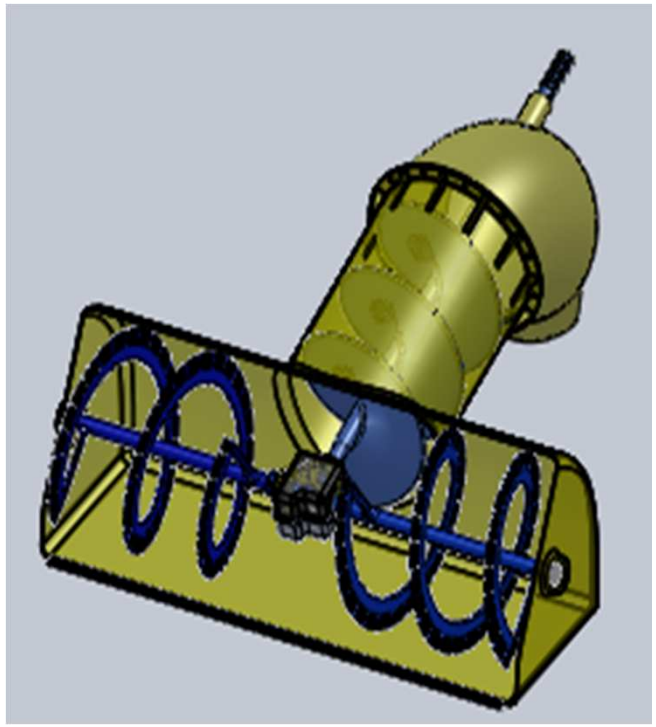
Two View - Horizontal

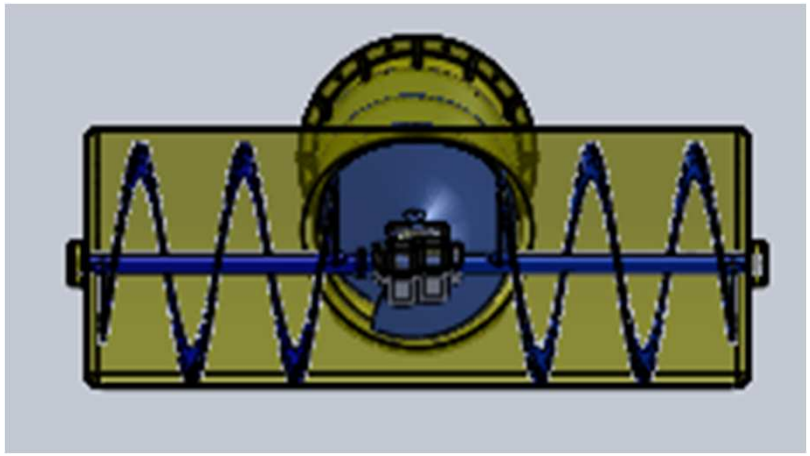


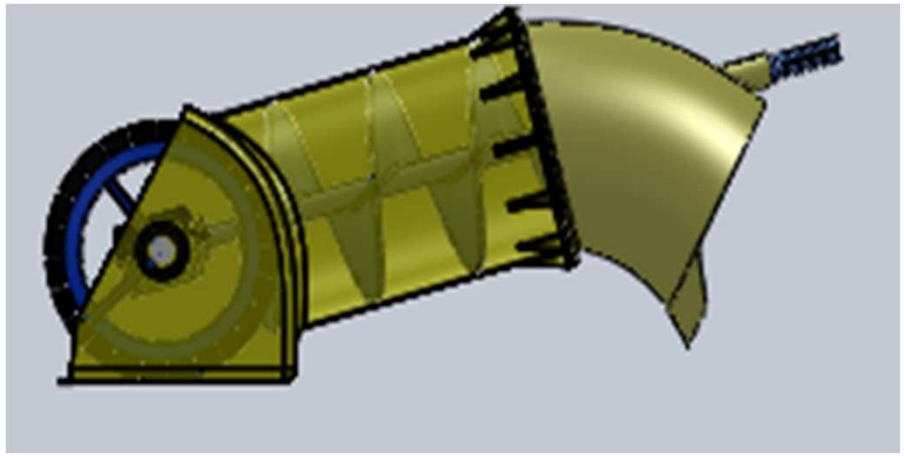


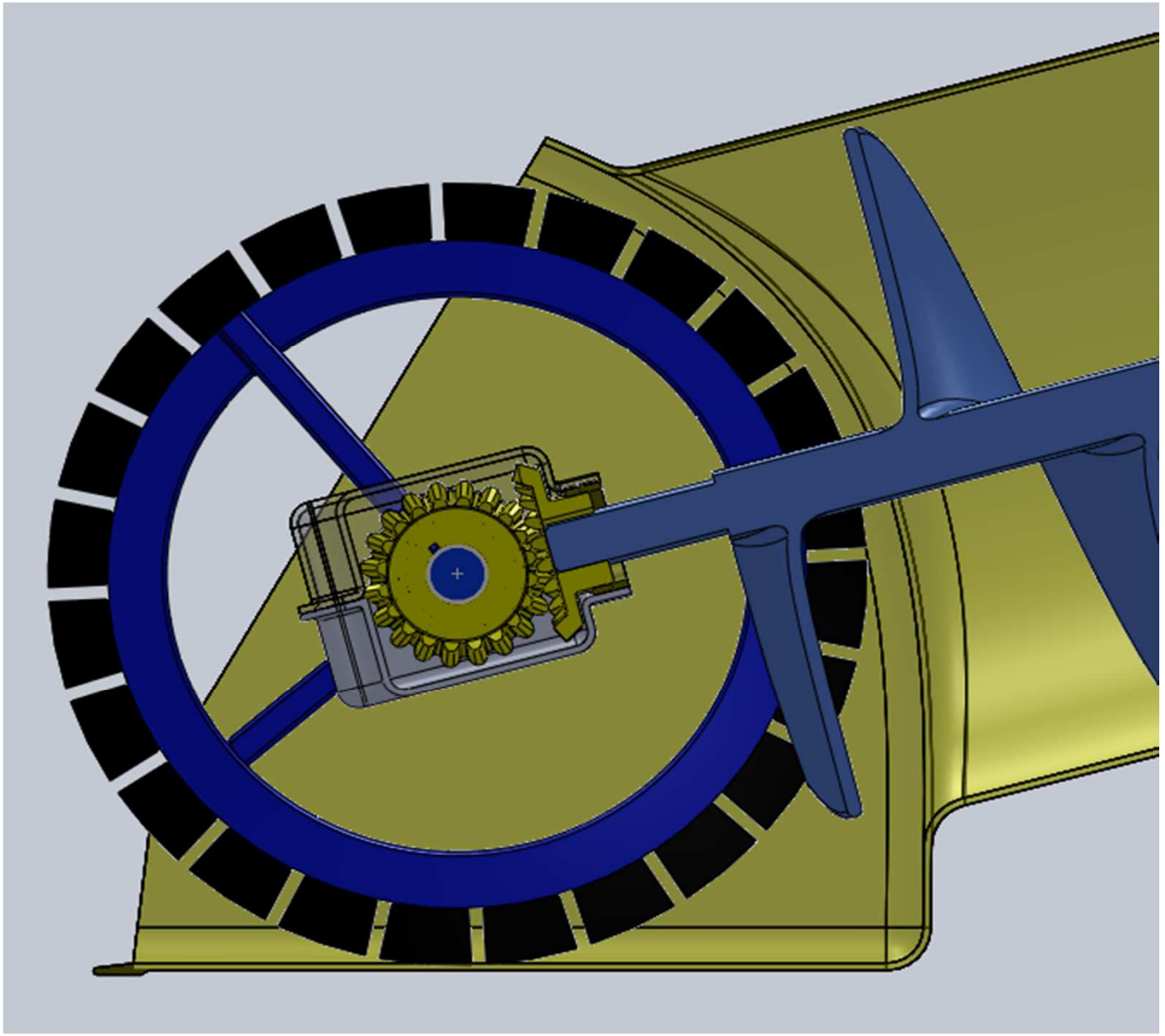
Top, Trimetric, Front, Right

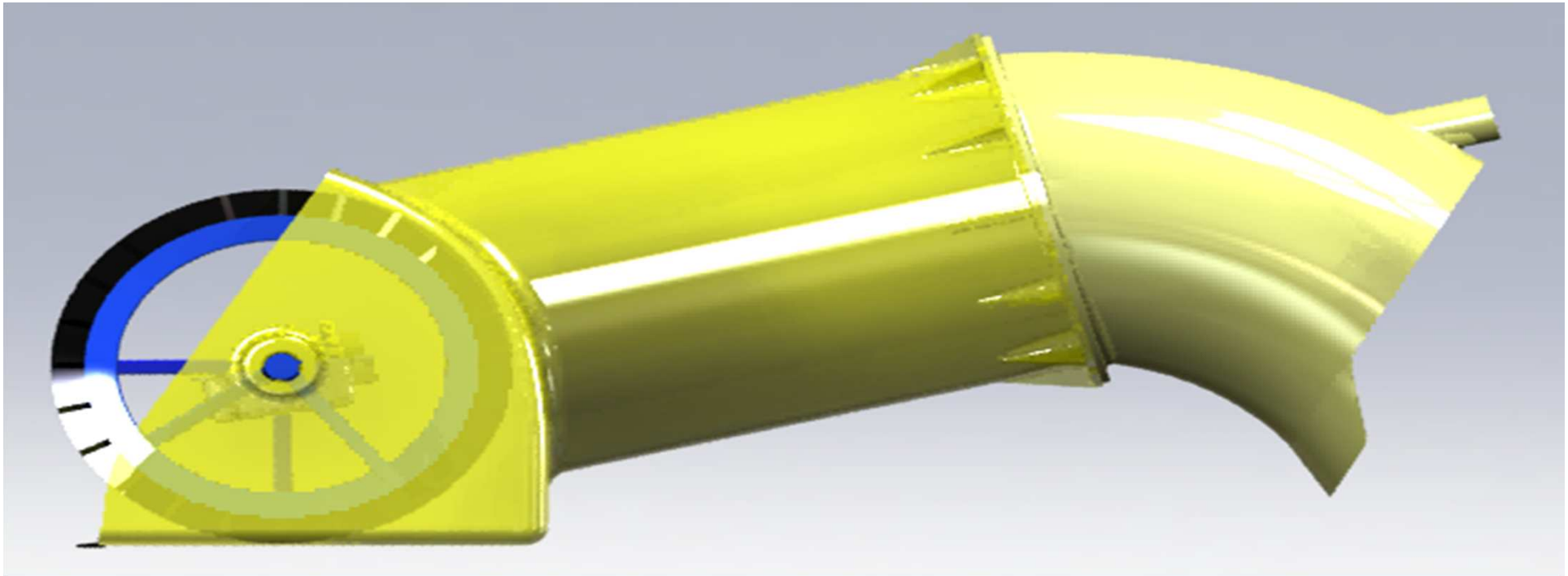


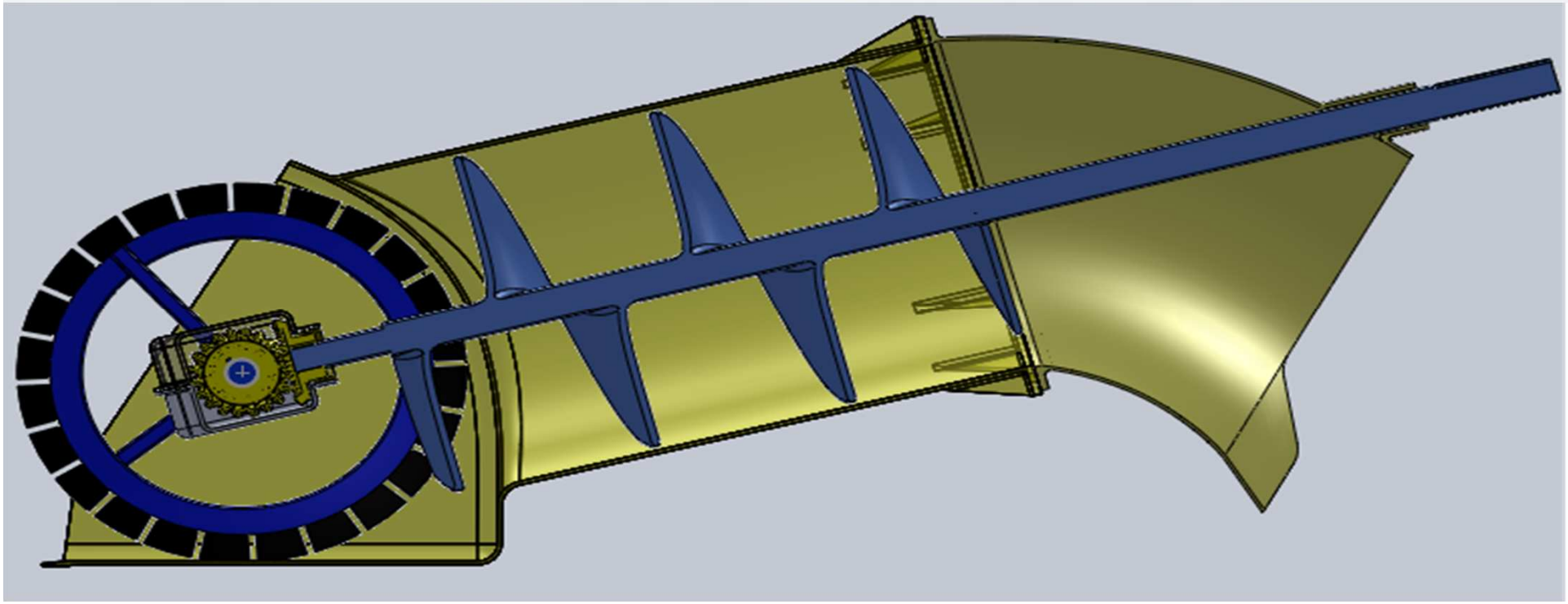












Project Plan Using Gantt Chart

Highway Sand Blower

Group 1 : Jamal Al-Saeed ID#200600177
Abdullah Al-Dossary ID#200600188
Ali Al-Bayat ID#200600246

Specifications:
Speed: 60 rpm
Capacity: 1.6 m wide x 0.6 m high scoop

Project Timeline

Item	Activity	Target Schedule										
		Week-1	Week-2	Week-3	Week-4	Week-5	Week-6	Week-7	Week-8	Week-9	Week-10	Week-11
1	**Project Introduction**											
	Group Brainstorming											
	a. *Gathering Literatures*											
	b. *Literature Survey*											
2	**Conceptualize Design**											
	a. *Sketching of Design Ideas*											
	b. *Use CAD Solidworks*											
3	**Identification of Design Critical Components**											
4	Performance Calculations											
	a. *Selection of Materials*											
	b. *Sizing & Strength Calculations*											
	c. *Submit Initial Design to Dr. Emad for comments*											
5	**Update Conceptual Design**											
	a. *CAD Solidworks Assembly*											
6	**Finetuning of CAD Design**											
	a. *Addition of Deferentials, Shafts, Bearings*											
7	**Prototyping by CAD / Simulation**											
	a. *Solidworks Simulation*											
	b. *Motion Study*											
	c. *Animation*											
8	Detailing of Design											
9	Final Report Generation											
10	Final Presentation											

Plan
Actual

Resources

1. Budynas-Nisbett. 2006. Shigley's Mechanical Engineering Design, 8th edition. New York: McGraw-Hill Primis.
2. http://www.pdblowers.com/t17-positive-displacement-blower-calculations.php
3. http://www.freewebs.com/snowblowerinnovations/p.html
4. Patents: http://www.freepatentsonline.com/3805421.html
5. http://www.kau.edu.sa/Files/195/Researches/55122_25447.pdf
6. SKF:http://www.skf.com/skf/productcatalogue/calculationsFilter?lang=en&newlink=&prodid=&action=Calc1

Thank You