PARAMETERIZATION OF DRIVE WHEEL ASSEMBLY OF AN APRON CONVEYOR USING PRO/PROGRAM

A PROJECT REPORT P-2229

Submitted By

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KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE – 641 006

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Bonafide Certificate

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**Parameterization of Drive Wheel Assembly of an Apron Conveyor using Pro/PROGRAM**" is the bonafide work of

Mr. B. N. Sreeharan - Register No. 71206402011

who carried out the project work under my supervision.

Signature of the HOD **Signature of the Supervisor**

6/6/2008

Internal Examiner **External Examiner**

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. B. N. Sreeharan** 2nd year M. E. (CAD/CAM) student of Kumaraguru College of Technology, Coimbatore – 641 006 has done his project on **"Parameterization of Drive Wheel Assembly of an Apron Conveyor using PRO/PROGRAM"** under the guidance of our organization during the period from July 2007 to February 2008.

He has taken sincere efforts and shown keen interest in completing the above project successfully. His conduct and character were found good throughout the tenure of the project. We wish him all success in his entire future endeavour.

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This is to certify that Mr/Ms/Mrs B. N. SREEHARAN has participated and presented a paper titled Program based parametric modeling using composite part concept in the 2nd National Conference on "ADVANCES IN MECHANICAL SCIENCES" during 27- 28, March 2008.

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Abstract

ABSTRACT

In order to gain competitive advantage in global market it is necessary to reduce the manufacturing lead time for every product. It is important to the industries to introduce into the market as quickly as possible the new product or new models of existing products. Otherwise competitors will be able to control the market through getting their products out faster.

To attain the above said there is a potential for time saving in the design process. In modeling process, the design can be automated by using parametric modeling technique.

This project work throws an insight towards the parameterization of drive wheel assembly of an Apron Conveyor using Pro/PROGRAM, a tool in Pro/ENGINEER Wildfire 3.0 software using parametric modeling technique. This work was intended to reduce the overall modeling time of the assembly. An attempt was also made to eliminate a part, the drive shaft, by modeling the same automatically. This project work was sponsored by M/s. Tractor Engineers Limited (TENGL), A Group of Larsen & Toubro Limited, Mumbai.

This parameterization technique is used for the different configurations for the possible specifications of the drive wheel assembly. Each specification of the assembly has its own modeling approach with all the geometrical parameters. This can be pre-defined at the design level itself. This ensures that the required specification can be loaded very quickly, without the need to remodel. This makes useful in reducing the modeling time of assembly, making modeling procedure simple and easy and increasing the accuracy and reducing the overall manufacturing lead time which inturn will increase the productivity and profit.

This project work was done in the following sequence.

- Initially data related to the drive wheel assembly were collected and tabulated.
- Modeling of the parts and subassemblies were carried out by parametric modeling technique using family table approach with relations.
- A Program has been developed for parameterization. This was done in three stages. First stage was the creation of planes for the assembly of the components. Second stage was the assembly of components over their respective planes. Final stage was the creation of drive shaft features automatically based on the relations involved with them. This eliminates separate component of drive shaft to be assembled.
- Moreover a drawing program also been developed to switch to the required dimension that has to be shown in the drawing sheet with respect to the types of assembly.

From these developed programs, the system is able to output assembly model of the drive wheel assembly with well reduced overall assembly time and time required to release of drawings. The modeling process is significantly simplified by reducing the number of the modeling steps thereby reducing modeling errors resulting in enhanced quality of the modeling process. The end user need not have designing skills or knowledge of using CAD systems. The complexity of the modeling is hidden from the user.

ஆய்வு சுருக்கம்

தற்பொழுதுள்ள உலகச்சந்தையில், தொழில் நிறுவனங்கள் தங்கள் நிலையை நிலைநாட்டிக் கொள்வதுடன் உயரச் செய்வதற்கு, உற்பத்தி நேரத்தை குறைப்பது இன்றியமையாததாகும். முக்கியமாக நிறுவனங்கள் தங்களுடைய புதிய ரகங்களை மற்றும் ஏற்கனவே உள்ள பொருள்களின் புதிய மாதிரிகளை, வெகு துரிதமாக சந்தையில் அறிமுகப்படுத்த வேண்டும். அவ்வாறு இல்லையெனில் போட்டியாளர்கள் விரைவாக சந்தையை தங்கள் கட்டுபாட்டில் கொண்டு வந்து விடுவார்கள்.

மேலே குறிப்பிட்டபடி அந்நிலையை அடைவதற்கு, வடிவமைத்தல் நிலையிலேயே காலத்தை சேமிக்கலாம். படிமமாக்கல் நிலையில், வடிவமைத்தலை "அளபுரு படிமமாக்கல் நுணுக்கமுறை" உதவியுடன் தானியங்க செய்யலாம்.

இந்த திட்ட பணி, ஒரு அப்ரான் கன்வேயரின் (ஒரு வகையான பொருள்கள் கையாளும் சாதனம்), இயக்கு சக்கரம் தொகுப்பை, புரோ/இஞ்னியர் வைல்டு பையர் 3.0 என்னும் மென்பொருள் உதவியுடன் அளபுரு படிமமாக்கல் நுணுக்கமுறையில் அளபுருமாக்குவதை விளக்குகிறது. இப்பணி, ஒட்டுமொத்த இயக்கு சக்கரத் தொகுப்பை உண்டாக்குவதற்காண நேரத்தை குறைக்கிறது. மேலும், இயக்கு சக்கரத் தொகுப்பில் உள்ள 'இயக்கு தண்டம்' என்ற ஒரு உறுப்பை, தானியங்கி முறையில் படிமமாக்கி, அவ்வுறுப்பை தனியே படிமமாக்குதல் முறையிலிருந்து குறைக்கிறது. இத்திட்ட பணியை திறன்பட முடிப்பதற்கு M/s. டென்கல், மும்பை, லார்சன் & டியூபுரோவின் நிறுவன அங்கம், ஆதரவளித்தது.

இந்த அளபுரு படிமமாக்கல் நுணுக்கமுறை, இயக்கு சக்கரம் தொகுப்பின் பல்வேறு ரகத்தை அளபருமாக்குகிறது. தொகுப்பில் உள்ள ஒவ்வொரு ரகமும் அதற்கு உண்டான படிமமாக்கல் முறையை கொண்டுள்ளது. இது வடிவமைத்தலின் முதல்நிலையிலேயே வரையறுத்து கொள்ளபடுகிறது. இம்முறையால் வேண்டும் தொகுப்பை மட்டும், விரைவாக படிமமாக்கி கொள்ளலாம். இதன் மூலம் எல்லாவற்றையும் மறுபடியும் மாற்றியமைத்தல் தவிர்க்கப்படுகிறது. இதனால் படிமமாக்கும் காலம் குறைந்து எளிதான வழிமுறையில் மிகவும் செம்மையாக படிமமாக்க முடிகிறது. மேலும் உற்பத்தி நேரத்தை குறைத்து, உற்பத்தி திறனை அதிகரித்து லாபத்தை கூட்டவும் உதவுகிறது.

இத்திட்டப்பணி பின்வருமாறு செயல்முறை படுத்தப்படுகின்றது.

- *முதலில் இயக்கு சக்கரம் தொகுப்புகளின் தரவுகள் திரட்டப்பட்டு, தொகுத்து அட்டவணை படுத்தப்படுகின்றது.*

- *பின்பு தேவைப்படும் உறுப்புகள் மற்றும் துணை தொகுப்புகள் அளபுரு படிமமாக்கல் நுணுக்கமுறை உதவியுடன் குடும்ப அட்டவணை மற்றும் தொடர்புகள் மூலமாக படிமமாக்கப்படுகின்றது.*

- *அதன் பின்பு ஒரு நிரல் உருவாக்கப்படுகிறது. இந்நிரல் மூன்று நிலைகளில் உருவாக்கப்படுகிறது. முதல் நிலையில் தொகுப்புகளில் உறுப்புகள் மற்றும் துணை தொகுப்புகள் தொகுக்க தேவைப்படும் தளங்கள் கட்டுப்படுத்தப்படுகிறது. இரண்டாவது நிலையில் உறுப்புகள் மற்றும் துணை தொகுப்புகள் அவைகளுக்குரிய இடத்தில் தொகுக்கப்படுகிறது. இறுதி நிலையில் தானியங்கி முறையில், இயக்கு தண்டம், தொடர்புகள் மூலம் படிமமாக்கப்படுகிறது. இதனால் இயக்கு தண்டம் என்ற உறுப்பு தனியே படிமமாக்கபடும் நிலை தவிர்க்கபடுகிறது.*

- *மேலும் வரைதல் நிரலும் உருவாக்கப்படுகின்றது. அந்நிரல் தேவைப்படும் இயக்கு சக்கரம் தொகுப்பின் ரகத்தை பொருத்து அதன் பரிமாணத்தை, வரைதல் தாளில் காட்ட உதவுகிறது.*

அறுதியாக, உருவாக்கபட்ட இந்நிரல் உதவியுடன், தேவைப்படும் இயக்கு சக்கரம் தொகுப்பினை விரைவாக மற்றும் செம்மையாக உருவாக்க முடிகின்றது. இதனால் இவைகளை உருவாக்க தேவைப்படுகின்ற நேரமும் மற்றும் வரைதல் தாள்களை வெளியிடப்படும் கால அவகாசமும் குறைக்கப்படுகின்றது. மேலும் இந்நிரலால் படிமமாக்கும் செயல்முறை எளிதாக அமைந்து படிமமாக்கும் பிழைகள் குறைக்கப்படுகிறது அல்லது தவிர்க்கப்படுகிறது. இதனால் இறுதி பயனர்களுக்கு வடிவமைத்தல் திறனும் மற்றும் கணினி வழி வடிவமைத்தல் பற்றிய அறிவும் தேவைப்படும் நிலை தவிர்க்கப்படுகின்றது. மேலும் படிமமாக்கும் கடினமும் அவர்களிடம் இருந்து மறைக்கப்படுகின்றது.

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Contents

CONTENTS

Title			Page No.
		6.7.6 MASS PROP	41
	6.8	Assembly Program	41
		6.8.1 Inputs	42
		6.8.2 First Stage	42
		6.8.3 Second Stage	45
		6.8.4 Final Stage	45
	6.9	Conclusion	53
		6.9.1 Axioms and guidelines adopted for design parameterization	53
Chapter 7	Conclusions		56
Appendices			59
References			63

List of Tables

LIST OF TABLES

List of Figures

LIST OF FIGURES

List of Abbreviations

LIST OF ABBREVIATIONS

Abbreviation	Definition
LBA	Left Bearing Assembly
RBA	Right Bearing Assembly
LSA	Left Sprocket Assembly
RSA	Right Sprocket Assembly
LSHE	Left Shaft End
RSHE	Right Shaft End
BGA	Bull Gear Assembly
GGA	Gear Guard Assembly
BLL	Bearing Length Left
BLR	Bearing Length Right
BGL	Bull Gear Length
PEL	Plate End Left
PER	Plate End Right
SLR	Sprocket Length Right
SLL	Sprocket Length Left
DD	Direct Drive
OP	Open Pair

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Now-a-days, the time-to-market for the products is becoming shorter, the lead time available for making the product is decreasing, it is very much necessary to gain and maintain a competitive advantage. For the same, firms have to introduce new product or new models of existing products as quickly as possible. As time to market is a very important aspect, if it takes too long to model a product then it will be hinder through competition. Competitors will be able to control the market through getting their products out faster.

There are also pressures forced by increasing global competition, developing technologies, firms have to change to survive. Additional pressures owe to costs, availability of people and skills, competitors' actions and market conditions. Goals of firms have to be reassessed and to be renovated. Firms have to introduce new product as soon as possible with better performance and right combination of cost and quality. There is the burden to short both development and production times of the product in required quality and with costs minimization. Products must be developed and manufactured fast so they get to market ahead of the competition.

Learning and creating new methods and methodologies for computers to provide more aid to the designer is a goal worth hundreds of millions of dollars to the world economy. The goal is to automate the product development process within the mechanical CAD/CAM environment as cited by Abdel-Malek (1999).

1.2 IDENTIFIED PROBLEM AND ITS IMPORTANCE

In order to achieve the above said objectives there is a potential for time saving in the design stage because a modeling process that is repeatable for every design can be captured and standardized. This can be realized by parameterization using parametric modeling technique.

This technique can be used for the different configurations for the possible specifications of the assembly. Each specification of the assembly has its own modeling approach with all the geometrical parameters. This can be pre-defined at the design level itself. This ensures that the required specification can be loaded very quickly, without the need to remodel. This reduces the modeling time of assembly, making modeling procedure simple and easy and increasing the accuracy and reducing the overall manufacturing lead time which intum will increase the productivity and profit.

1.3 SCOPE OF THE PROJECT

This project work throws an insight towards this approach by parameterization of a drive wheel assembly of an Apron Conveyor using Pro/PROGRAM, a tool in Pro/ENGINEER Wildfire 3.0 software by controlling the geometrical parameters, using parametric modeling technique. This work is intended to reduce the overall modeling time of an assembly there by reducing the manufacturing lead time and also with more increased accuracy. It also made an attempt to eliminate a part, the drive shaft, by modeling the same automatically. This project work is sponsored by M/s. Tractor Engineers Limited (TENGL), A Group of Larsen & Toubro Limited, Mumbai.

1.4 OUTLINE OF THE PROJECT REPORT

This project report is organized into following eight chapters which describes the purpose of the project.

Chapter 1: Introduction
Chapter 2: Details of the organization
Chapter 3: Problem chosen for the study
Chapter 4: Literature survey

Chapter 5: Data collection

Chapter 6: Methodology

Chapter 7: Conclusions

Chapter 1 presents the introduction of this project work with describing about the problem identified and its importance, scope of the project work.

Chapter 2 highlights the organization, infrastructural facilities, research activities carried out, etc. where the project was carried out.

Chapter 3 states the problem chosen for this project work. It describes the nature of problem giving the details of present situation of the problem and the technique to be adopted to solve the problem.

Chapter 4 reveals the relevant work done earlier related to the problem identified and the approach adopted to solve the problem. It gives the description of literature reviewed from various research papers published in international and national journals, proceedings of various conferences, etc.

Chapter 5 explains about collected data relevant to this project work.

Chapter 6 presents the methodology adopted to solve the identified problem such as design standardization, parameterization, relation building, etc are detailed in this chapter. Data identified, the method applied, technique utilized, way it has been approached, etc. are explained in this chapter.

Chapter 7 presents the results obtained from this project work viz., the expected benefits and concludes the project with the advantages and also the scope for further work in the field, where the project was carried out.

Chapter 2

Details of the Organization

CHAPTER 2

DETAILS OF THE ORGANIZATION

2.1 INTRODUCTION

This project work was carried out at M/s. Tractor Engineers Limited (TENGL), Mumbai. It is a wholly owned subsidiary of Larsen & Toubro Limited, technology-driven engineering and construction organization was established in 1963.

TENGL was established as a joint venture between Caterpillar Inc U.S.A. and Larsen & Toubro Limited, Mumbai. Both Caterpillar and L & T had equal (50% each) shareholding in TENGL. It started manufacturing at Powai in a new factory in 1965 and initially made spares for CAT Machines (primarily DOZERS) in India and sold them through CAT Dealers in India. Now it is a wholly owned subsidiary of L & T. In 1969, it started supplying undercarriage to BEML. In 1970's it made Battle Tank Pins for HVF Avadi. It started tracking undercarriage for Hydraulic Excavators of Poclain design in 1974.

TENGL has the experience and expertise to track any equipment that crawls. For over four decades, TENGL has established a professional identity as a dependable source of products, services and parts. Whether it is for earthmoving, construction, road building, material handling or any other industrial requirement, TENGL has the know-how to address specific needs.

2.2 INFRASTRUCTURE

TENGL manufactures at its modern factory at Powai, Mumbai. The Company has a second manufacturing facility located around 150 km from Mumbai. A fully integrated ERP system SAP R-3 supports and interfaces all processes. The manufacturing set up has a high level of automation, with modern in process gauging along with single piece flow concept. TENGL continues to make a major investment in upgrading its manufacturing base and R & D facilities as part of its enduring commitment to customer needs.

A specialized Technology Centre carries out design validation through field testing of parts. This involves deployment of state-of-the-art and high-end instrumentation like strain gauges, load cells, computerized load measurement methods, etc. Sophisticated control systems for dimensional and micro-structural inspection characterize the manufacturing process and ensure reliable and consistent product quality. A parts quality verification program entails component testing till destruction. Actual failure results are compared with theoretically expected failure zones arrived at by stress analysis technique employing FEA. New generation image analysis software provides a micro-structural analysis of destroyed parts.

TENGL's modern manufacturing facilities are equipped with advanced manufacturing techniques like single flow system, and online inspection checks. Metallurgy and heat treatment processes ensure high quality of parts. The factory also has a fully equipped prototype shop, where design and manufacturing process concepts are tested and proven. This manufacturing set-up has a high level of automation, integrated with modern in-process gauging along with single piece flow concept. Special heat treat processes ensure consistency and good hardened depth with a strong core for excellent component performance, durability and long life.

TENGL components are engineered to work as a system and manufactured to last. Surface hardness in TENGL parts is precisely matched for dependability. Product excellence is maintained by exercising strict quality control in its manufacturing activity. TENGL puts the best parts together to give you a complete picture of undercarriage efficiency.

2.3 IT INFRASTRUCTURE

As a global player, the world-class products and track solutions of TENGL are supported by equally effective and efficient connectivity for customers. Anywhere, anytime communication with global web mails keeps

TENGL always connected to customers. TENGL business processes are fully integrated with state-of-the-art SAP R3 ERP system, which ensures business efficiency and enhances customer satisfaction. The Company's website, www.tenglindia.com is a convenient access point for e-commerce activities. It disseminates comprehensive information on various facets of products, services and capabilities for complete track system solutions. TENGL IT infrastructure is on the global path with fibre-optic gateway for high speed success.

2.4 LEADING CUSTOMERS

Some of the leading customers of TENGL are as follows:

- TELCO Construction Equipment Co. Ltd, Jamshedpur
- Ingersoll-Rand India Ltd, Bangalore
- Revathi Equipment Ltd, Coimbatore
- Bharat Earthmovers Ltd, Kolar Gold Fields, Karnataka
- Chennai Port Trust, Chennai
- TISCO, Sukhinda & Jamshedpur
- Kolkata Port Trust, Kolkata
- Great Eastern Shipping Co., Mumbai
- Cement Corporation of India, New Delhi
- J K Cement, Rajasathan
- Birla Cement Works, Rajasthan
- Dalmia Cement, Bangalore

Chapter 3

Problem chosen for the study

CHAPTER 3

PROBLEM CHOSEN FOR THE STUDY

3.1 INTRODUCTION

As it has been discussed earlier, in this competitive world today, where nothing but change is constant, it is very much necessary to gain and maintain a competitive advantage. For the same, firms have to introduce new product or new models of existing products as quickly as possible.

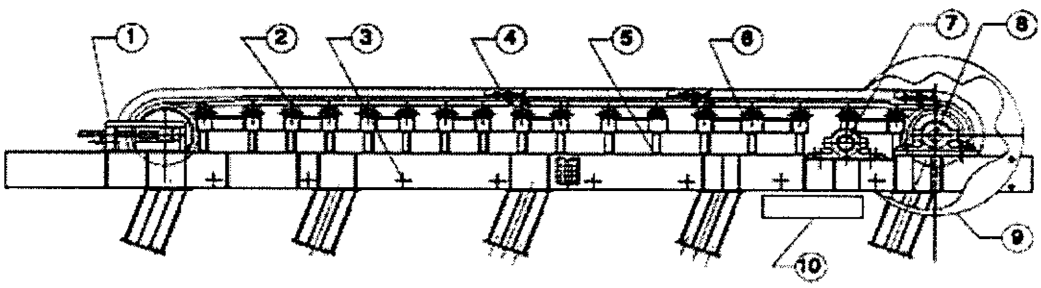
The same concept is applied to M/s. TENGL also. It is required to deliver the product to the customers at the earliest with greater quality. And also it was identified that the Apron Conveyor, a material handling equipment, which is mainly used in mining operations which when while installing in customer base its specification changes eventually. Depending upon the required specification, every time it is required to redesign the equipment for which modeling and assembly has to be done repeatedly. In order to facilitate the process it is decided to parameterize the design process so that the manufacturing time can be reduced with greater increase in quality.

Modeling process that is repeatable for every design can be captured and parametric modeling can be used to model the new design so that there will considerable time saving in the design stage itself. For achieving this there are many techniques that have been employed. Parametric modeling is among them. In addition, there is an increasing trend towards achieving a higher level of integration between the design and manufacturing functions in a firm.

This work deals with assembly of a drive wheel assembly used in apron conveyor whose details are given below by controlling the geometrical parameters using parametric modeling technique, the parameterization.

3.2 APRON CONVEYOR

The Apron Conveyor, shown in figure 3.1 comprises a specially fabricated frame on which two heavy-duty endless link assemblies are wound. The apron flights of steel are bolted on the chains and are used for conveying the material. The link assemblies and the flights are supported and guided on top of the frame by deck rollers and are supported on the return side by return rollers. The drive arrangement comprises an electric motor and a gearbox connected to the countershaft of the Apron Conveyor which drives the drive shaft through a spur gear pair. The drive shaft has two sprocket assemblies, which mesh with the Link Assemblies and drive the Apron Conveyor. On the rear end of the Apron Conveyor is the tail wheel assembly for guiding the link assemblies.



Assembly No.	Description
1	Tail Wheel Assembly
2, 6	Deck Roller Assembly
3	Return Roller GP. With Bracket
4	Deck Assembly
5	Main Frame Assembly
7	Counter Shaft Assembly
8	**Drive Wheel Assembly**
9	Gear Guard Assembly
10	Drive Frame Assembly

Figure 3.1 Sub-assemblies of Apron Conveyor

3.3 Drive Wheel Assembly

The Drive Wheel Assembly which is of two types, the open type and direct type as shown in figures 3.2 to 3.5 consists of Sprocket Assemblies mounted on Drive Shaft, which runs in Spherical Roller Bearings at two ends. Sprocket Assemblies are held by means of Locking Assemblies, which sustain radial, torsional and axial loads. Bearings are located in Plummer Block Assemblies, which are bolted to the Conveyor Main Frame Assembly. Plummer Block Assemblies are sealed by dual Seal Group comprising an inner Lip Seal and an outer Labyrinth Seal. Bull Gear is keyed to the Shaft and locked via End Plate and hardwares.

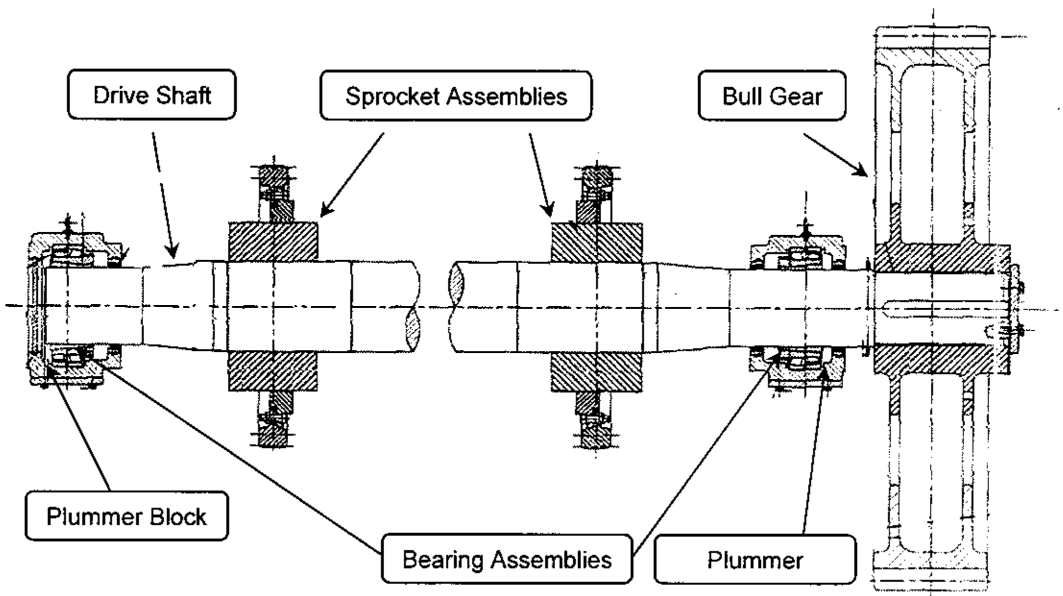
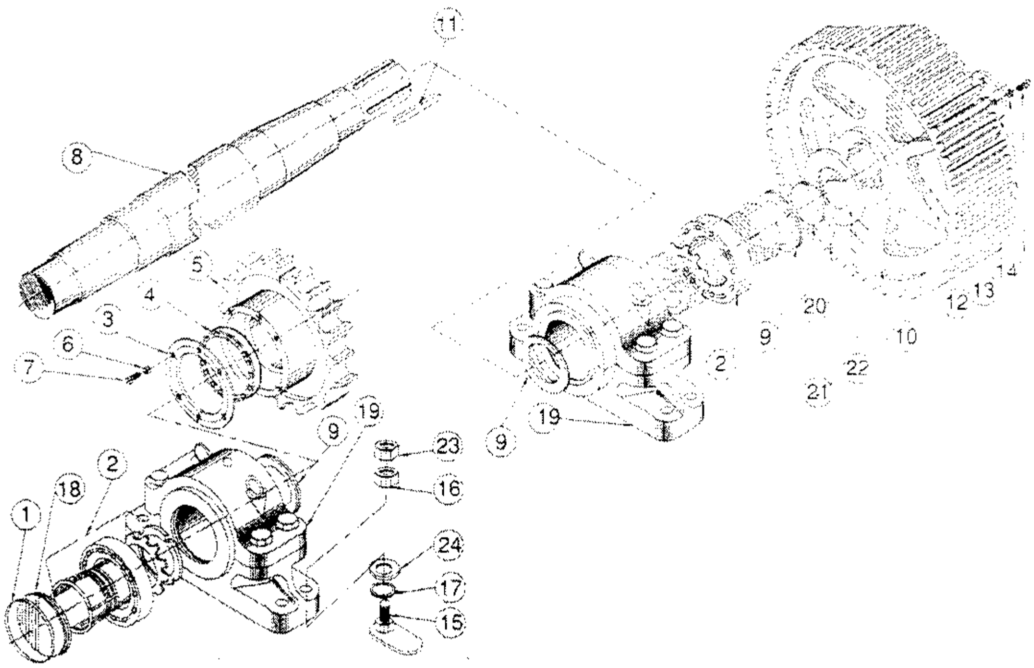


Figure 3.2 Open type Drive Wheel Assembly

The exploded view of open type drive wheel assembly is shown in the figure 3.3 along with all the accessories.



Part No.	Description	Part No.	Description	Part No.	Description
1	Seal O Ring	9	Seal Group	17	Lock Washer
2	BRG S. R. + AD. Sleeve	10	Bull Gear	18	Cover
3	Plate Cover	11	Key	19	Plummer Block Assembly
4	Locking Assembly	12	Bolt – Hex	20	Felt Strip
5	Sprocket Assembly	13	Lock Washer	21	Dowel Pin
6	Lock Washer	14	Plate End	22	Collar (Gear Guard)
7	Screw – Hex	15	Bolt - Hex	23	Lock Nut - Hex
8	Drive Shaft	16	Nut - Hex	24	Washer Machined

Figure 3.3 Exploded view of Open type Drive Wheel Assembly

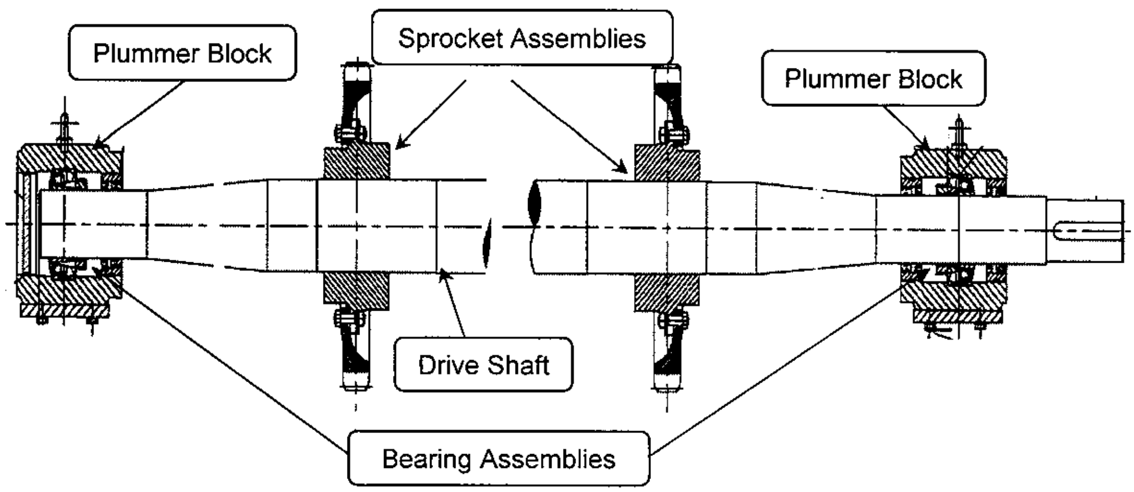
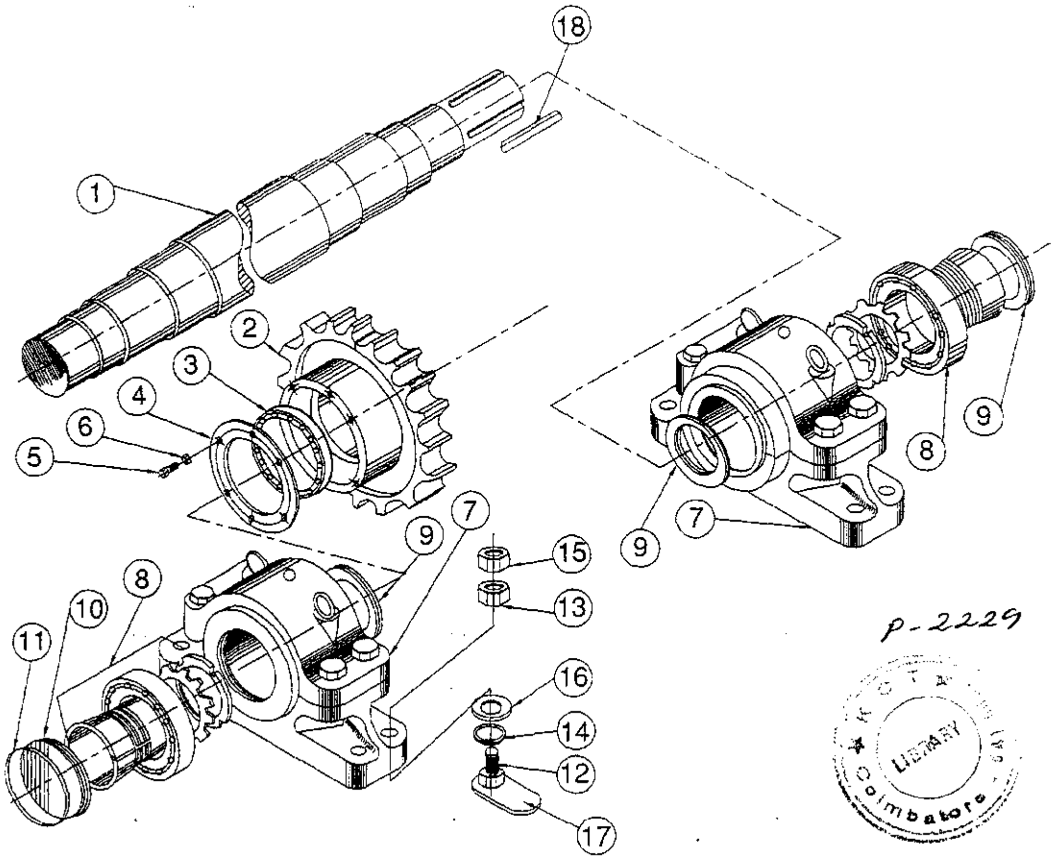


Figure 3.4 Direct type Drive Wheel Assembly

The exploded view of direct type drive wheel assembly is shown in the following figure 3.5 along with all the accessories.



Part No.	Description	Part No.	Description	Part No.	Description
1	Drive Shaft	7	Plummer Block	13	Nut - Hex
2	Sprocket Assembly	8	BRG S. R. + AD. Sleeve	14	Locknut Washer
3	Locking Assembly	9	Seal Group	15	Locknut - Hex
4	Plate Cover	10	Cover	16	Washer Machined
5	Screw Hex	11	Seal O Ring	17	Strip Lock
6	Lock Washer	12	Bolt - Hex	18	Key

Figure 3.5 Exploded view of Direct type Drive Wheel Assembly

The parametric modeling technique based parameterization used in this project work will be very much handy in reducing the modeling time of the assembly, making modeling procedure simple and easy and increasing the accuracy and reducing the overall manufacturing lead time which inturn will increase the productivity and profit.

Chapter 4

Literature Review

CHAPTER 4

LITERATURE REVIEW

Following are the overview of the relevant work done earlier related to the identified problem and the methodology to be adopted to solve the chosen problem for this work. This section describes the literature reviewed from various research papers published in journals, conference proceedings and books.

Kun-Hur Chen et al. (1998) from their research contributed the followings (1) the feature converter automates the design critique processes between the CAD system and the proposed design critique expert system. This improved data integrity therefore significantly minimizes the documentation errors by the manual process.
(2) The early design critique module eliminates possible design mistakes that may happen in the downstream design activities. This will result in fewer costly design changes and thus reduce product development time and production cost. (3) Using ICEDMP, the designer is able to create, maintain, evaluate and improve the design work in one integrated software environment and increase the quality of the designing processes.

Abdel-Malek et al. (1999) shown that mechanical parts represented in a CAD environment could be modeled into a mechanism comprising joints and links. It was shown that the deformation of the solid sustained by introducing a design variation is computed using a kinematic model. It was also shown that design changes through the mechanism are propagated such that an admissible configuration is computed using an efficient iterative generalized inverse method. The emphasis on masking this formulation from the CAD user is highlighted because of the long-term ramifications implied herein. The use of the inherent mechanism kinematics in modeling and providing solutions to the design assembly and parameterization scheme are automated in nature.

Abdulhameed Arwani et al. (1999) provided a report giving the means of putting design procedures of certain structural elements in standard form. Its advance comes from that it can help in making the design process faster, easier, more accurate, and easy to be checked. It also used the spreadsheet programming to prepare the interactive spreadsheet files that facilitate the design procedure of the selected elements. In conclusion, they are recommended to be used as educational tools as they provide user friendly and interactive designs.

Abdel-Malek et al. (DETC99: 1999) presented a broadly applicable formulation for automating the redesign of mechanical parts in a concurrent engineering environment. The iterative process typically associated with mechanical design is reduced by the use of such automated methods. Mathematical formulations based on earlier work are further expanded in this paper and are demonstrated to the automated computer-aided design of mechanical parts in a CAD environment. The significance of this formulation is evidenced in that it characterizes an alternative efficient method to the common parametric methods currently used.

Edwin Hardee et al. (1999) presented the purpose of design parameterization is to characterize the changes in dimensions. These design variables are allowed to vary in the design process. This paper shows that variable dimensions may be used as the design variables for standardization of the design and the CAD model may be used directly in the developing the detailed design. No auxiliary geometric model or additional geometric information is necessary.

Alexander Inozemtsev et al. (2000) concluded that the implementation of parametric modeling in industrial and design enterprises will result in increasing the ability of computer graphics users to reduce redundant labor practices by the creation of interactive databases. Designers and production staff would have the luxury of being able to edit these databases rather than always having to redesign models required to meet current needs or updated specifications. The regeneration of parametric models allows reduced time in "art to part" production as well as providing a foundational database upon which future product development and revisions may rest.

Senyun Myung and Soonung Han (2001) proposed a system in paper that can parametrically change assemblies, whereas the commercial CAD systems can handle parts geometry. Parametric modeling of assemblies requires parts geometry. Parametric modeling of assemblies requires the reasoning process based on heuristic expert knowledge. The proposed system can reduce the time for design modifications. The parametric changes are based on the knowledge-base which contains constraints between parts. With the proposed system, the modified product model can be quickly obtained through the design reasoning process. The pilot system of intelligent CAD systems is illustrated with an experiment.

Jason Turk (2002) highlighted the basic concepts of using Pro/PROGRAM to manipulate and automate a model. Assembly techniques are not represented although the concept was similar.

Lin and Farahati (2003) presented a methodology for quantifying the blade assembly process which is a step towards future fully automated assembly planning. The proposed method was aimed at eliminating expensive and time-consuming physical prototyping by analyzing and evaluating the feasibility of the blade assembly using a CAD-based virtual prototyping technique. The model development word was implemented using Pro-Engineer. The modeling requirements, the design intents, pertinet parameters, and their relationships in the blade assembly process have been captured and integrated into the CAD model. The virtual prototyping model developed in this work has been tested and verified to be effective. The results of the experiments were proved to be satisfactory.

Vasiliki Stamati et al. (2005) introduced a novel CAD approach to designing handmade objects of complex and sophisticated craftsmanship. Also presented ByzantineCAD, a parametric system for the design of pierced Byzantine jewellery. ByzantineCAD is an automated parametric system where the design of a piece of, jewellery is expressed by a collection of parameters and constraints and the user's participation in the design process is through the definition, of the parameter values. This system provides the user with the capability of designing custom pierced jewellery in an easy-to-use and efficient manner, using a parametric feature-based design concept. The final piece of jewellery is produced by applying a sequence of operations on a number of elementary solids.

Alberto Jose and Michel Tollenaere (2005) provided a review of modular design methodologies. An analysis of the literature showed that the efficient design is the one that allows an easy upgrade to develop different products, as well as product life cycle savings. A methodology in this sense should be considered an efficient analysis of component parameters to satisfy each product family requirements. Such methodology should be linked the most important costs, the economic savings and the design choices.

Kim et al. (2006) proposed a method for generating a solid model and drawing using profile replacement technique. The common surface portions are modeled by changing some dimensions of the template model. The free-form surface portions are obtained by replacing the old profile curves of the template with new profiles. With the proposed approach, the associativity between the 3D model and the drawing can be maintained completely, so the drawing is created automatically. The proposed method has been implemented using a commercial CAD/CAM system, Unigraphics, and API functions written in C-language, and were applied to the blade of a steam turbine generator, shortened modeling time, and reduced the time for drawings.

Kuang-Hua Chang and Sung-Hwan Joo (2006) presented an open and integrated tool environment that enables engineers to effectively search, in a CAD solid model form, for a mechanism design with optimal kinematic and dynamic performance. In order to demonstrate the feasibility of such an environment, design parameterization that supports capturing design intents in product solid models was done, and advanced modeling, simulation, and optimization technologies implemented in engineering softwar tools were incorporated. In the proposed environment, Pro/ENGINEER and SolidWorks are supported for product model representation, In addition to the commercial tools, a number of software modules have been implemented to support the integration; e.g., interface modules for data retrieval, and model update modules for updating CAD and simulation models in accordance with design changes.

Chih-Hsing Chu et al. (2006) proposed a parametric design system that effectively enables 3D tire mold design with minimal user interactions. Groove shapes commonly used in the tire industry have been analyzed and classified into distinct types. The design parameters for each groove and its geometric modeling procedure with these parameters are also obtained. The results serve as a foundation for standardization of the 3D mold design process. The construction process of 3D groove surface based on 2D tire drawings is significantly simplified by reducing the number of the modeling steps, and potential user errors are thus prevented. The results have indicated several advantages of introducing the parametric design system. First, the complexity of the mold design is hidden from the user. Modeling errors are reduced due to fewer user interactions resulted from the automatic groove construction by the design table. As a result, the quality of the mold design is enhanced.

Ali Kamrani (2006) explained parametric design approach. In this approach, the designer will define a set of geometric constraints and engineering relationships that are used for creating the geometry of the object, and also establishing the associativities among the objects within the design itself. A set of expressions and variables are also used to define the dimension of the object. When the numerical quantities of parameters are changed, the characteristics of the features are also updated concurrently. Although it is considered to be a complex approach, it will provide the necessary flexibility and increased designer efficiency by creating a new design by altering existing models.

Bor-Tsuen Lin et al. (2007) presented an automated design system for drawing dies, which was built on top of CATIA CAD software. Upon receiving the initial design information from design engineers, the system is able to automatically generate the final design of main components of the die. Design formulae and geometric operations of modeling processes are generated by the system using the built-in modules of CATIA V5, such as Part Design, Automation and Scripting, and Knowledge Advisor. Experimental results show that the system has successfully reduced the design time from several working days to within one hour when designing a drawing die, which saves a great deal of development time and cost and achieves high product quality and design flexibility.

This project work deals with modeling a drive wheel assembly used in an apron conveyor by controlling the geometrical parameters using parametric modeling technique.

Chapter 5

Data Collection

CHAPTER 5

DATA COLLECTION

5.1 INTRODUCTION

The statistical data collected forms the basic raw material from which analysis is made, policies are formulated and conclusions are drawn. The value of analysis depends upon the care and accuracy with which the data is obtained. Utmost care must be exercised in the collection of data.

The following factors should be considered for the collection of data

- Objectives and scope of the study
- Statistical units to be used
- Sources of information
- Method of data collection and
- Degree of accuracy aimed at in the final results.

This chapter deals with collected data and relevant analysis made for the project work.

5.2 COLLECTED DATA

The data related to this project work, the parts that are being used to make up the drive wheel assembly have been collected and wherever possible it has been standardized.

It has been identified that for open type drive wheel assembly only two models are exists. They are.

- Model T – 23
- Model T – 50

Similarly for the direct type drive wheel assembly three models as follows exists.

- Model T – 13
- Model T – 23
- Model T – 50

Further, different configurations of drive wheel assembly for open type and direct type were collected based on the pan width used along with the bill of materials for each and every different configurations of drive wheel assembly and tabulated in table 5.1.

Table 5.1 Bill of Materials of Open type Drive Wheel Assembly for Model T – 23

Model T – 23						
Parts	Pan Width					
	1200			1400	1500	
	Type – 1	Type – 2	Type – 3	Type – 1	Type – 1	Type – 2
Conv. Drive Wheel Assembly	TB 0304	TB 0829	TB 3191	TB 2607	TB 1976	TB 2651
Conv. Drive Shaft	TB 0171	TB 0838	TB 0171	TA 9714	TB 1920	TB 2619
Sprocket Assembly	TB 0172	TB 0185	TB 0172	TA 8424	TA 8424	TA 8999
Locking Assembly	TA 3291	TA 3291	TA 3291	TA 3831	TA 3831	TA 4226
Plate Cover	TA 4640	TA 4640	TA 4640	TA 4438	TA 4438	TA 4898
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 4648	TA 6127	TA 4648	TA 4259	TA 4259	TA 6392
Spherical Roller Bearing	TA 4639	TA 1387	TA 4639	TA 3850	TA 3850	TA 6378
Seal Group	TA 4643	TA 4073	TA 4643	TA 4258	TA 4258	TA 6384
Cover	TA 4647	TA 4071	TA 4647	TA 3639	TA 3639	TA 4647
Seal O-ring	TA 3843	TA 4072	TA 3843	TA 3640	TA 3640	TA 3843
Bolt Hex	TA 4646	TA 3083	TA 0513	TA 2827	TA 2827	TA 0481
Nut Hex	TA 0515	TA 2252	TA 0515	TA 3841	TA 3841	TA 0515
Lock Washer	TA 0514	TA 0057	TA 0514	TA 0477	TA 0477	TA 0514
Lock Nut	TA 0516	TA 3546	TA 0516	TA 2633	TA 2633	TA 0516
Washer Machined	TA 4811	TA 4529	TA 4811	TA 1379	TA 1379	TA 4811
Strip Lock	TA 6371	---	---	TA 6286	TA 6286	TA 6371
Key	TA 4644	TA 4047	TA 4644	TA 3830	TA 3830	TA 6390
Bull Gear	TA 4554	TA 6133	TA 4554	TA 3851	TA 3851	TA 6175
Plate End	TA 4645	TA 4048	TA 4645	TA 3833	TA 3833	TA 3579

Model T – 23						
Parts	Pan Width					
	1200			1400	1500	
	Type – 1	Type – 2	Type – 3	Type – 1	Type – 1	Type – 2
Washer	TA 2237	TA 2237	TA 2237	TA 0055	TA 0055	TA 055
Bolt Hex	TA 1395	TA 1395	TA 1395	TA 1494	TA 1494	TA 1494
Felt Strip	TA 1385	TA 1391	TA 1385	TA 1574	TA 1574	TA 1574
Collar (Gear Guard)	TA 4649	TA 1390	TA 4649	TA 4093	TA 4093	TA 6394
Dowel Pin	TA 2670	TA 2670	TA 2670	TA 2670	TA 2670	TA 2670

Model T – 23					
Parts	Pan Width				
	1600	1800			
	Type – 1	Type – 1	Type – 2	Type – 3	Type – 4
Conv. Drive Wheel Assembly	TB 0730	TA 9979	TB 0628	TB 0658	TB 2497
Conv. Drive Shaft	TB 0749	TA 9990	TB 0498	TB 0512	TA 6522
Sprocket Assembly	TA 8424	TA 9914	TA 8999	TA 8999	TA 8424
Locking Assembly	TA 3831	TA 3648	TA 4226	TA 4226	TA 3831
Plate Cover	TA 4438	TA 8337	TA 4898	TA 4898	TA 7688
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 4259	TA 4221	TB 0497	TB 0513	TA 4259
Spherical Roller Bearing	TA 3850	TA 3650	TA 6378	TA 4639	TA 3850
Seal Group	TA 4258	TA 3636	TA 6384	TA 4643	TA 4258
Cover	TA 3639	TA 3639	TA 4647	TA 4647	TA 3639
Seal O-ring	TA 3640	TA 3640	TA 3843	TA 3843	TA 3640
Bolt Hex	TA 2827	TA 2827	TA 0481	TA 4646	TA 2927
Nut Hex	TA 3841	TA 3841	TA 0515	TA 0515	TA 3841
Lock Washer	TA 0477	TA 0477	TA 0514	TA 0514	TA 0477
Lock Nut	TA 2633	TA 2633	TA 0516	TA 0516	TA 2633
Washer Machined	TA 1379	TA 1379	TA 4811	TA 4811	TA 1379
Strip Lock	TA 6286	TA 6286	TA 6371	TA 6371	TA 6286
Key	TA 3830	TA 3647	TA 6390	TA 4644	TA 3830
Bull Gear	TA 3851	TA 3653	TA 6175	TA 4554	TA 3851
Plate End	TA 3833	TA 3469	TA 3579	TA 4645	TA 3833
Washer	TA 0555	TA 0057	TA 0055	TA 2237	TA 0055
Bolt Hex	TA 1494	TA 2542	TA 1494	TA 1395	TA 1494
Felt Strip	TA 1574	TA 1574	TA 1574	TA 1385	TA 1574
Collar (Gear Guard)	TA 4093	TA 1348	TA 6394	TA 4649	TA 4093

Model T – 23					
Parts	Pan Width				
	1600	1800			
	Type – 1	Type – 1	Type – 2	Type – 3	Type – 4
Dowel Pin	TA 2670	TA 2670	TA 2670	TA 2670	TA 2670

Model T – 23						
Parts	Pan Width					
	2000			2200		
	Type – 1	Type – 2	Type – 3	Type – 1	Type – 2	Type – 3
Conv. Drive Wheel Assembly	TB 1801	TA 4503	TA 8429	TA 4023	TB 0028	TB 0052
Conv. Drive Shaft	TB 1806	TA 4440	TA 8438	TA 4046	TA 4046	TB 0017
Sprocket Assembly	TB 1807	TA 4439	TA 8424	TA 4058	TB 0185	TA 8424
Locking Assembly	TA 3571	TA 3831	TA 3831	TA 3291	TA 3291	TA 3831
Plate Cover	TB 1894	TA 4438	TA 4438	TA 3292	TA 4640	TA 4438
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3238	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 3239	TA 1233	TA 1233
Plummer Block Assembly	TA 6392	TA 4259	TA 4259	TA 4068	TB 0031	TB 0021
Spherical Roller Bearing	TA 6378	TA 3850	TA 3850	TA 1387	TA 1387	TA 3850
Seal Group	TA 6384	TA 4258	TA 4258	TA 4073	TA 4073	TA 4258
Cover	TA 4647	TA 3639	TA 3639	TA 4071	TA 4071	TA 3639
Seal O-ring	TA 3843	TA 3640	TA 3640	TA 4072	TA 4072	TA 3640
Bolt Hex	TA 0481	TA 2410	TA 2827	TA 4078	TA 4078	TA 2827
Nut Hex	TA 0515	TA 3841	TA 3841	TA 2252	TA 2252	TA 3841
Lock Washer	TA 0514	TA 0477	TA 0477	TA 0057	TA 0057	TA 0477
Lock Nut	TA 0516	TA 2633	TA 2633	TA 3546	TA 3546	TA 2633
Washer Machined	TA 4811	TA 1379	TA 1379	TA 4529	TA 4529	TA 1379
Strip Lock	TA 6371	---	TA 6286	TA 6371	TA 6371	TA 6286
Key	TA 6390	TA 3830	TA 3830	TA 4047	TA 4047	TA 3830
Bull Gear	TA 6175	TA 3851	TA 3851	TA 6133	TA 6133	TA 3851
Plate End	TA 3579	TA 3833	TA 3833	TA 4048	TA 4048	TA 3833
Washer	TA 0055	TA 0055	TA 0055	TA 2237	TA 2237	TA 0055
Bolt Hex	TA 1494	TA 1494	TA 1494	TA 1395	TA 1395	TA 1494
Felt Strip	TA 1574	TA 1574	TA 1574	TA 1391	TA 1391	TA 1574
Collar (Gear Guard)	TA 6394	TA 4093	TA 4093	TA 1390	TA 1390	TA 4093
Dowel Pin	TA 2670	TA 2670	TA 2670	TA 2670	TA 2670	TA 2670

Table 5.2 Bill of Materials of Open type Drive Wheel Assembly for Model T – 50

Model T – 50					
Parts	Pan Width				
	1600	1800		2250	
	Type – 1	Type – 1	Type – 2	Type – 1	Type – 2
Conv. Drive Wheel Assembly	TB 1656	TB 0005	TB 2156	TA 6454	TA 6854
Conv. Drive Shaft	TA 6765	TA 9924	TA 2136	TA 6485	TA 6863
Sprocket Assembly	TA 6523	TA 6715	TA 6482	TA 6482	TA 6864
Locking Assembly	TA 3831	TA 6731	TA 3648	TA 3648	TA 4216
Plate Cover	TA 6772	TA 6714	TA 6481	TA 6481	TA 6713
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 4259	TA 4221	TA 4669	TA 4669	TA 4221
Spherical Roller Bearing	TA 3850	TA 3650	TA 3321	TA 3321	TA 3650
Seal Group	TA 4258	TA 3636	TA 4666	TA 4666	TA 3636
Cover	TA 3639	TA 3639	TA 4668	TA 4668	TA 3639
Seal O-ring	TA 3640	TA 3640	TA 4664	TA 4664	TA 3640
Bolt Hex	TA 2410	TA 4134	TA 3316	TA 3316	TA 4134
Nut Hex	TA 3841	TA 3841	TA 3317	TA 3317	TA 3841
Lock Washer	TA 0477	TA 0477	TA 2697	TA 2697	TA 0477
Lock Nut	TA 2633	TA 2633	TA 3318	TA 3181	TA 2633
Washer Machined	TA 1379	TA 1379	TA 3351	TA 3351	TA 1379
Strip Lock	---	TA 6371	TA 6371	TA 6371	TA 6371
Key	TA 3830	TA 3647	TA 3323	TA 3323	TA 3647
Bull Gear	TA 3851	TA 3653	TA 4667	TA 4667	TA 3653
Plate End	TA 3833	TA 3649	TA 3322	TA 3322	TA 3649
Washer	TA 0055	TA 0057	TA 0057	TA 0057	TA 0057
Bolt Hex	TA 1494	TA 2542	TA 2542	TA 2542	TA 2542
Felt Strip	TA 1574	TA 1574	TA 4008	TA 4008	TA 1574
Collar (Gear Guard)	TA 4093	TA 1348	TA 4009	TA 4009	TA 1348
Dowel Pin	TA 2670	TA 2670	TA 2670	TA 2670	TA 2670

Model T – 50			
Parts	Pan Width		
	2350	2400	2500
	Type – 1	Type – 1	Type – 1
Conv. Drive Wheel Assembly	TB 2451	TB 1331	TB 1618
Conv. Drive Shaft	TB 2417	TB 1328	TA 6897
Sprocket Assembly	TA 6864	TA 6523	TA 6864

Model T – 50			
Parts	Pan Width		
	2350	2400	2500
	Type – 1	Type – 1	Type – 1
Locking Assembly	TA 4216	TA 3831	TA 4216
Plate Cover	TA 6713	TA 6772	TA 6713
Screw Hex	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 4221	TA 4259	TA 4221
Spherical Roller Bearing	TA 3650	TA 3850	TA 3650
Seal Group	TA 3636	TA 4258	TA 3636
Cover	TA 3639	TA 3639	TA 3639
Seal O-ring	TA 3640	TA 3640	TA 3640
Bolt Hex	TA 4134	TA 2410	TA 4134
Nut Hex	TA 3841	TA 3841	TA 3841
Lock Washer	TA 0477	TA 0477	TA 0477
Lock Nut	TA 2633	TA 2633	TA 2633
Washer Machined	TA 1379	TA 1379	TA 1379
Strip Lock	TA 6371	---	TA 6371
Key	TA 3647	TA 3830	TA 3647
Bull Gear	TA 3653	TA 3851	TA 3653
Plate End	TA 3649	TA 3633	TA 3649
Washer	TA 0057	TA 0055	TA 0057
Bolt Hex	TA 2542	TA 1494	TA 2542
Felt Strip	TA 1574	TA 1574	TA 1574
Collar (Gear Guard)	TA 1348	TA 4093	TA 1348
Dowel Pin	TA 2670	TA 2670	TA 2670

Table 5.3 Bill of Materials of Direct type Drive Wheel Assembly for Model T – 13

Model T – 13					
Parts	Pan Width				
	1000	1100		1200	1700
	Type – 1	Type – 1	Type – 2	Type – 1	Type – 1
Conv. Drive Wheel Assembly	TB 2828	TB 2703	TB 3006	TB 2028	TB 2753
Conv. Drive Shaft	TB 2786	TB 2644	TB 2947	TB 2020	TB 2671
Sprocket Assembly	TB 2643	TB 2643	TB 2643	TB 1892	TB 2670
Locking Assembly	TA 6767	TA 6767	TA 6767	TA 3291	TA 9195
Plate Cover	TB 2910	TB 2910	TB 2910	TB 1361	TB 2909

Model T – 13					
Parts	**Pan Width**				
	1000	**1100**		**1200**	**1700**
	Type – 1	**Type – 1**	**Type – 2**	**Type – 1**	**Type – 1**
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 6127	TA 6127	TA 6127	TA 6127	TA 6127
Spherical Roller Bearing	TA 1387	TA 1387	TA 1387	TA 1387	TA 1387
Seal Group	TA 4073	TA 4073	TA 4073	TA 4073	TA 4073
Cover	TA 4071	TA 4071	TA 4071	TA 4071	TA 4071
Seal - O - Ring	TA 4072	TA 4072	TA 4072	TA 4072	TA 4072
Bolt Hex	TA 6418	TA 6418	TA 6418	TA 6418	TA 6418
Nut Hex	TA 2252	TA 2252	TA 2252	TA 2252	TA 2252
Lock Washer	TA 0057	TA 0057	TA 0057	TA 0057	TA 0057
Lock Nut	TA 3546	TA 3546	TA 3546	TA 3546	TA 3546
Washer	TA 4529	TA 4529	TA 4529	TA 4529	TA 4529
Key	TA 9727	TA 4943	TA 0967	TA 9727	TB 2749

Model - 13						
Parts	**Pan Width**					
	1400				**1500**	
	Type – 1	**Type – 2**	**Type – 3**	**Type – 4**	**Type – 1**	**Type – 2**
Conv. Drive Wheel Assembly	TB 1728	TB 2218	TB 3028	TB 3353	TB 1776	TB 3603
Conv. Drive Shaft	TB 1674	TB 1674	TB 2988	TB 3340	TB 1758	TB 3622
Sprocket Assembly	TB 1673	TB 1892	TB 2982	TB 1673	TB 1892	TB 1892
Locking Assembly	TA 3291	TA 3291	TA 3291	TA 3291	TA 3291	TA 3291
Plate Cover	TB 1361	TB 1361	TB 1361	TB 1361	TB 1361	TB 1361
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 6127	TA 6127	TA 4611	TA 6127	TA 6127	TA 6127
Spherical Roller Bearing	TA 1387	TA 1387	TA 4607	TA 1387	TA 1387	TA 1387
Seal Group	TA 4073	TA 4073	TA 4608	TA 4073	TA 4073	TA 4073
Cover	TA 4071	TA 4071	TB 1936	TA 4071	TA 4071	TA 4071
Seal - O - Ring	TA 4072	TA 4072	TA 4612	TA 4072	TA 4072	TA 4072
Bolt Hex	TA 6418	TA 6418	TA 6418	TA 6418	TA 6418	TA 6418
Nut Hex	TA 2252	TA 2252	TA 2252	TA 2252	TA 2252	TA 2252
Lock Washer	TA 0057	TA 0057	TA 0057	TA 0057	TA 0057	TA 0057
Lock Nut	TA 3546	TA 3546	TA 3546	TA 3546	TA 3546	TA 3546
Washer	TA 4529	TA 4529	TA 4529	TA 4529	TA 4529	TA 4529

Model - 13						
Parts	Pan Width					
	1400				1500	
Key	TA 9727	TA 9727	TB 3016	TA 9727	TB 1912	TB 1912

Table 5.4 Bill of Materials of Direct type Drive Wheel Assembly for Model T – 23

Model T - 23				
Parts	Pan Width			
	1100	1200	2000	1400
	Type – 1	Type – 1	Type – 1	Type – 1
Conv. Drive Wheel Assembly	TB 1951	TB 2426	TB 1551	TB 3754
Conv. Drive Shaft	TB 1889	TB 2413	TB 1547	TB 3762
Sprocket Assembly	TB 0172	TA 8999	TB 0185	TA 7805
Locking Assembly	TA 3291	TA 4226	TA 3291	TA 4226
Plate Cover	TA 4640	TA 4898	TA 4640	TA 7804
Screw Hex	TA 3997	TA 3997	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233	TA 1233	TA 1233
Plummer Block Assembly	TA 4611	TA 4648	TA 4648	TA 4648
Spherical Roller Bearing	TA 4607	TA 4639	TA 4639	TA 4639
Seal Group	TA 4608	TA 4643	TA 4643	TA 4643
Cover	TB 1936	TA 4647	TA 4647	TA 4647
Seal - O - Ring	TA 4612	TA 3843	TA 3843	TA 3843
Bolt Hex	Ta 3082	TA 4646	TA 4646	TA 4646
Nut Hex	TA 2252	TA 0515	TA 0515	TA 0515
Lock Washer	TA 0057	TA 0514	TA 0514	TA 0514
Lock Nut	TA 3546	TA 0516	TA 0516	TA 0516
Washer	TA 4529	TA 4811	TA 4811	TA 4811
Strip Lock	---	TA 6371	---	TA 6371
Key	TA 0923	TA 3581	TB 1682	TB 2749

Table 5.5 Bill of Materials of Drive Wheel Assembly for Model T – 50 (Direct Drive)

Model T - 50		
Parts	Pan Width	
	2000	2250
Conv. Drive Wheel Assembly	TB 2126	TB 0103
Conv. Drive Shaft	TB 2116	TB 0084
Sprocket Assembly	TB 2225	TA 6864
Locking Assembly	TA 3240	TA 4216

Model T - 50		
Parts	**Pan Width**	
	2000	**2250**
Plate Cover	TB 2512	TA 6713
Screw Hex	TA 3997	TA 3997
Lock Washer	TA 1233	TA 1233
Plummer Block Assembly	TB 2236	TA 4221
Spherical Roller Bearing	TB 2115	TA 3650
Seal Group	TB 2340	TA 3636
Cover	TB 2496	TA 3639
Seal - O - Ring	TB 2337	TA 3640
Bolt Hex	TA 3336	TA 4134
Nut Hex	TA 3317	TA 3841
Lock Washer	TA 2697	TA 0477
Lock Nut	TA 3318	TA 2633
Washer	TA 3351	TA 1379
Strip Lock	TA 6371	TA 6371
Key	---	TB 0726

Collected data are tabulated as per the requirement, from which the parts are to be modeled.

Chapter 6

Methodology

CHAPTER 6

METHODOLOGY

6.1 INTRODUCTION

This chapter gives the details of the methodology adopted in this project work. It gives the detailed description about the design automation, parametric modeling along with parametric and dimension driven CAD tool, Pro/ENGINEER Wildfire 3.0 software with family table, relation and Pro/PROGRAM features which are used to model the subassemblies and parameterize them.

6.2 DESIGN AUTOMATION

As discussed earlier, the goal for any industries in today's environment is to automate the product development process using CAD/CAM environment.

Design automation stands out as an effective means of dramatically cutting costs and speed up the process. It is needed where the demand is rapid; accuracy is a requisite; consistent in engineering is compulsory and most importantly where minimum time is required to finish the product delivery.

The purpose of design automation is to characterize the changes in dimensions. These dimension variables are allowed to vary in the modeling process. Automated design methods in computer aided design pertaining to parameterization and constraint definitions have met with great success in recent years. In commercial Computer Aided Design, computer code has provided versatile venues for end-users to automate the design process.

6.3 PARAMETRIC MODELING

A 3D solid model is used in various stages of manufacturing processes such as design, drafting, manufacturing, and so on. It is a time-consuming and skilled job. According to Kim et al. (2006) the most current CAD/CAM/CAE software utilizes a parametric design feature, a method of linking dimensions and variables to geometry in such a way that when the values change, the part and the drawing change as well.

Parametric modeling technology has been adopted in mainstream of Computer-Aided Design tools used by industry. This technology provides designers with tremendous flexibility to explore feasible design alternatives. In order to support design decision making for trade-offs between product performance and cost, engineers often depend on Computer-Aided Engineering tools to realize product performance as per Kuang-Hua Chang (2005). The introduction of the parametric design significantly enhances the efficiency of the mold design process. The company estimates that the time of the 3D model construction is shortened by around 30% for the test example according to Chih-Hsing Chu (2006).

The feature-based parametric modeling technique enables the designer to incorporate the original design intent into the construction of the model. The word parametric means the geometric definitions of the design, such as dimensions, can be varied at any time in the design process. Parametric modeling is accomplished by identifying and creating the key features of the design with the aid of computer software. The design variables, described in the sketches and features, can be used to quickly modify/update the design according to Randh Shih. From a designer's point of view, feature-based design offers possibilities for supporting the design process better than current CAD systems. Kun-Hur Chen (1998) pointed out the implementation of the feature-based design method which includes feature recognition, part representation, and design with features. Kamrani (2006) defined parametric design approach as a feature-based design system, in which features are defined by a set of parameterized data.

The implementation of parametric modeling in industrial and design enterprises reduces redundant labor work by the creation of interactive databases. Designers can now just edit these databases rather than redesigning the models that is required to meet current needs or updated one. It also provides a foundational database upon which future product development and revisions may rest according to Alexander Inozemtsev (2000). Chih-Hsing Chu (2006) developed a

Computer aided parametric design system for 3D tire mold production in CATIA using CAA.

Edwin Hardee (1999) said in Pro/ENGINEER, the design engineer can more easily capture design intent in the CAD model. He first concentrates on the shape of the part leaving certain dimensions and features as variables, which may be modified later in the design process. If these get changed, the model regenerates automatically. This provides the designer with the ability to rapidly create custom-designed products. The advantage of such a system is that the end user need not have designing skills or knowledge of using CAD systems. According to Vasiliki Stamati (2005) by parameter modeling, it is very easy to modify characteristics of the products such as the size and the designs represented.

6.3.1 Parameter

Parametric modeling uses parameters defined earlier to define a new model (dimensions and features for example for the parameters). A parameter is also a characteristic feature of something that can be varied without changing its essential nature. The parameter may be modified later, and the model will be updated to reflect the modification. It is very powerful but yet it requires more skill in model creation. For example, consider a complicated model, which has may be a thousand features. Modifying one earlier feature may lead to failure of others. So, intense care is to be taken for creating the parametric models. Once created it is very easier to maintain and modify. By using parametric modeling a whole family of capscrews can be contained in one model, for example.

The word parametric means the geometric definitions of the design, such as dimensions, can be varied at any time in the design process. Parametric modeling is accomplished by identifying and creating the key features of the design with the aid of computer software. The design variables, described in the sketches and features, can be used to quickly modify/update the design. In most cases, parametric technology has been implemented characterized by sets of rules associating dimensions by simple equations.

For example, the diameter of two flanges d_1 and d_2 may be related parametrically by one equation as $d_1 = d_2 * t$, where, 't' thickness, is the parameter. This indicates that a change in the diameter of 'flange 2' will automatically change the diameter of 'flange 1'. Similarly, a change in any geometry causes a change in another geometric property.

However, the parametric model is generic, and can be easily modified by changing values of the parameters that determine the dimensions and the type of construction. In order to establish modeling parameters, it is necessary to identify the important parameters that make up the part. Starting from these parameters, it is possible to create a complete product.

6.4 PRO/ENGINEER WILDFIRE

Pro/ENGINEER is a computer graphics system for modeling various mechanical designs and for performing related design and manufacturing operations. The system uses a 3D solid modeling system as the core, and applies the feature-based, parametric modeling method. In short, Pro/ENGINEER is a feature-based, parametric solid and surface modeling system with many extended design and manufacturing applications.

Pro/ENGINEER is the first commercial CAD system entirely based upon the feature-based design and parametric modeling philosophy. Today most software producers have recognized the advantage of this approach and changed their products onto this platform. Some of the features are:

- Ease of Use
- Full Associativity
- Parametric, Feature-Based Modeling
- Powerful Assembly Capabilities
- Robustness
- Change Management
- Hardware Independence

6.5 FAMILY TABLE

Family Tables are collections of parts (or assemblies or features) that are essentially similar, but deviate slightly in one or two aspects, such as size or detail features.

For example, wood screws come in various sizes, but they all look alike and perform the same function. Thus, it is useful to think of them as a family of parts. Parts in Family Tables are also known as table-driven parts.

Using Family Tables, it is possible to:

- Create and store large numbers of objects simply and compactly.
- Save time and effort by standardizing part generation.
- Generate variations of a part from one part file without having to re-create and generate each one.
- Create slight variations in parts without having to use relations to change the model.
- Create a table of parts that can be saved to a print file and included in part catalogs.
- Promote the use of standardized components.

6.5.1 Family Table Structure

Family Tables are essentially spreadsheets, consisting of columns and rows. They consist of the following three components:

1. The base object on which all members of the family are based.
2. Dimensions and parameters, feature numbers, user-defined feature names, and assembly member names that are selected to be table-driven.
3. Names of all family members created by the table and the corresponding values for each of the table-driven items.

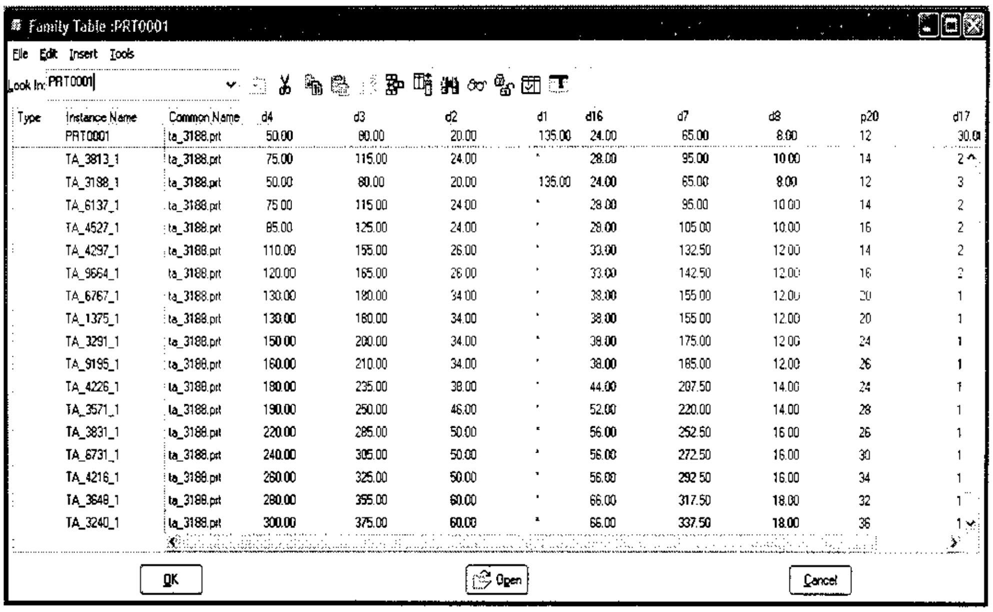
Rows contain instances of parts and their corresponding values; columns are used for items. The column headings include the instance name, and the names of all of the dimensions, parameters, features, members, and groups that were selected for the table.

The generic model is in the first row in the table. The table entries belonging to the generic can be changed only by modifying the actual part, suppressing, or resuming features; but cannot change the generic model by editing its entries in the Family Tables. Family Table names are not case-sensitive. Therefore, any subsequent references to inserted names show them in uppercase letters.

For each instance, it is possible define whether a feature, parameter, or assembly name is used in the instance either by indicating whether it is present in the instance (Y or N) or by providing a numeric value (in the case of a dimension). All dimension cells must have a value, either a number or asterisk (*) to use the generic's value.

All aspects of the generic model that are not included in the Family Table automatically occur in each instance. For example, if the generic model has a parameter called Material with a value Steel; all instances will have the same parameter and value.

In this project work, using parametric modeling technique with the use of Pro/ENGINEER Wildfire 3.0 along with family table feature, parts that are required for the drive wheel assembly both for open type and direct type from the tables 5.1 to 5.5 were modeled. Some of the parts *hat were modeled as shown in the following figures.



Type	Instance Name	Common Name	d4	d3	d2	d1	d16	d7	d8	p20	d17
	PRT0001	ta_3188.prt	50.00	80.00	20.00	135.00	24.00	65.00	8.00	12	30.0
	TA_3813_1	ta_3188.prt	75.00	115.00	24.00	*	28.00	95.00	10.00	14	2
	TA_3188_1	ta_3188.prt	50.00	80.00	20.00	135.00	24.00	65.00	8.00	12	3
	TA_6137_1	ta_3188.prt	75.00	115.00	24.00	*	28.00	95.00	10.00	14	2
	TA_4527_1	ta_3188.prt	85.00	125.00	24.00	*	28.00	105.00	10.00	16	2
	TA_4297_1	ta_3188.prt	110.00	155.00	26.00	*	33.00	132.50	12.00	14	2
	TA_9664_1	ta_3188.prt	120.00	165.00	26.00	*	33.00	142.50	12.00	16	2
	TA_6767_1	ta_3188.prt	130.00	180.00	34.00	*	38.00	155.00	12.00	20	1
	TA_1375_1	ta_3188.prt	130.00	180.00	34.00	*	38.00	155.00	12.00	20	1
	TA_3291_1	ta_3188.prt	150.00	200.00	34.00	*	38.00	175.00	12.00	24	1
	TA_9195_1	ta_3188.prt	160.00	210.00	34.00	*	38.00	185.00	12.00	26	1
	TA_4226_1	ta_3188.prt	180.00	235.00	38.00	*	44.00	207.50	14.00	24	1
	TA_3571_1	ta_3188.prt	190.00	250.00	46.00	*	52.00	220.00	14.00	28	1
	TA_3831_1	ta_3188.prt	220.00	285.00	50.00	*	56.00	252.50	16.00	26	1
	TA_6731_1	ta_3188.prt	240.00	305.00	50.00	*	56.00	272.50	16.00	30	1
	TA_4216_1	ta_3188.prt	260.00	325.00	50.00	*	56.00	292.50	16.00	34	1
	TA_3648_1	ta_3188.prt	280.00	355.00	60.00	*	66.00	317.50	18.00	32	1
	TA_3240_1	ta_3188.prt	300.00	375.00	60.00	*	66.00	337.50	18.00	36	1

Figure 6.1 Generation of parts using family table

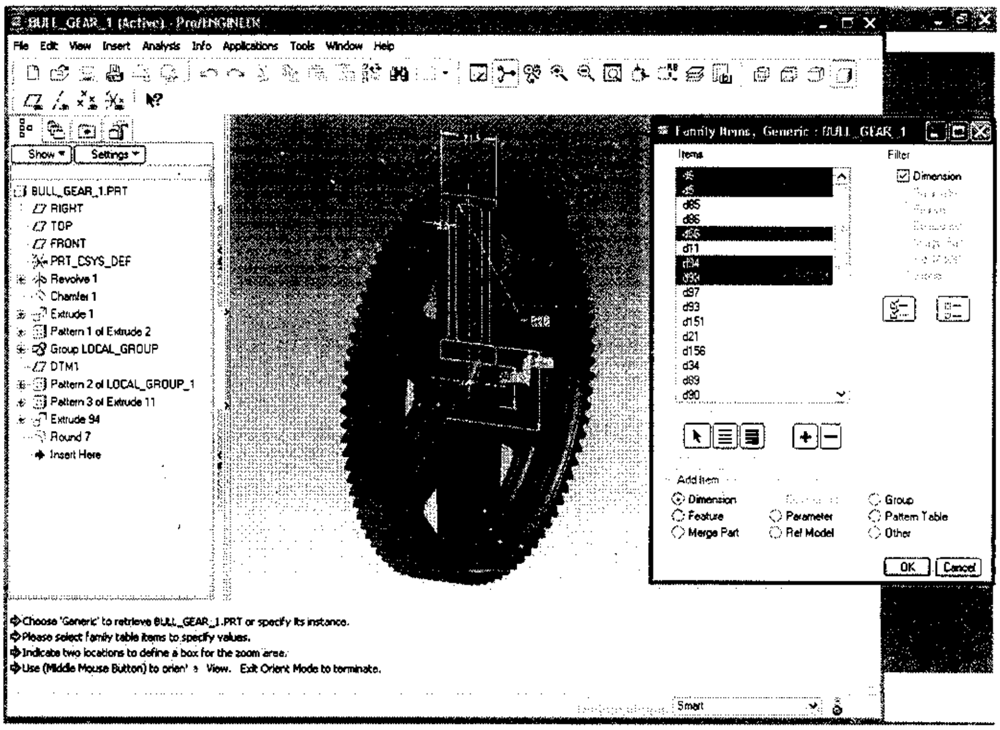


Figure 6.2 Modeling of Bull Gear using family table

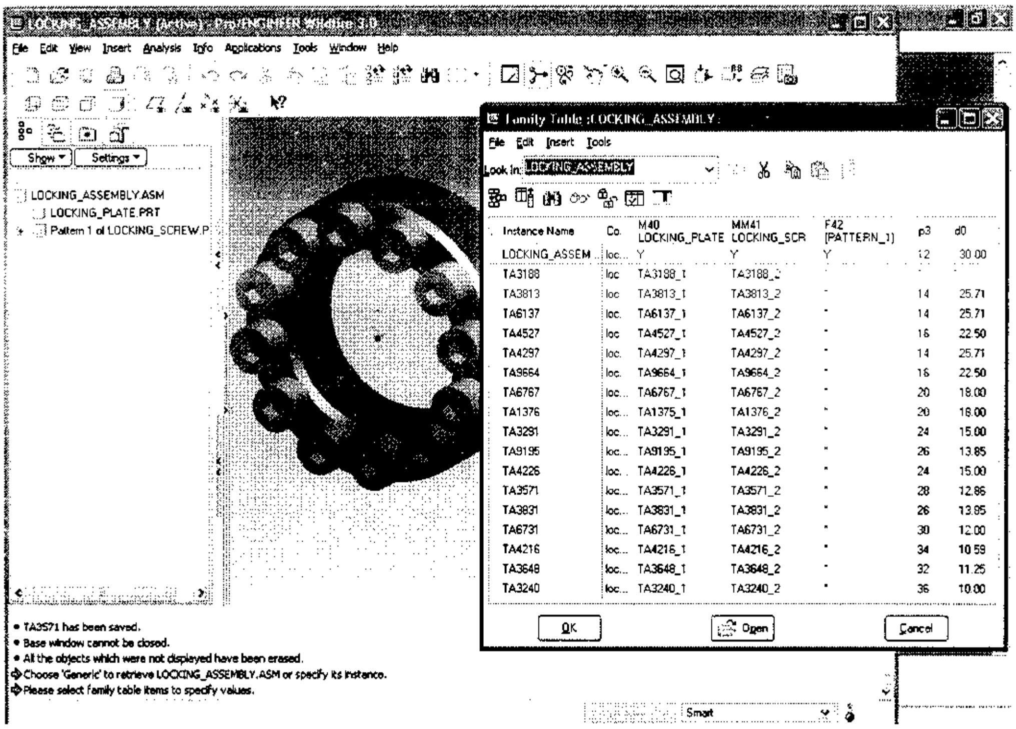


Figure 6.3 Modeling of Locking Assembly using family table

Similarly, wherever required, parts and subassemblies were modeled based on the above procedure.

6.6 PARAMETRIC RELATIONS

Relations (also known as parametric relations) are user-defined equations written between symbolic dimensions and parameters. Relations capture design intent by defining relationships within features or parts, or among assembly components.

Relations in the modeling process are used:

- To control the effects of modifications on models
- To define values for dimensions in parts and assemblies
- To set constraints for design conditions. For example, by specifying the location of a hole in relation to the edge of a part.
- To describe conditional relationships between different parts of a model or assembly.

6.6.1 Levels of Relations

Relations can be created on different levels: assembly, part, feature, or section.

6.6.1.1 Section relations

Relations created in Sketcher to control geometry of complex sections. Unless a section dimension changes, section relations generally are regenerated during part regeneration.

6.6.1.2 Part relations

Relations added on a part level. During a part regeneration, these relations get resolved before features are regenerated.

6.6.1.3 Feature relations

Relations added to a selected feature. During part regeneration, these relations are resolved after part relations, but before the regeneration of the feature to which they apply. These feature relations are used to change feature geometry only after part relations are applied and some features have been regenerated.

6.6.2 Rules for Using Relations

Assigning a relation outside the section to a parameter that is already driven by a section relation, an error message will triggered when the system regenerates the model. The same applies to assign a relation to a section parameter that is already driven by a relation outside the section. Removing one of the relations and regenerating model is the only solution.

- If an assembly tries to assign a value to a dimension variable that is already driven by a part or subassembly relation, there will be an error message. Solution for this will be removing one of the relations and regenerating the model.
- Modifying the units of a model can invalidate relations, as they are not scaled along with the model.

6.6.3 Order of Evaluation of relations during regeneration

Relations are not evaluated until the model is regenerated. During regeneration, relations are evaluated in the following order:

1. At the beginning of regeneration, the system solves model relations in the order in which they were entered. In an assembly, the assembly relations are calculated first. Then the system calculates all subassembly relations in order of component placement. This means that all subassembly relations are calculated before any features or components begin regeneration.

2. The system starts regenerating features in the order of creation. If a feature has feature relations attached to it, these relations are solved before regenerating that feature.

3. If it is specified any relations as Post Regeneration, the system solves these relations after the regeneration is complete.

6.6.4 Operators used in relations

The following operators can be used in relations, both in equations and in conditional statements.

6.6.4.1 Arithmetic Operators

+ - Addition
– - Subtraction
/ - Division
* - Multiplication
^ - Exponentiation
() - Parentheses for grouping for example, $d_0 = (d_1 - d_2) * d_3$

6.6.4.2 Assignment Operator

= - Equal to

The equal (=) sign is an assignment operator that equates the two sides of an equation or relation. When the equal sign is used, the equation can have only a single parameter on the left side.

6.6.4.3 Comparison Operators

Comparison operators are used when a TRUE/FALSE value can be returned. The following comparison operators are supported:

== - Equal to
> - Greater than
>= - Greater than or equal to
!=, <>,~= - Not equal to
< - Less than
<= - Less than or equal to
| - Or
& - And
~, ! - Not

In this project work, the output required in the drafting layout for the open type drive wheel assembly is shown in the figure 6.4.

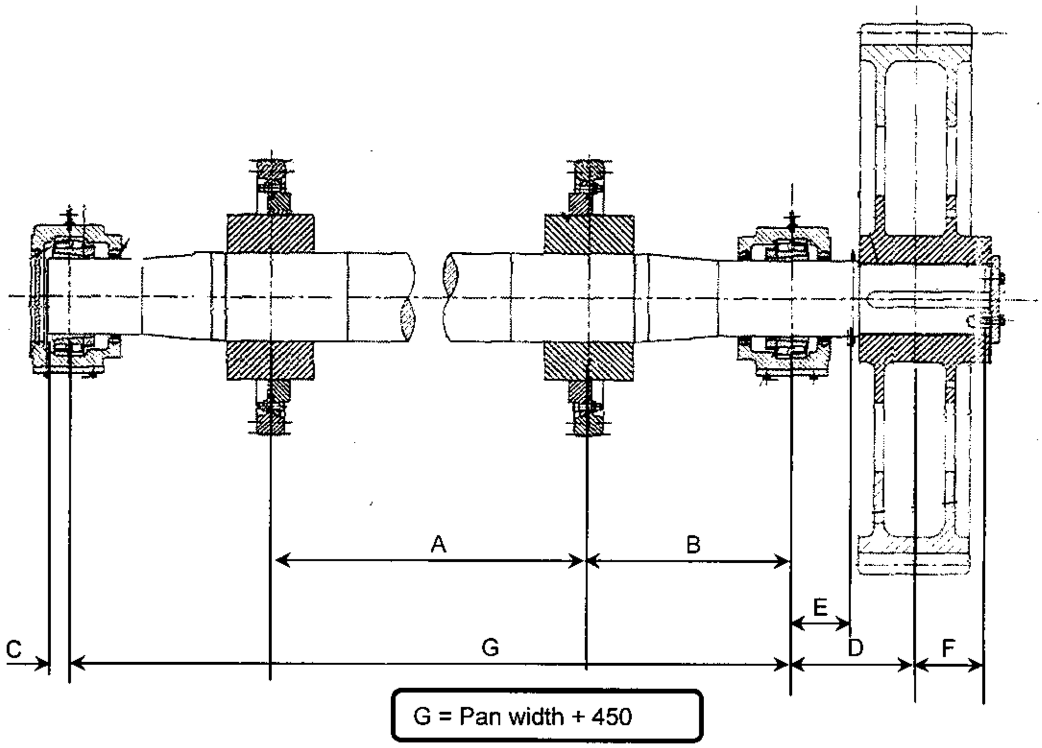


Figure 6.4 Relation for location of subassemblies in Open type Drive Wheel Assembly

Location of subassemblies changes with respect to the pan width. Relations between the pan width and location of subassemblies such as sprocket assemblies, bearing assemblies, bull gear assembly, gear guard assembly and the drive shaft has been studied and tabulated in terms of mm as per tables 6.1 and 6.2 for open type. G always remains to be same for the both the open type and direct type.

Table 6.1 Location of Sub-assemblies of Open type for Model T – 23

Model T – 23							
Parameters	Pan Width						
	1200			1400	1500		1600
	Type – 1	Type – 2	Type – 3	Type – 1	Type – 1	Type – 2	Type – 1
A	660	660	660	770	880	880	880
B	495	495	495	540	535	535	585
C	45	45	45	70	70	55	70
D	282	252.5	282	320	320	292.5	320
E	141	110	14.1	163	163	151.5	163
F	92	75.5	92	145	145	102.5	145

Model T – 23							
Parameters	Pan Width						
	1800				2000		
	Type – 1	Type – 2	Type – 3	Type – 4	Type – 1	Type – 2	Type – 3
A	990	990	990	990	1100	1100	1100
B	630	630	630	630	675	675	675
C	70	55	50	65	55	64	70
D	370	292.5	282	320	292.5	315	320
E	207	151.5	141	163	151.5	163	163
F	200	102.5	92	145	102.5	145	145

Model T – 23			
Parameters	Pan Width		
	2200		
	Type – 1	Type – 1	Type – 1
A	1210	1210	1210
B	720	720	720
C	43.5	43.5	70
D	252.5	252.5	320
E	110	110	163
F	75.5	75.5	145

Table 6.2 Location of Sub-assemblies of Open type for Model T – 50

Model T-50								
Parameters	Pan Width							
	1600	1800		2250		2350	2400	2500
	Type – 1	Type – 1	Type – 2	Type – 1	Type – 2	Type – 1	Type – 1	Type – 1
A	880	990	990	1320	1320	1320	1320	1430
B	585	630	630	690	690	740	765	760
C	65	70	70	70	66	66	70	66
D	320	370	352	382	370	370	320	370
E	163	207	215	215	207	207	163	207
F	145	200	234	234	200	200	145	200

Similarly, the output required in the drafting layout for the direct type drive wheel assembly is shown in the figure 6.5.

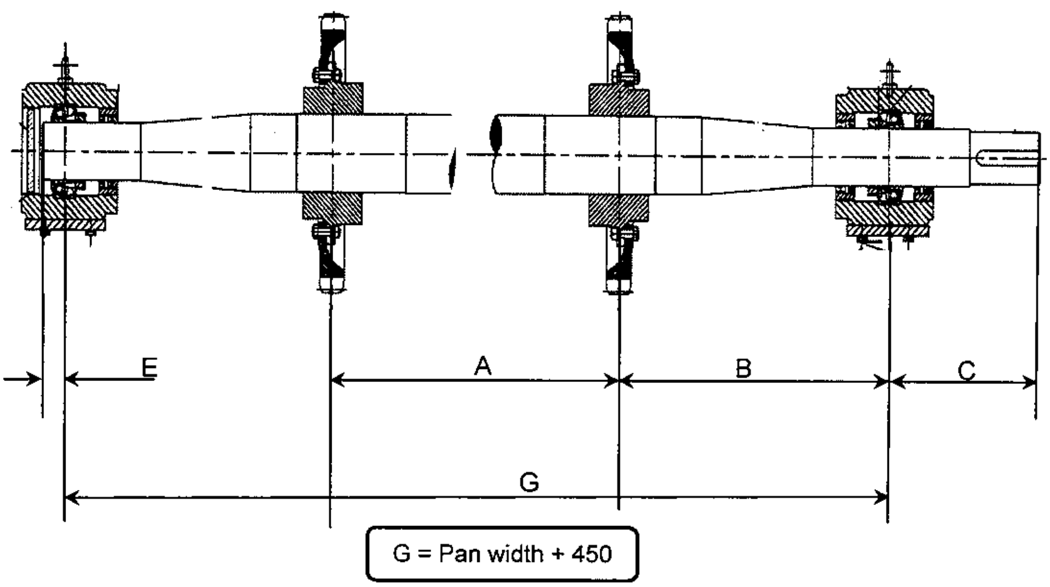


Figure 6.5 Relation for location of subassemblies in Direct type Drive Wheel Assembly

Similarly the location of subassemblies in the direct type drive wheel assembly changes with respect to the pan width. Relations between the pan width and subassemblies such as sprocket assemblies, bearing assemblies and the drive shaft has been studied and tabulated in terms of mm as per tables 6.3 and 6.4.

Table 6.3 Location of Sub-assemblies of Direct type for Model T – 13

Model T - 13								
Parameters	Pan Width							
	1000	1110		1200	1400			
	Type – 1	Type – 1	Type – 2	Type – 1	Type – 1	Type – 2	Type – 3	Type – 4
A	550	660	660	660	770	770	770	770
B	450	445	445	495	540	540	540	540
C	300	300	350	290	2902	290	350	320
E	45	45	45	45	45	45	48	45

Model T - 13			
Parameters	Pan Width		
	1500		1700
	Type – 1	Type – 1	Type – 1
A	880	880	990
B	535	535	580
C	300	350	350
E	45	45	50

Table 6.4 Location of Sub-assemblies of Direct type for Model T – 23 and T – 50

Parameters	Model T - 23			Model T - 50		
	Pan Width			Pan Width		
	1100	1200	2000	1400	2000	2250
	Type – 1	Type – 1	Type – 1	Type – 1	Type – 1	Type – 1
A	660	660	1100	770	1100	1320
B	445	495	675	540	675	690
C	320	350	300	345	510	465
E	48	50	45	50	85	70

6.7 PRO/PROGRAM

Each model in Pro/ENGINEER contains a listing of major design steps and parameters that can be edited to work as a program. By running the program, it is possible to change the model according to new design specifications.

The Pro/PROGRAM environment support quick and relatively straightforward interactive graphical programming in Pro/E for every user. It allows making changes to the model through "Programming Logic" rather than through "drawing and modeling". The programming environment is simply Pro/E and Microsoft Notepad or Word. One can enter the Pro/PROGRAM environment, by clicking Tools > Program... from the pull-down menu in the Pro/E PART or ASSEMBLY mode. To show or edit the program, one can click Show Design or Edit Design from the PROGRAM menu.

A typical Pro/PROGRAM routine may contain any of the following:

- Input variables with their current values
- Relations
- IF-ELSE clauses
- Lists of all the features, parts, or assemblies in the design, which, when enclosed within "IF condition... ELSE... END IF" statements, create alternate design branches
- EXECUTE statements (Assembly mode only)
- INTERACT statements
- Feature suppression and order
- MASSPROP statement

After the Pro/PROGRAM routine is edited, the user will be asked whether the changes are to be incorporated (in the message window at the bottom). To proceed, enter Y. If N entered, the program will not be executed and changes will be lost.

6.7.1 Input Variables

INPUT variables may be specified at the beginning of the listing. A typical use of an INPUT variable is to supply a value for a dimension. This is a parameter later used in a relation or as input for model names used in assemblies. The INPUT statement must define the name and type of the variable. Variable names must always begin with a character. The following variable types are supported: Number, String, Logical (YES_NO)

6.7.2 Relations

All valid relations in a Pro/ENGINEER model can be entered in a Pro/PROGRAM.

6.7.3 IF-ELSE Clauses

Conditional statements, i.e. IF _ ELSE, can be used to create a program branch.

6.7.4 Lists of Features and Parts

The program that Pro/PROGRAM brings up simply includes all feature building commands used in creating the model and the properties of the features.

6.7.5 EXECUTE

EXECUTE statements are valid for assembly listings only. They provide a link between input variables in an assembly and input variables for programs in parts and in the subassemblies that make up the assembly.

6.7.6 INTERACT

INTERACT statements provide a placeholder for creating interactive part and assembly features. They can be inserted anywhere within the FEATURE ADD - END ADD or PART ADD - END ADD statement.

6.7.7 MASSPROP

Use the MASSPROP statement to update mass properties each time geometry changes. After you have specified parts or assemblies for which mass properties are to be updated, you can request the current value of a required parameter through the relations mechanism.

6.8 ASSEMBLY PROGRAM

The programming for assembly was done in three stages. The relations for the programming were executed simultaneously.

- The first stage was the creation of planes for the assembly of the components.

- The second stage was the assembly of components over their respective planes.

- The third stage was the creation of drive shaft features automatically based on the relations involved with them. This eliminates separate component of drive shaft to be assembled.

6.8.1 Inputs

Before getting into programming inputs that were required from the users were decided and based on that program is developed. The following were the inputs common to both open type and direct type assemblies:

- Type of Drive
- Pan width
- Bearing Assembly Number
- Sprocket Assembly Number

The input that was additional for the open type was:

- Gear Module Number

The input that was additional for the direct type was:

- Counter Shaft Extension
- Coupling Diameter
- Coupling Length
- Number of Keys
- Key Part Number

6.8.2 First Stage

In the first stage of programming, program was developed for the creation of planes which is required for subassemblies and components to be assembled at their respective locations and the same is given in Appendix 1. This was done based on the relations that have been formed from tables 6.1 to 6.4 for both the open type and direct type. This is explained as follows.

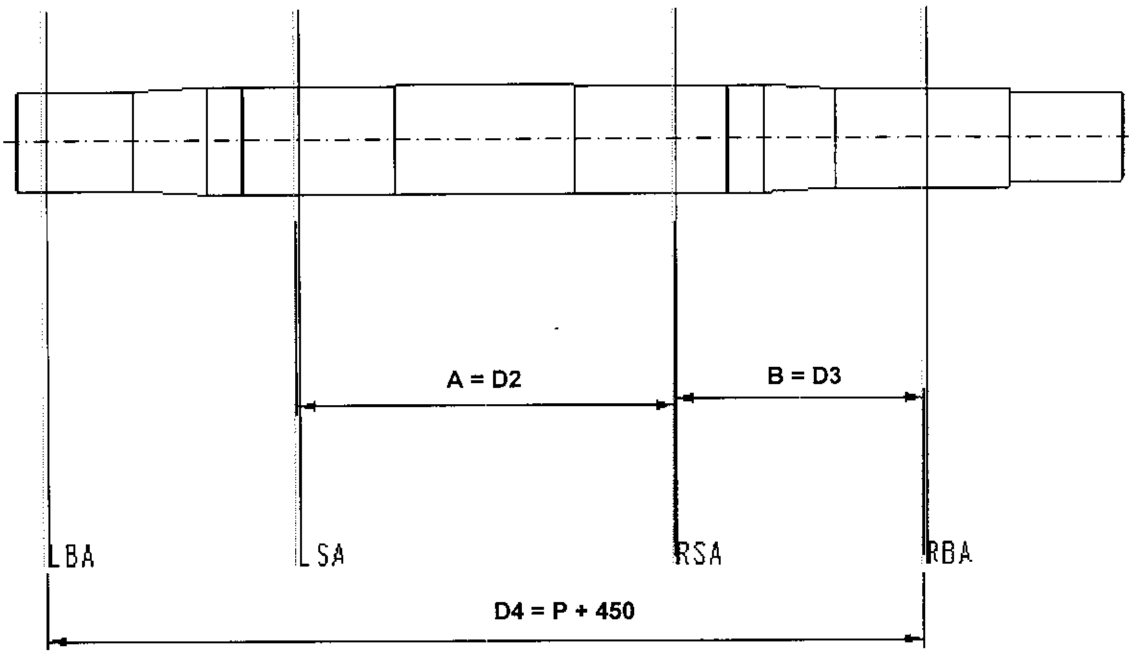


Figure 6.6 Relations for location of Sprocket and Bearing assemblies (A & B)

CALCULATION OF 'A' AND 'B'

- PAN_WIDTH < 800 D1 = 550/2
- PAN_WIDTH > 800 & PAN_WIDTH <= 1000 D1 = 550/2
- PAN_WIDTH > 1000 & PAN_WIDTH <= 1200 D1 = 660/2
- PAN_WIDTH > 1200 & PAN_WIDTH <= 1400 D1 = 770/2
- PAN_WIDTH > 1400 & PAN_WIDTH <= 1600 D1 = 880/2
- PAN_WIDTH > 1600 & PAN_WIDTH <= 1800 D1 = 990/2
- PAN_WIDTH > 1800 & PAN_WIDTH <= 2000 D1 = 1100/2
- PAN_WIDTH > 2000 & PAN_WIDTH <= 2200 D1 = 1210/2
- PAN_WIDTH > 1200 & PAN_WIDTH <= 2400 D1 = 1320/2
- PAN_WIDTH > 2400 & PAN_WIDTH <= 2600 D1 = 1430/2
- PAN_WIDTH > 2600 D1 = 1430/2
- D2 = 2 * D1
- D3 = ((PAN_WIDTH + 450) - D2) / 2
- D4 = PAN_WIDTH + 450

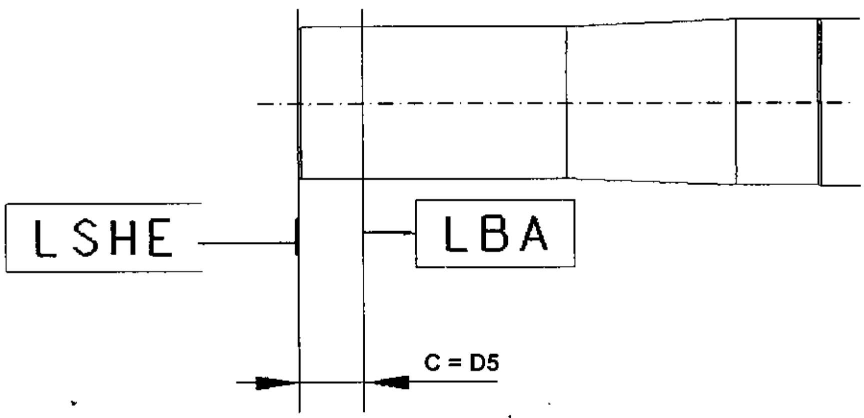


Figure 6.7 Relation for location of Drive Shaft (C)

CALCULATION OF 'C'

- BEARING_ASSEMBLY_NO == "TA4639" D5 = 50
- BEARING_ASSEMBLY_NO == "TA1387" D5 = 45
- BEARING_ASSEMBLY_NO == "TA3850" D5 = 65
- BEARING_ASSEMBLY_NO == "TA6378" D5 = 55
- BEARING_ASSEMBLY_NO == "TA3321" D5 = 70
- BEARING_ASSEMBLY_NO == "TA3650" D5 = 70
- BEARING_ASSEMBLY_NO == "TA4607" D5 = 48
- BEARING_ASSEMBLY_NO == "TB2115" D5 = 85

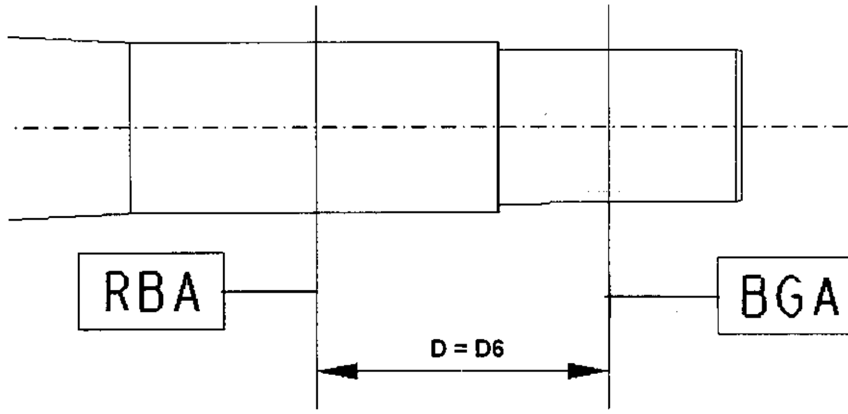


Figure 6.8 Relation for location of Bull Gear (D)

CALCULATION OF 'D'

- TYPE_OF_DRIVE == "Direct Drive" D6 = COUNTERSHAFT_EXTENSION - (D30/2)
- GEAR_MODULE_NO == 12 D6 = 252.5
- GEAR_MODULE_NO == 14 D6 = 282
- GEAR_MODULE_NO == 16 D6 = 292.5
- GEAR_MODULE_NO == 20 D6 = 320
- GEAR_MODULE_NO == 24 D6 = 370
- GEAR_MODULE_NO == 30 D6 = 382

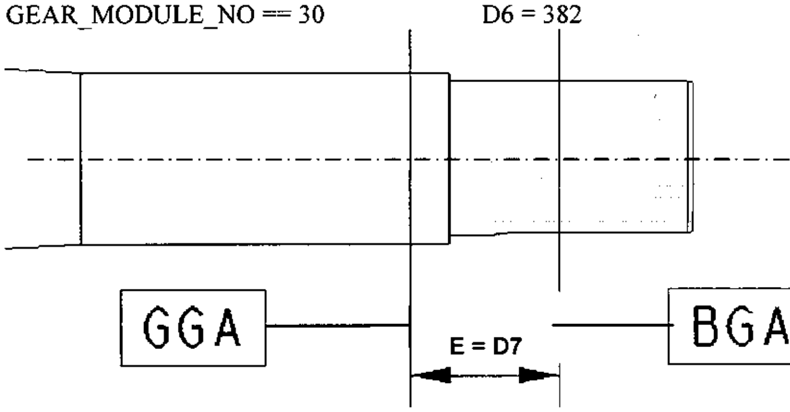


Figure 6.9 Relation for location of Gear Guard Assembly (E)

CALCULATION OF 'E' FROM GA

- GEAR_MODULE_NO == 12 D7 = 110
- GEAR_MODULE_NO == 14 D7 = 141
- GEAR_MODULE_NO == 16 D7 = 151.5
- GEAR_MODULE_NO == 20 D7 = 163
- GEAR_MODULE_NO == 24 D7 = 207

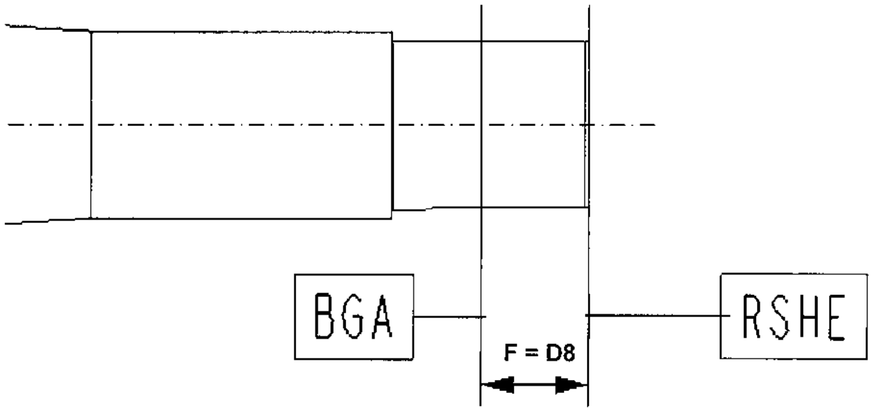


Figure 6.10 Relation for location of Drive Shaft (F)

CALCULATION OF 'F'

• TYPE_OF_DRIVE == "Direct Drive"	D8 = D30/2
• GEAR_MODULE_NO == 12	D8 = (189 + 185) - D6
• GEAR_MODULE_NO == 16	D8 = (210 + 185) - D6
• GEAR_MODULE_NO == 20	D8 = (265 + 200) - D6
• GEAR_MODULE_NO == 24	D8 = (365 + 205) - D6
• GEAR_MODULE_NO == 30	D8 = (406 + 210) - D6

6.8.3 Second Stage

In the second stage of programming, program is developed based on the above mentioned relations, so that respective subassemblies along with other accessories will be assembled at their respective locations. Programming for the same is enclosed as Appendix 1.

6.8.4 Final Stage

During the progress of developing the program, it has been decided that drive shaft can be modeled automatically based on the relations. This eliminates the assembly of separate drive shaft component. Automatic Modeling of drive shaft based on the relations associated with it is explained as follows.

To start with, program is developed for planes, which is used to control the various lengths of the drive shaft.

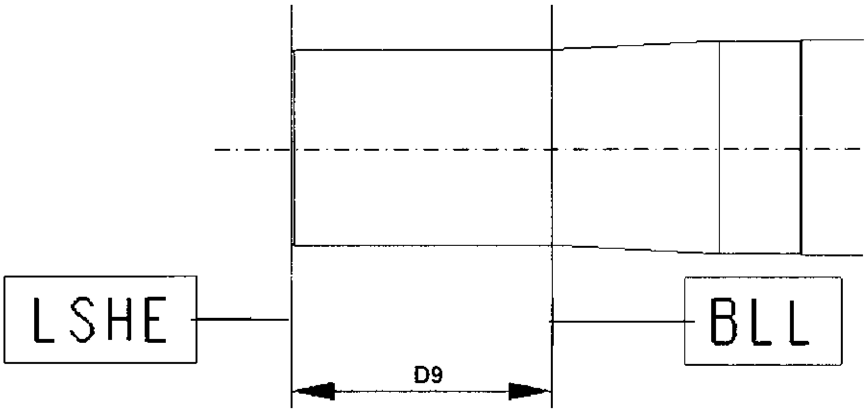


Figure 6.11 Relation for first length of Drive Shaft

CALCULATION OF FIRST LENGTH FROM LEFT OF DRIVE SHAFT (BLL)

- BEARING_ASSEMBLY_NO == "TA4639" D9 = 215
- BEARING_ASSEMBLY_NO == "TA1387" D9 = 200
- BEARING_ASSEMBLY_NO == "TA3850" D9 = 270
- BEARING_ASSEMBLY_NO == "TA6378" D9 = 220
- BEARING_ASSEMBLY_NO == "TA3321" D9 = 300
- BEARING_ASSEMBLY_NO == "TA3650" D9 = 275
- BEARING_ASSEMBLY_NO == "TA4607" D9 = 203
- BEARING_ASSEMBLY_NO == "TB2115" D9 = 335

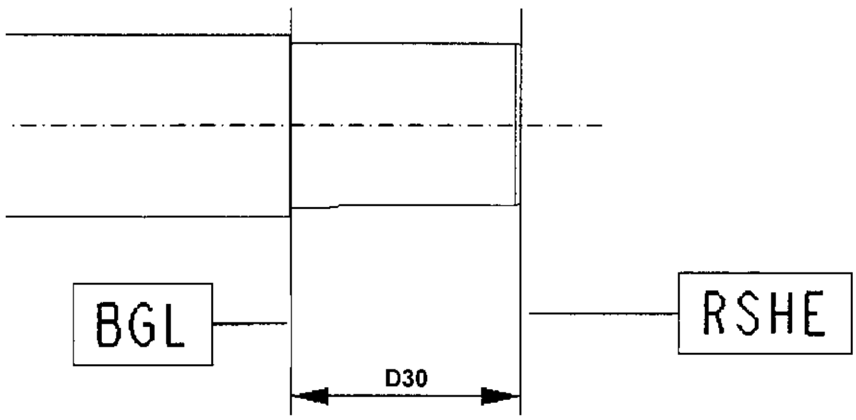


Figure 6.12 Relation for Bull Gear Width Length of Drive Shaft

CALCULATION OF BULL GEAR WIDTH LENGTH (BGL) FROM RIGHT OF DRIVE SHAFT

- TYPE_OF_DRIVE == "Direct Drive" D30 = COUPLING_LTH
- GEAR_MODULE_NO == 12 D30 = 153
- GEAR_MODULE_NO == 14 D30 = 189
- GEAR_MODULE_NO == 16 D30 = 210
- GEAR_MODULE_NO == 20 D30 = 265
- GEAR_MODULE_NO == 24 D30 = 365
- GEAR_MODULE_NO == 30 D30 = 406

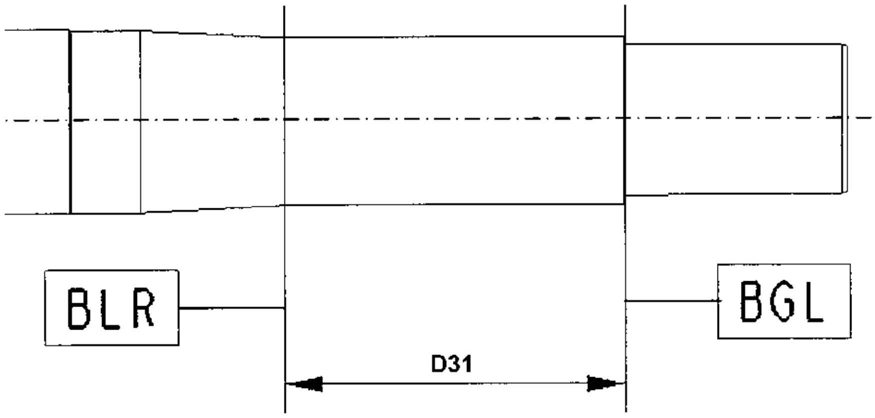


Figure 6.13 Relation for Bearing Assembly Length of Drive Shaft

CALCULATION OF BEARING ASSEMBLY LENGTH RIGHT (BLR) OF DRIVE SHAFT

• TYPE_OF_DRIVE = "Direct Drive"	D31 = (D9 - D5) + (COUNTERSHAFT_EXTENSION - D30)
• GEAR_MODULE_NO == 12	D31 = (D9 - D5) + 175
• GEAR_MODULE_NO == 14	D31 = (D9 - D5) + 185
• GEAR_MODULE_NO == 16	D31 = (D9 - D5) + 185
• GEAR_MODULE_NO == 20	D31 = (D9 - D5) + 200
• GEAR_MODULE_NO == 24	D31 = (D9 - D5) + 205
• GEAR_MODULE_NO == 30	D31 = (D9 - D5) + 210

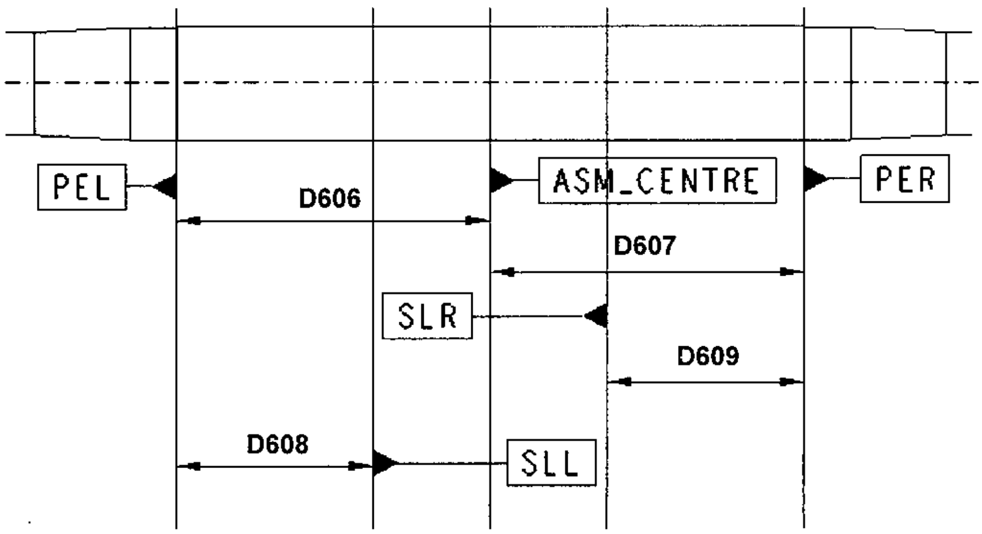


Figure 6.14 Relation for Sprocket Assembly Length of Drive Shaft

CALCULATION OF SPROCKET ASSEMBLY LENGTHS ON THE DRIVE SHAFT

SPROCKET_ASSEMBLY_NO == "TB0172"

- D606 = D1 + 105
- D607 = D1 + 105
- D608 = 280
- D609 = 280

Further for the generation of different diameters of the drive shaft relations were formed and which is explained as follows.

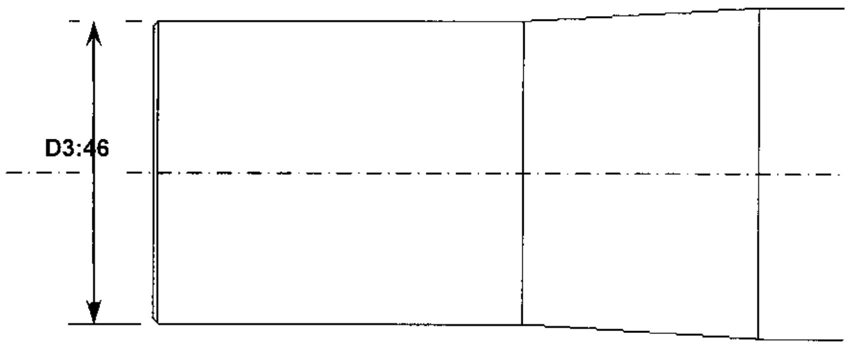


Figure 6.15 Relation for diameter 1 from left of Drive Shaft

CALCULATION OF DIAMETER 1

• BEARING_ASSEMBLY_NO == "TA4639"	D3:46 = 135
• BEARING_ASSEMBLY_NO == "TA1387"	D3:46 = 110
• BEARING_ASSEMBLY_NO == "TA3321"	D3:46 = 240
• BEARING_ASSEMBLY_NO == "TA3650"	D3:46 = 220
• BEARING_ASSEMBLY_NO == "TA3850"	D3:46 = 200
• BEARING_ASSEMBLY_NO == "TA4607"	D3:46 = 125
• BEARING_ASSEMBLY_NO == "TA6378"	D3:46 = 150
• BEARING_ASSEMBLY_NO == "TB2115"	D3:46 = 280

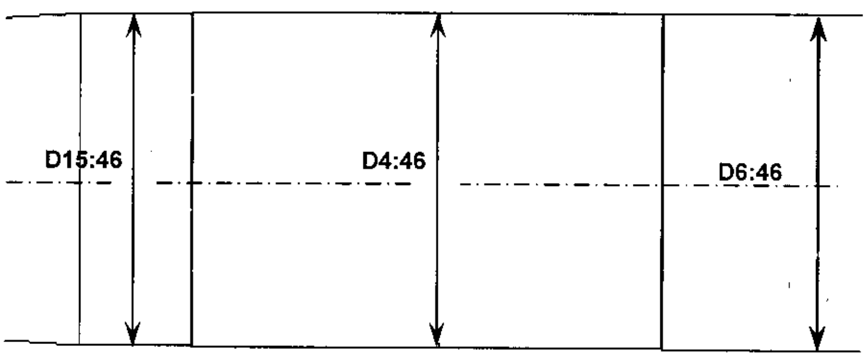


Figure 6.16 Relation for diameter 2 and others from left of Drive Shaft

CALCULATION OF DIAMETER 2 and allied

• SPROCKET_ASSEMBLY_NO == "TB0172"	D4:46 = 150
• SPROCKET_ASSEMBLY_NO == "TB0185"	D4:46 = 150
• SPROCKET_ASSEMBLY_NO == "TA8424"	D4:46 = 220
• SPROCKET_ASSEMBLY_NO == "TA8999"	D4:46 = 180
• SPROCKET_ASSEMBLY_NO == "TA9914"	D4:46 = 280
• SPROCKET_ASSEMBLY_NO == "TB1807"	D4:46 = 190
• SPROCKET_ASSEMBLY_NO == "TA4439"	D4:46 = 220

- D15:46 = D4:46 - 2
- D6:46 = D4:46 + 1

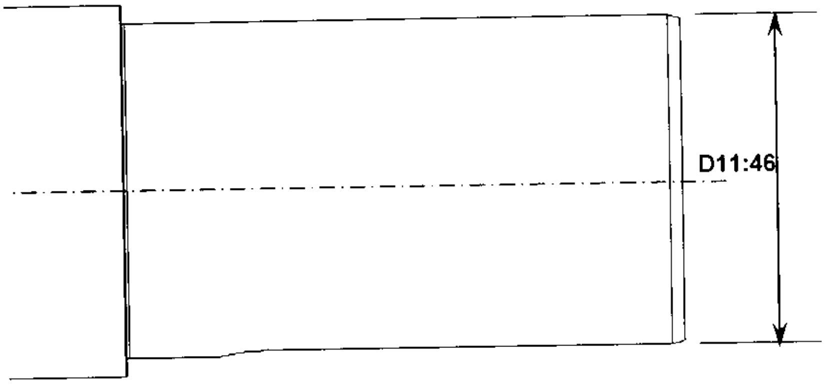


Figure 6.17 Relation for diameter 1 from right of Drive Shaft

CALCULATION OF DIAMETER 1 FROM RIGHT

• TYPE_OF_DRIVE == "Direct Drive"	D11:46 = COUPLING_DIAMETER
• GEAR_MODULE_NO == 12	D11:46 = 100
• GEAR_MODULE_NO == 14	D11:46 = 125
• GEAR_MODULE_NO == 16	D11:46 = 140
• GEAR_MODULE_NO == 20	D11:46 = 180
• GEAR_MODULE_NO == 24	D11:46 = 200
• GEAR_MODULE_NO == 30	D11:46 = 230

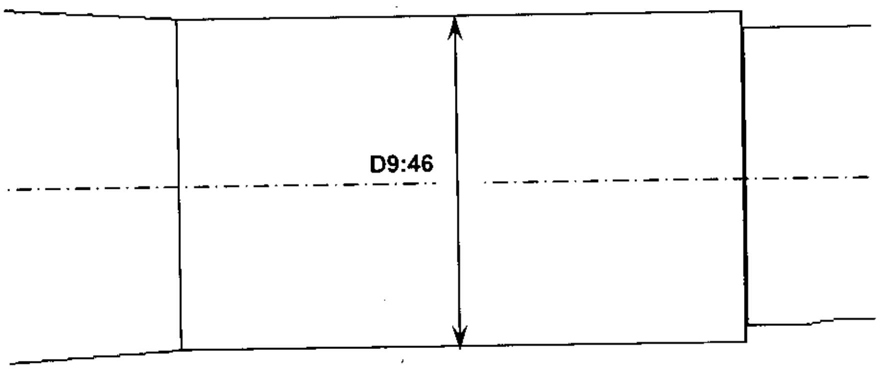


Figure 6.18 Relation for diameter 2 from right of Drive Shaft

CALCULATION OF DIAMETER 2 (BEARING DIAMETER) FROM RIGHT

• BEARING_ASSEMBLY_NO == "TA4639"	D9:46 = 135
• BEARING_ASSEMBLY_NO == "TA1387"	D9:46 = 110
• BEARING_ASSEMBLY_NO == "TA3321"	D9:46 = 240
• BEARING_ASSEMBLY_NO == "TA3650"	D9:46 = 220
• BEARING_ASSEMBLY_NO == "TA3850"	D9:46 = 200
• BEARING_ASSEMBLY_NO == "TA4607"	D9:46 = 125
• BEARING_ASSEMBLY_NO == "TA6378"	D9:46 = 150
• BEARING_ASSEMBLY_NO == "TB2115"	D9:46 = 280

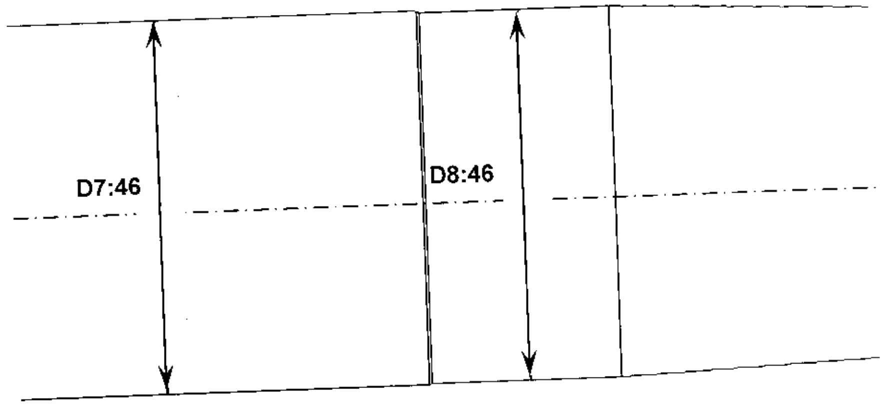


Figure 6.19 Relation for diameter 3 from right of Drive Shaft

CALCULATION OF DIAMETER 3 (SPROCKET DIAMETERS) FROM RIGHT

- SPROCKET_ASSEMBLY_NO == "TB0172" D7:46 = 150
- SPROCKET_ASSEMBLY_NO == "TB0185" D7:46 = 150
- SPROCKET_ASSEMBLY_NO == "TA8424" D7:46 = 220
- SPROCKET_ASSEMBLY_NO == "TA8999" D7:46 = 180
- SPROCKET_ASSEMBLY_NO == "TA9914" D7:46 = 280
- SPROCKET_ASSEMBLY_NO == "TB3562" D7:46 = 120
- SPROCKET_ASSEMBLY_NO == "TB1807" D7:46 = 190
- SPROCKET_ASSEMBLY_NO == "TA4439" D7:46 = 220
- D8:46 = D7:46 – 2

In addition, the taper that is provided in the drive shaft has been related as follows and the same is incorporated into the program which is given as enclosure as Appendix 1.

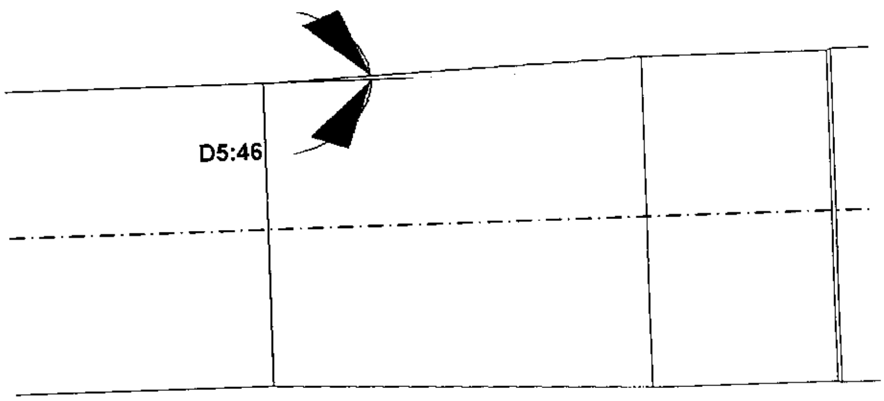


Figure 6.20 Relation for taper angle of Drive Shaft

CALCULATING TAPER ANGLE OF DRIVE SHAFT

- D5:46 = CEIL (ATAN (((D15:46 - D3:46)/2) / ((((D4/2) + D5) - D9) - D606)))
- D10:46 = D5:46 (Taper on other side)

Chamfers that are existing in both the sides of the drive shaft have been related based on the bearing assembly and gear module which is explained as follows.

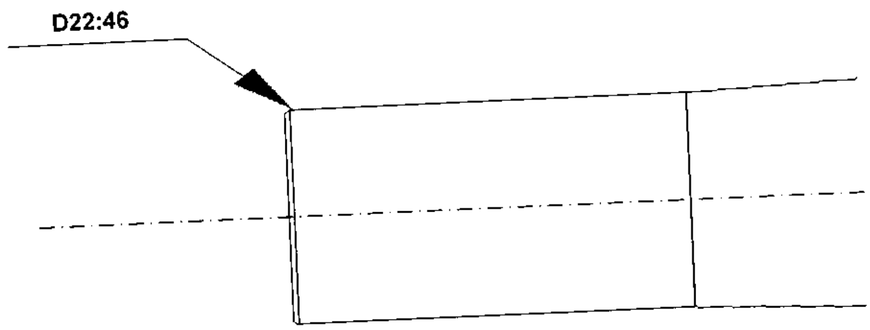


Figure 6.21 Relation for chamfer on left side of Drive Shaft

CALCULATION OF CHAMFER OF DRIVE SHAFT

- BEARING_ASSEMBLY_NO == "TA4639" D22:46 = 2
- BEARING_ASSEMBLY_NO == "TA1387" D22:46 = 2
- BEARING_ASSEMBLY_NO == "TA6378" D22:46 = 2

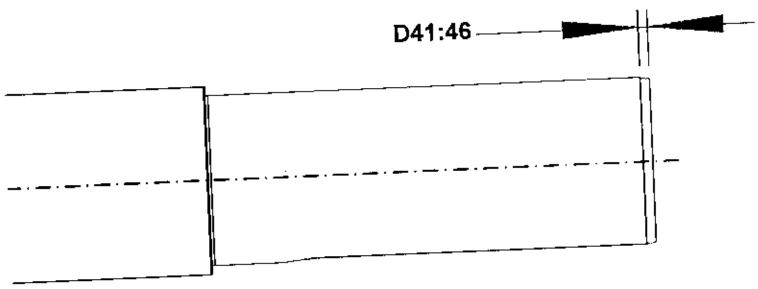


Figure 6.22 Relation for chamfer on right side of Drive Shaft

USED FOR CALCULATION OF CHAMFER RIGHT SIDE OF OPEN TYPE

TYPE_OF_DRIVE == "OPEN PAIR"

- GEAR_MODULE_NO == 14 D41:46 = 6
- GEAR_MODULE_NO == 12 D41:46 = 4

TYPE_OF_DRIVE == "DIRECT DRIVE"

- COUPLING_DIAMETER <= 100 D41:46 = 4
- COUPLING_DIAMETER > 100 D41:46 = 6

Holes that are provided in the right hand side of drive shaft for fixing the end plate has been modeled based on the relations with gear module as explained below.

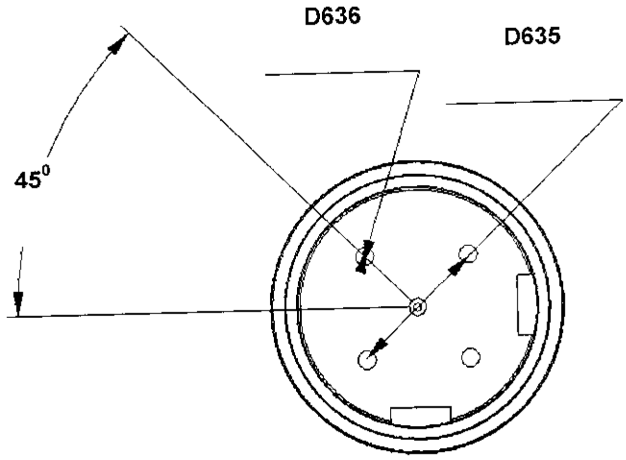


Figure 6.23 Relation for holes on right side of Drive Shaft

HOLES IN THE DRIVESHAFT RIGHT

GEAR_MODULE_NO == 12

- D636 = 10.25
- D635 = 55
- D633 = 30

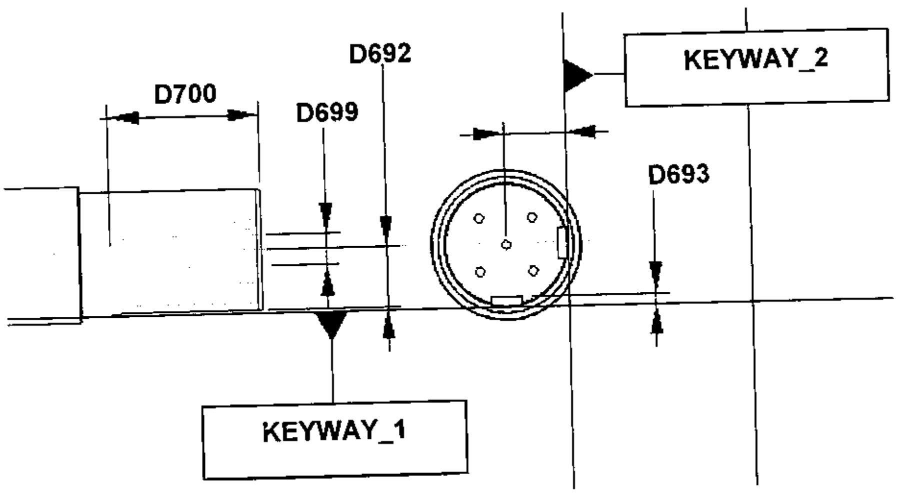


Figure 6.24 Relation for keyways of the Drive Shaft

TO CONTROL THE KEY WAY_1 DATUM PLANE

- GEAR_MODULE_NO == 14 D692 = 125/2
- GEAR_MODULE_NO == 12 D692 = 100/2

TO CONTROL THE KEYWAY_1 DIMENSIONS

GEAR_MODULE_NO == 14

- D700 = 160
- D699 = 32
- D693 = 11

TO CONTROL THE KEYWAY_2 DIMENSIONS

GEAR_MODULE_NO == 14

- D702 = 160
- D701 = 32
- D696 = 11

CALCULATION OF KEYWAY_1_DDR & KEYWAY_2_ DDR DIMENSION

- D739 = COUPLING_DIAMETER/2
- D740 = COUPLING_DIAMETER/2

USED FOR CALCULATION OF KEYWAY_1 IN DIRECT DRIVE

- KEY_PART_NO == "TA9727"
- D742 = 28
- D741 = 10
- D743 = 110

6.9 CONCLUSION

It is noted that the following axioms and guides provided by Chih-Hsing Chu (2006) were adopted during the modeling and building the relations.

6.9.1 Axioms and guidelines adopted for design parameterization

Axiom 1: Maintain the independence of design intents

Axiom 2: Minimize the information content of the design intents.

Axiom 1 implies that changing the value of dimension design variables has an effect only on the corresponding design intent. In other words, it is desirable to uncouple the design intents whenever possible. Axiom 2 states that the amount of information (number of dimensions) that is available to the engineer for capturing the design intent must be minimized.

Thus a program has been developed, which is enclosed in Appendix 1 for parameterizing the drive wheel assembly of the apron conveyor. Final drive wheel assembly of both the open type and direct type is shown in the following figures 6.25. and 6.26.

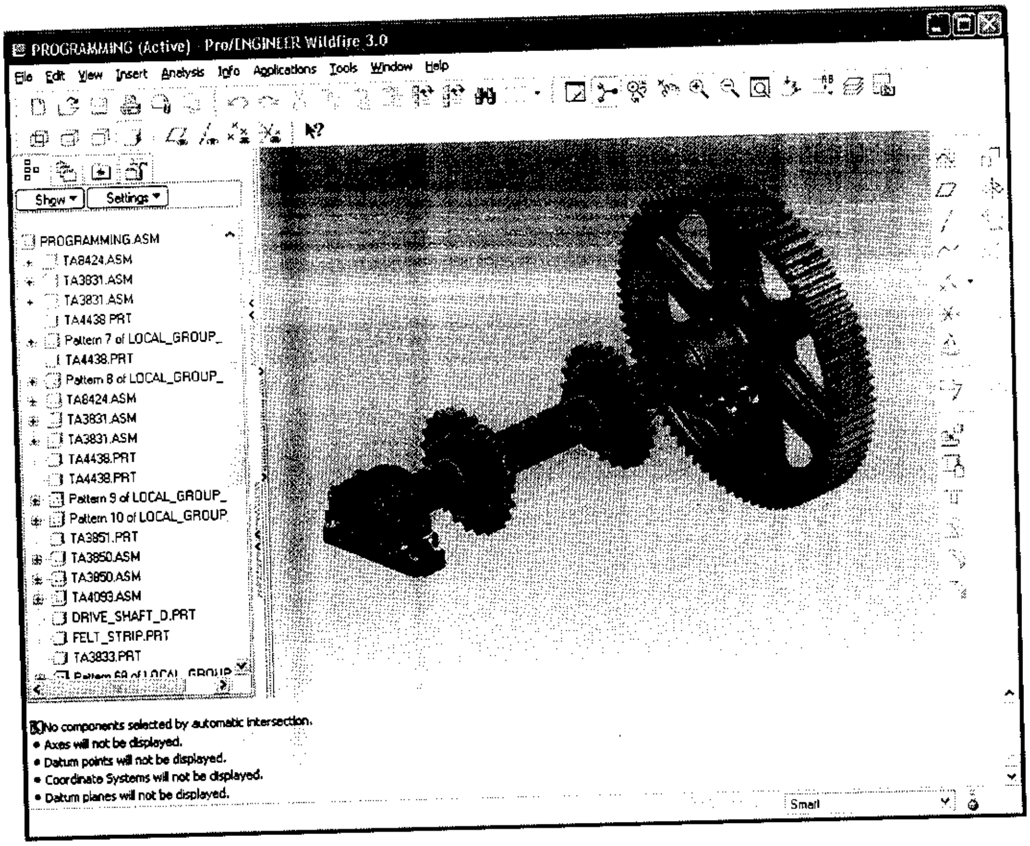


Figure 6.25 Modeled Open type Drive Wheel Assembly

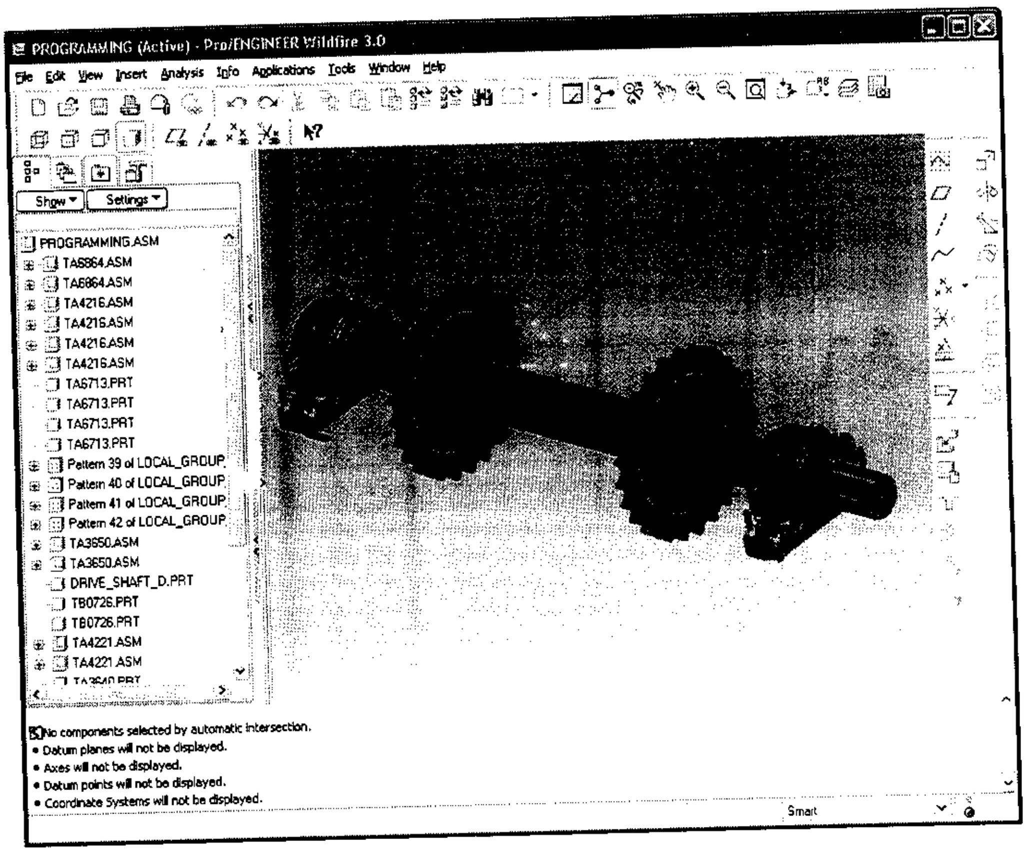


Figure 6.26 Modeled Direct type Drive Wheel Assembly

Chapter 7

Conclusions

CHAPTER 7

CONCLUSIONS

A Pro/PROGRAM has been developed to assemble different configuration of drive wheel assembly for both open type and direct type with minimum inputs. Moreover the output drafting of the assembly along with bill of materials and balloon has been obtained, which is shown in figures 7.1 and 7.2.

It has been estimated that the release of the drawing (shown in figures 7.1 and 7.2) takes about 48 hours i.e. 6 working days before implementing this project. Now, it has been estimated that it will take about only 4 hours to release the drawings. A drawing program also been developed to switch to the required dimension that has to be shown in the drawing sheet with respect to the open type or direct type. Drawing program developed is as follows

```
IF TYPE_OF_DRIVE:1 == "DD"
SET STATE DD
ENDIF
IF TYPE_OF_DRIVE:1 == "OP"
SET STATE OP
ENDIF
```

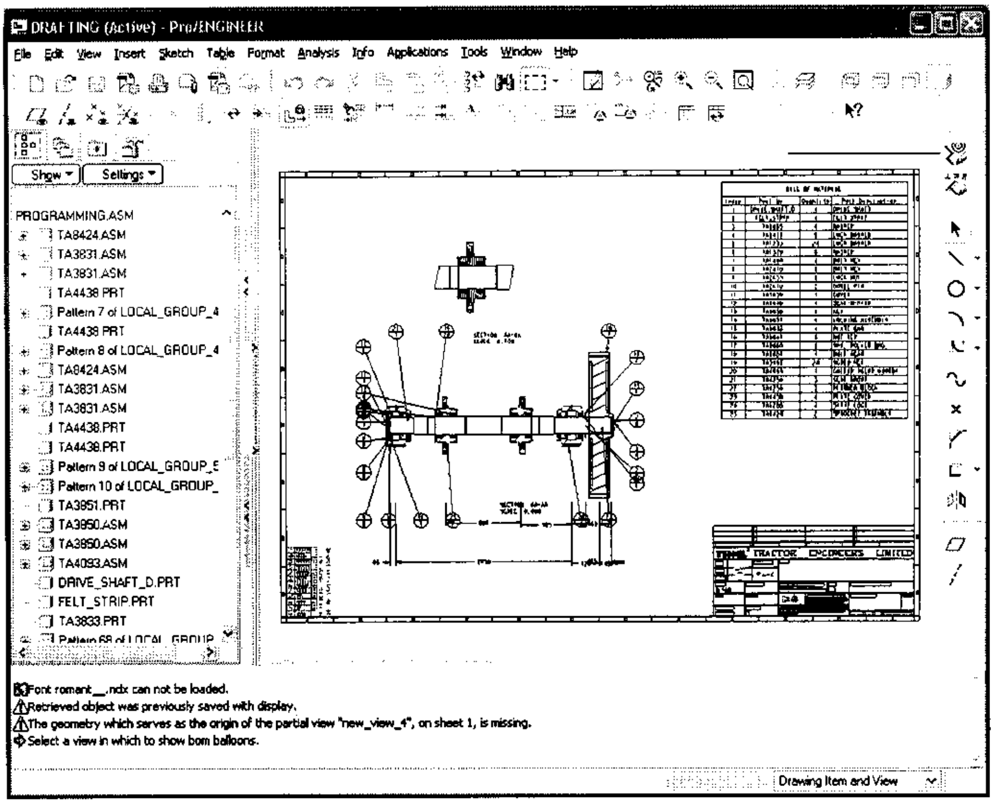


Figure 7.1 Drafting output of Open type Drive Wheel Assembly

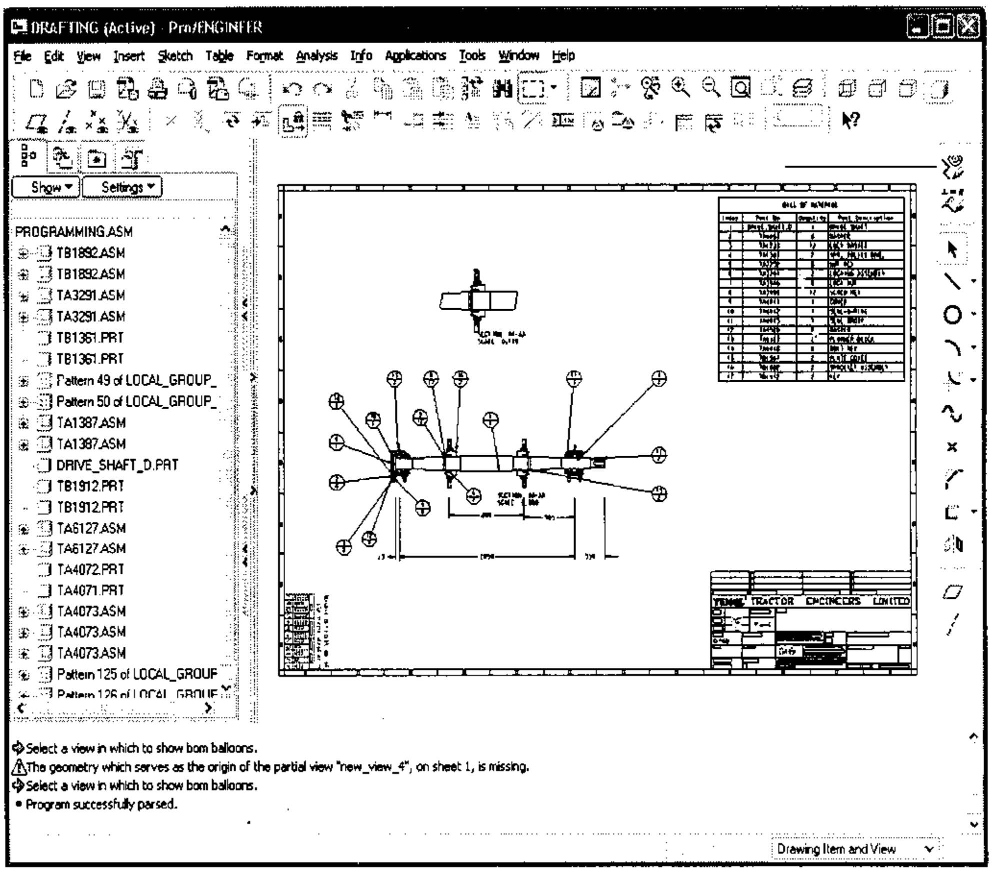


Figure 7.2 Drafting output of Direct type Drive Wheel Assembly

Appendix 1

Sample Program

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