Analysis on Double Disk Grinding Carry Plate Gearbox

B. Balamurali, B. Ashvin, N. Gowtham and B. Jagan

Abstract--- *The worm gear in carry plate gear box gets worn out within 2025 hours to 3000 hours of work time. We have design and analysed a standard gear box for reason for failure. The suggested gear box have undergone many constrains like heat dissipation, torque applied, shock load, strain, yield strength and elasticity. By considering all constrains, newly designed carry plate gearbox life has increased its life time from 2025hrs to 21000hrs..*

Keywords--- *high torque, increasing life, worm gear, carry plate, double disk grinding, and gear box*

I. Introduction

Double-disc grinding has always offered a highly productive and accurate means for machining to-size parts with flat and parallel sides. In this grinding method, two opposed abrasive discs, each mounted on its own spindle, simultaneously grind opposite and parallel faces on work pieces traversed between them via any of several featuring/carrier techniques. Because double-disc grinding can remove up to 1/8 inch of stock in a single pass, and multiple parts are ground on both sides simultaneously, production rates are generally 100 percent greater than those obtained with surface grinding.

Typically, however, double-disc grinding can hold size tolerances to as close as 0.0001 inch and flatness to within 50 micro inches, while achieving surface finishes as fine as 5 rms with conventional abrasive discs. (Polishing discs typically produce surfaces of 1 to 2 rms.) The ability to achieve tight tolerances often eliminates the need for lapping or polishing work, fine grind work and secondary inspections. It also reduces part handling, scrap and rework.

- Machines up to 4-axes CNC control
- User-friendly grinding cycles by customized screen (picto programming).
- Preloaded antifriction guide ways for precise positioning and rigidity.
- Super precision antifriction bearings for grinding spindles.
- Direct driven ball screws with AC digital servomotors for linear axes.
- Hydraulic swing arm dresser.
- Automatic centralized lubrication system.
- Free-standing electrical panel and hydraulic power pack.
- Pendant type operator panel.
- Built-in safety interlocks.
- Input resolution 0.0001 mm

Rotary Carry Plate

The rotary type fixture is recommended for medium or small size parts where high production and accuracy are required. This type of fixture lends itself to automatic loading and unloading of parts such as bearing rollers, valve inserts, piston pins, pump vanes, snap rings, etc. A continuously rotating disc (feed wheel) provided with suitable openings is arranged to hold and carry the work between the abrasive discs.

ARF is a variable speed rotary feeder for bulk materials that works in harmony with the natural flow of the material being fed. The ARF, using a rotating member and articulable gate, controls the volume of material flow based on the material's inherent angle of repose. The speed of rotation and the positioning of the articulable gate provides a consistent feed of your material. Drum rotation allows the material to be gently fed without retarding material flow, while minimizing surge loading, product degradation, dust generation and maintaining uniformity of material flow

Rotary valves are available with square or round inlet and outlet flanges. Housing can be fabricated out of sheet material or cast. Common materials are cast iron, carbon steel, 304 SS, 316 SS, and other materials. Rotary airlock feeders are often available in standard and heavy duty models, the difference being the head plate and bearing configuration.

Heavy duty models use an outboard bearing in which the bearings are moved out away from the head plate. Housing inlet and discharge configurations are termed drop-thru or side entry. Different wear protections are available such as hard chrome or ceramic plating on the inner housing surfaces. Grease and air purge fittings are often provided to prevent contaminants from entering the packing seals.

Rotary airlock feeders have wide application in industry

B. Balamurali, Mechanical Department, SNS College of Engineering.
B. Ashvin, Mechanical Department, SNS College of Engineering. E-mail:ashvinae@gmail.com
N. Gowtham, Mechanical Department, SNS College of Engineering. E-mail:gowtham051196@gmail.com
B. Jagan, Mechanical Department, SNS College of Engineering.
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wherever dry free-flowing powders, granules, crystals, or pellets are used. Typical materials include: cement, ore, sugar, minerals, grains, plastics, dust, fly ash, flour, gypsum, lime, coffee, cereals, pharmaceuticals, etc.

Back Ground of the Problem

The machine works for 18hrs a day and within 4 to 5 months of (2050hrs to 3000hrs) working the gears inside the carry plate speed reduction gearbox gets worn-out or breakdown due to improper or not suitable gearbox, so the carry plate connected to gearbox is getting slag and surface finish of the component is rough.

The load applied is higher than the capacity of the gearbox so the heat produced is high and material inside gets worn-out faster, and while maintenance the production is affected and due to that about 28hrs of production is affected.

There was a complain that output component must be again surface finished in next processor for proper sealing of oil, in surface finish 30micron of surface material must be removed for proper sealing.

This was reported to maintenance team and they had many projects so they were unable to focus on this problem, so they were replacing the broken component and started the production, for each breakdown there was expense about 30thousand to 35 thousand.

When we pointed this problem and approached the maintenance team for solution, this problem was given as a project so that they can find a solution and we can also get some knowledge about it.

II. Components

Carry Plate

ARF is a variable speed rotary feeder for bulk materials that works in harmony with the natural flow of the material being fed. The ARF, using a rotating member and articulable gate, controls the volume of material flow based on the material's inherent angle of repose. The speed of rotation and the positioning of the articulable gate provides a consistent feed of your material.

Carry Plate Drive Shaft

A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it.

29 Tooth Worm Gear

CuAl10Fe3 Mn2 DIN 17665 / 17672, relatively hard anti-friction materials for high loads and relatively low rotational speeds.

20 Tooth Worm Gear

Cu Sn 12 Ni DIN 1705, relatively soft material with very high wear resistance: suitable for very high sliding speeds

III. CAD Model

Existing Setup

Specifications

1. Big gear OD : 127mm
2. Gig gear ID: 60mm
3. Tooth depth: 8mm
4. Small gear OD: 80mm
5. Small gear ID: 40mm
6. Pitch: 11mm
7. Material: aluminum bronze
8. Worm screw Big gear side : 2 start
9. Worm screw Small gear side: 1 start
10. Input: 450rpm
11. Output: 1.5rpm

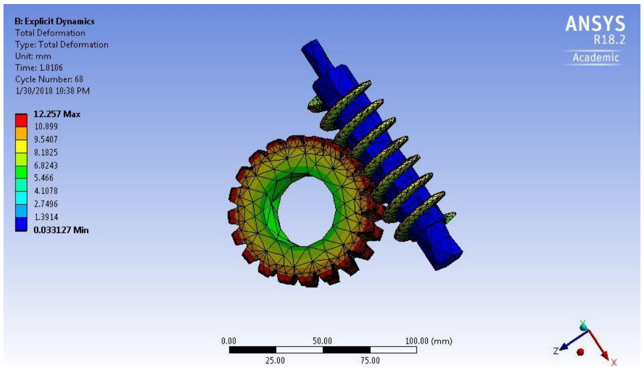
IV. Analysis

This is the gear arrangement inside the gearbox of a carry plate drive. Here 29 tooth worm gear is connected to carry plate drive which is driven by 20 tooth worm gear driven by motor.

To transmit 1500Nm of torque this setup is used but this gear can handle only up to 1300Nm of torque. So there is deflection in the gear and they cannot handle the torque of it.

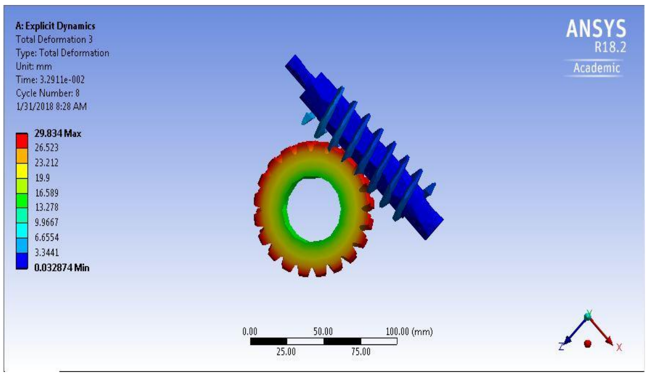
Deflection

So here color represents the deflection in the gear



Due to excessive torque the gears get heated and material is removed from the worm gear. This gear ratio can transmit about 270Kn of torque but due to grinding procedure here **358Kn** of torque is applied to the carry plate so the load is transmitted to the gears.

Due to worm gear the material used is **C954 aluminum bronze.** It has tensile strength about **500Kn** and yield strength about **200Kn** at .5% exerted load condition.



The material and gear ratio looks good but life of the gear for working hours of 18hrs out of 24hrs it withstands only about 90 to 100 days **300 minutes** of breakdown period, machine capacity is about 400nos/hr, so when there is break down there is lot of losses to the production. While applying load and passing through analysis there is a failure detected.

So with the collected data and calculated values the gear fails in the analysis. The deflection is about 29.88m of max so there is wear and tear is happening in the system.

Calculation

STEP-1: Selection of Material
Worm – Steel
Wheel – Bronze (sand cast), selected from Table PSG. 8.5

STEP-2: Calculation of Initial Design Torque

[Mt]=Mt x K x Kd.
Initially, Assume K x Kd = 1.
Mt=60 x p / 2ΠN.
Mt= (60 x 1.5 x 10^3 / 2πN2) = 596.83 N-m

K.Kd = 1

[Mt]= 596.83 N-m

STEP-3: Selection of Z_1&Z_2.

Select Z1, η desired = 80%,, Z1 = 3 PSG. 8.46
Z_2 = i x Z_1.= 10 x 3 = 30

STEP-4: Selection of [σb] & [σc] PSG.8.45
For bronze wheel бu < 390 N / mm^2, [бb]= 50 N/ mm^2 is selected in one rotation in one direction

[бc]= 159 N / mm^2 is selected

STEP-5: Calculation of Centre Distance PSG.8.44

a = [(z/q)|+1] x 3√[540/(Z/q) x [σc]]2 x [Mt] / 10

a = [(30/11)|+1] x 3√[540/(30/11) x [σc]]2 x [596.83x 10^3] / 10

a = 168.6 mm

STEP-6: Calculation of Axial Module PSG.8.43
m= 2a / (q+z)
m= 2168.6/ (11+30) = 8.22 mm

STEP-7: Calculation of Revised Centre Distance PSG.8.43
a=0.5m (q+Z_2)

a=0.5x 10 (11+30) = 205 mm

STEP-8: Calculation of d, v, γ, Vs.
d = q x m
d 1= q x m= 11 x 10 = 110 mm

d 2= Z2 x m= 30 x 10 = 300 mm

v_1 = πdn $_1$/ 60= 1.382 m / s
v_2= πdn $_2$/60= 0.377 m / s

γ = tan^{-1} {Z/q} = 15.25 °
Vs = v/cos γ = 1.432 m/s

STEP-9: Recalculation of Design Contact Stress Using Vs.
For vs = 1.432 m /s , [бc] = 172 N/ mm^2 PSG.8.45

STEP-10: Revise K, d, Mt Values.

[Mt]=Mt x K x Kd.
= 596.83 x 1 x1 = 596.83 N-m

STEP-11: CHECK FOR BENDING STRESS PSG.8.44

[σb] = 1.9[Mt] / m3 x q x z x y

[σb] = 1.9 x 596.863 x 10^3 / 10^3 x 11 x 30 x 0.432

= 7.6 N / mm^2

STEP-12: Check for Wear σc

Бc = 540 / (Z2/q) √((Z2/ q) +1) / a $)^3$ x (Mt / 10)

= 118.59 N / mm^2

STEP-13: Check for Efficiency
η=0.95 x tan γ/tan (γ+ρ)
ρ=TAN-1(μ) = 2.862 °
η=0.95 x tan γ/tan (γ+ρ) = 80%

STEP-14: Calculation of Cooling Area Required
(1-η) x INPUT POWER = Kt x A (to-ta)

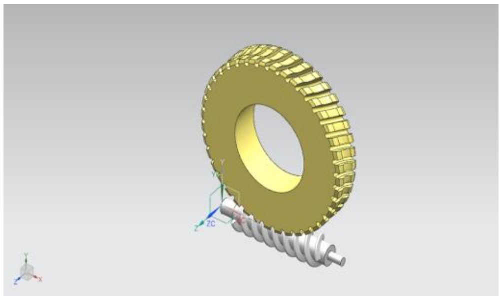
` (1 – 0.8) x 1.5 x 10^3 = 10 x A x 45°
= 0.666 m^2

STEP-15: Calculation of Basic Dimensions PSG.8.43
Axial module = Mx = 10 mm
Number of starts = Z1 = 3
Number of teeth = Z2 = 30
Length of worm 152 mm (L≥ (12.5 + 0.09 x Z2) mx = 152 mm
Center distance = a = 205 mm
Height factor = 1

V. New Design

After considering the torque applied to the gearbox, new design should withstand high shock load and torque. So the gears are beefed-up made with same CuAl10Fe3 Mn2 DIN 17665 / 17672 aluminum bronze.

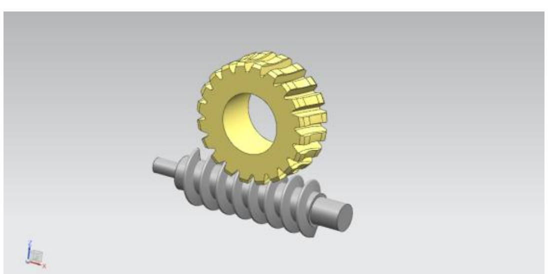
The module has been increased from 4 to 5, so the diameter and no of tooth are increased. The new gears can withstand about 3200Nm of torque and also its heat dissipating capacity has increased.



Worm gears are made of aluminum bronze so they cannot be replaced without research and development. But the specification of the gears and cooling of the gearbox can be changed for bettering the performance.

Self-locking is affected by the lead angle, the roughness of the flanks, the sliding speed, the lubricant and increases in temperature. Self-locking can be dynamic or static. Dynamic self-locking: lead angle up to 3° with grease lubricant; lead angle up to 2.5° with synthetic oil lubricants. Static self-locking: lead angle from 3° to 5° with grease lubricant; lead angle from 2.5° to 4.5° with synthetic oil lubricants. No self-locking facility is available for lead angles over 4.5° or 5°.

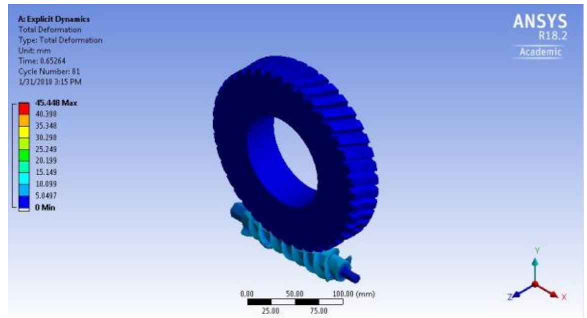
Jarring and vibration can prevent gears from self-locking. Self-locking can also be adversely affected if sliding conditions are particularly good. This can be caused by a number of factors relating to the lubricant, sliding speed and loading. For this reason we are unable to assume any warranty obligations for self-locking.



Specification

1. Big gear OD: 210mm
2. Big gear module: 5
3. Big gear tooth: 40
4. Gear width: 40mm
5. Small gear OD: 110mm
6. Small gear module: 5
7. Small gear tooth: 22

Gear width: 40mm



VI. RESULT

There are several standard gearbox for this kind of speed reduction application where it has a ratio of **623** and torque about **3000Kn** rated so they will suite the application.

The suggested gearbox is "**VARVEL 2 STAGE WORM GEARBOX- RA SERIES"**

Input data		
System of measurement		Metric
Input type		Input shaft
Input speed	[rpm]	1400
Output speed	[rpm]	2.25
Ratio (i=)		623
Requested input power	[kW]	0.85
Service factor		1
Rated Power P1	[kW]	0.85
Output data		
Gear unit		**_ RA 100/150 PC 12 623 AC 55 B3**
Type		RA - Worm speed reducers
Input type		_
Size		100/150
Ratio (i=)		623
Gearbox ratio		100.00
Pre-stage ratio		6.23
Mounting position		B3
Input speed	[rpm]	1400
Output speed	[rpm]	2.25
Nom. output torque (sf = 1)	[Nm]	1700
Service Factor		1
Efficiency		0.47
Gear unit configuration		
Output shaft		Hollow output shaft
Fixing		Shaft mounting
Version		PC
Attachment position		12
Output radial and axial loads		
Ball bearings output radial load	[N]	15000
Taper bearings output radial load	[N]	19500
Ball bearings output axial load	[N]	3000
Taper bearings output axial load	[N]	3900
Accessories		
Hollow output shaft		AC 55

With the same specification there is a standardized gearbox available in the market so we have check it with 3D model and analysis was safe, the worm double gearbox can transmit up to **3200Kn** of torque so this will be safer to use

VII. CONCLUSION

Existing design of gearbox is not suitable for the application so maintenance and production cost is increased so while changing the setup for preferred rated there will be no breakage.

So here we conclude that going for a standardized gearbox so that maintenance and replaceable will be easier in case any damage occurs

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