Abstract

Conveyor system is an essential part in a Semiconductor Industry. It is used to transfer leadframes from one work station to another. As leadframe is a very delicate item and care must be taken not to damage them as any scratch marks or dents found on it will lead to it being scraped. Therefore, the design of the conveyor system is important. A good conveyor system will help to save up in the production process, time and most importantly cost.

Nowadays, companies with high end products have suddenly swamp into Singapore. This is due to its attractive location, extensive telecommunications connectivity, superior logistics and supply chain infrastructure. Companies like Matsushita Electric and Chartered Semiconductor has invested hundreds of million dollar into it. These show that the semiconductor market is in the midst of a strong growth in equipment and materials, and all indications are that this trend will continue for a long time. Therefore a good process line is required for the manufacturing of the products in order to keep pace with the ever increasing demand. This is when a good conveyor system comes in handy.

The main objectives of this research project are to:

- Design and develop a custom made conveyor system to help in transferring the leadframe from the press machine to the stacker, whereby the leadframe will be nicely stack up after being cut, without damage.
- Separate the four strands of leadframes that is been cut out from a coil by the press machine, to aid in the stacking process.
- Save production process, time and cost.
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Prof G Baker
Dean
Faculty of Engineering and Surveying
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I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

LIM DOOU GIE

Student Number : 0031135732

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Signature

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Date
Acknowledgements

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Chapter 1

Introduction

Nowadays modern manufacturing methods dictate the use of material handling systems. Material handling is an integral part of many continuous processes. There are two basic methods used for moving materials: nonpowered material handling systems and powered material handling systems.

Nonpowered systems use gravity as the motive force and include devices such as chutes and slides, which are the simplest and least expensive methods available. However they require the starting point to be at a certain minimum elevation higher than the end point. In most material handling situations, this is rarely the case.

For moving material horizontally, vertically, over extended distances, or in a controlled fashion, powered material handling systems are required.

1.1 Importance of a Conveyor System

Conveyors, a type of materials handling system, are an essential part of large-scale production and continuous processes. They are used in such diverse fields as agriculture, food processing, plastics manufacturing, mining industries, and most
important of all, semiconductor industries. Some conveyors can provide minor processing functions such as heating and cooling, but this is supplementary to the primary materials handling function.

Conveyor system is an essential part in a Semiconductor Industry. It is needed during the work process to transfer leadframe from one work station to another. Leadframe is a very delicate item and care must be taken not to damage them as any scratch marks or dents found on it will lead to it being scrapped. Therefore, the design of the conveyor system is important. The materials, speed and belt used play an important part in the designing process. A good conveyor system will help to save up in the production process, time and most importantly cost.

1.2 Definition of Conveyor System

The following gives the definition of a conveyor:

A conveyor includes all fixed and portable equipment capable of moving material in a continuous or intermittent fashion, between two or more points, along a fixed path. While the material may be delivered intermittently, the drive operates continuously. The movement of material can be horizontal, vertical, inclined, or any combination of the three.

In order for a person to select a conveyor system, one is to have an understanding and familiarity of the specific process to which the equipment is to be applied. This knowledge is invaluable and may make the difference between a successful application and a failure. It is the small neglected detail in the process or the conveyed material that can lead to a system plagued with problems and unexpected downtime.
1.3 Types of Conveyer System

There are so many kinds of conveyer in the market. Which one of them is most suitable to be used in this project has to depend on its functionality. Let us look at some of the common types of conveyer.

1.3.1 Powered Rollers

Powered rollers conveyors, straight or curved, are extensively used for heavy and arduous applications such as rolling mills and foundries. They are also an ideal medium in package handling for systems where it is necessary to stop, meter, or manipulate articles without stopping the conveyer. It is also an economical way of moving heavy loads in limited space.

1.3.2 Chain

Chain conveyors have been designed to cover many varied applications in industry and employ several distinct patterns including twin chain, multiple chain, in-floor, on-floor and heavy duty overhead. They are particularly useful where high temperatures are involved, and special designs with expansion joints and automatic spray lubrication are available.

1.3.3 Belt

Belt conveyors are probably the most widely used of all the various types of conveying equipment. They are extremely versatile and there are many variations. The range varies from very small conveyors used in packaging machinery through to heavy duty conveyors used for bulk materials. They usually consist of moving single or multiple endless bands of material upon which the product sits and is conveyed. The belts can take a straight path or can be twisted through more complex paths.
1.3.4 Slat

Slat conveyors are most suitable for use when the unit loads are beyond the capacity of belt conveyors, or where heat or other adverse conditions render the use of the latter impracticable. They are frequently fitted with chains having oversized rollers. The larger the roller diameter, by reducing the number of revolutions per roller, increases chain life and also allows the use of heavier chain sprockets. Slat conveyors are extremely versatile, not only because their design and construction is simple but also because maintenance and tracking problems are minimal. They are also excellent for heavy loads and rough treatment.
Chapter 2

Background

Nowadays, companies with high end products have suddenly swamp into Singapore. This is due to its attractive location, extensive telecommunications connectivity, superior logistics and supply chain infrastructure. These show that there is a high demand for the semiconductor products.

2.1 Overview of Semiconductor Industry

According to Stanley T. Myers, President and CEO, SEMI, these companies continue to see Singapore as an attractive location because of its business-friendly environment, respect for intellectual property, extensive telecommunications connectivity, skilled workforce, and superior logistics and supply chain infrastructure.

Evidence of this is the continued investments in the IC manufacturing sector that have reinforced Singapore’s role as a regional center for semiconductor production.
STMICROELECTRONICS NV, Europe’s largest semiconductor maker, will invest another $2 billion over the next two years in Singapore, a move that will bring its total investment here to $6.7 billion by the end of 2006.

STMicroelectronics, which accounted for about 19 per cent of Singapore’s semiconductor production last year, will invest the funds to increase its capacity. Last year, its manufacturing output in Singapore was $3.9 billion, compared with overall industry production in the nation of $21 billion, according to Trade Minister Lim Hng Kiang.

STMicroelectronics, based in Geneva, said that it made chips in Singapore for products such as cell phones equipped with digital cameras. According to a company press release, STMicroelectronics is the only semiconductor company in Singapore with a fully-integrated manufacturing value-chain employing about 7400 staff.

Several other device makers have increased their resources in Singapore recently. They include Matsushita Electric Industrial, which selected Singapore as the site for a new S$150 million assembly and test facility for charged coupled device (CCD) image sensors. Last year Infineon Technologies announced plans to increase its R&D headcount here to more than 350 and to make Singapore its global logic IC testing hub. In February, Xilinx said it would establish its Asia Pacific headquarters in Singapore, employing about 200 people. Then a month later foundry Chartered Semiconductor Manufacturing revealed plans to start outfitting its 300mm fab shell.

For SMMAP, the sponsor of this project, it has been constantly upgrading its working processes and machine performances to cope with the ever increasing high demands and standards of semiconductor products.

In addiction to device makers, equipment and materials suppliers view Singapore as a favourable location for key manufacturing and logistics operations. Over the past few years, several equipment suppliers have boosted their presence here, by
tapping into the excellent infrastructure for the manufacture of subsystems and components.

All these companies have invested millions of dollars for the new technologies and facilities. These show that the semiconductor market is in the midst of a strong growth in equipment and materials, and all indications are that this trend will continue for a long time.

According to a source from SICAS, in a market where the 2004 August year-to-date world growth rate is 35%, Asia-Pacific is growing at a rate of 50% and the three other regions are growing by roughly half of that. The Asia-Pacific share of the world market has grown to 42%. Semiconductors are made to be assembled into end electronic equipment, which is what Asia-Pacific has grown increasingly adept at doing well and at the right price. Figure 2.1 shows the regional market trends for Semiconductors.

Figure 2.1 Regional Market Trends for Semiconductors
These show that there is a high demand for the semiconductor products. Therefore a good process line is required for the manufacturing of the products in order to keep pace with the ever increasing demand. This is when a good conveyor system comes in handy.

2.2 Definition of Leadframe

Other than common items like IC Chips, transistor, LED & wafers, leadframes are also one of the products from semiconductor industry. Over SMMAP, surface plating of lead frame is been processed and the end products are mainly in both coil form or strip form. It is the processing of leadframe that SMMAP is dealing with. Figure 2.2 shows the different types of leadframes.

![Figure 2.2 Different Types of Leadframes](image)

Leadframe is the skeleton of the IC package, providing mechanical support to the die during its assembly into a finished product. It consists of a die paddle, to which the die is attached, and lead fingers, which serve as the means for external electrical connection to the outside world. The die is connected to the lead fingers by wires through wirebonding or by tape automated bonds. Figure 2.3 shows the features of a leadframe. Leadframes are used in almost all semiconductor packages.
Plastic package leadframes are made of alloys that meet the following critical properties: good adherence to the molding compound, a coefficient of thermal expansion as close as possible to those of the die and the molding compound, high strength, good formability, and high electrical and thermal conductivities. Alloy 42 is an example of such an alloy. However most of the leadframes are made of Cu.

2.3 Most Common Basic Elements

2.3.1 Silicon

Si is the most commonly used basic building block of integrated circuits. Si is a semiconductor, which means that its electrical behavior is between that of a conductor and an insulator at room temperature.

Aside from being used as semiconductor substrate, Si is also widely used as dielectric in integrated circuits, usually in the form of silicon dioxide. Dielectric
layers are used to isolate conductive lines and the individual components in the circuit from each other.

Si is also widely used in semiconductor packaging, being the main ingredient of plastic encapsulants for integrated circuits. It is also used in die overcoats.

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Table 2.1 Silicon’s Basic Properties

2.3.2 Aluminium

Al is a lightweight metal with silvery appearance. It is the most abundant metallic element on earth. It is used in many aspects of semiconductor manufacturing. On the integrated circuit, Al metal lines are commonly used as the main conductor between components, mainly because of its low resistivity (2.7 mohm-cm). As a thin film, it also has good adherence to silicon dioxide.

Al is also the metallization used for the bonding and probing pads on the die. When used for IC metallization, Al is usually very lightly doped with other elements such as Si and/or Cu to improve its characteristics and reliability.

In semiconductor assembly, ceramic packages are composed mainly of alumina. Al is also used for wirebonding integrated circuits in ceramic packages.
Table 2.2 Aluminium’s Basic Properties

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2.3.3 Gold

Au is a soft metallic element that is bright yellowish in color. A good conductor of heat and electricity, it is also the most malleable and ductile of all metals.

Au is used in many aspects of semiconductor manufacturing, particularly in the assembly or packaging processes. Its most widespread use is in wirebonding. Because of its excellent conductivity and ductility, it is extensively used in making wires for the connection of the integrated circuit to the leads of the package. Aside from manufacturability, the ductility of Au wires offers one more advantage when used in plastic-encapsulated devices, i.e., it makes the wires resistant to wire breaking during the encapsulation process.

Au is also used as die attach material for the eutectic die attach process, which is commonly used in old hermetic assembly processes. It is also used to cover the die cavity and bonding posts of ceramic packages to protect these from chemical degradation.
### Table 2.3 Gold’s Basic Properties

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### 2.3.4 Silver

Ag is a shiny metallic element used for ornamental and coinage purposes since the ancient times. It is next only to gold in terms of malleability and ductility, and is also a good conductor of heat and electricity. In fact, silver is the best conductor of electricity, better even than copper and gold.

Ag, like Au, is used in many facets of semiconductor manufacturing, again more particularly in the assembly or packaging processes. Most epoxy die attach materials contain silver fillers for increased thermal and electrical conductivity. Ag is also used to cover the surfaces of the die pad and bonding fingers of the leadframes of plastic packages to prevent chemical degradation of these areas, which may lead to die attach and bonding problems.

### Table 2.4 Silver’s Basic Properties

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2.3.5 Copper

Cu is one of the most widely used metals in the history of mankind, mainly because of its many desirable properties. It is the second best conductor of electricity, next only to silver but better even than gold. It is also very malleable and ductile, and is also a good conductor of heat.

Cu is also widely used in semiconductor assembly. For instance, most leadframes for plastic packages are composed of copper. The leadframe is the skeletal support of a plastic package.

Cu, being an excellent conductor, would have been a very good candidate for use in metal lines in an integrated circuit, but difficulties in the manufacturing of IC's using Cu for metallization resulted in Al being the metal of choice for this purpose. Recent technological advancements though have already allowed the use of Cu as metal lines in semiconductor devices.

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Table 2.5 Copper’s Basic Properties

2.4 Types of Processes

The processes of a leadframe can be categorized into two types: the wet process and the dry process.
2.4.1 The Wet Process

In wet process, chemical solutions and water is used throughout the etching, plating and cleaning processes. Etching consists of selectively covering the sheet metal with photoresist in accordance with the pattern of the leadframe. The sheet metal is then exposed to chemical etchants that remove areas not covered by photoresist.

Silver plating is done on the bonding fingers and die-pad to improve wirebond and die attach quality. After that the whole strip is cleaned with distilled water to remove all the chemical solution before passing through a blower to dry up. The end product is then coil up again for the subsequent dry process.

2.4.2 The Dry Process

For dry process, no chemical or water is needed. During this stage, taping, down-setting and cutting is done.

Taping consists of putting a lead lock tape over the leads to prevent lead deformation, while downsetting consists of pushing the die paddle down relative to the bonding fingers in compliance with standard industry requirements.

In Cutting, the required length of the leadframe is cut out from the long strip of coil using a stamping machine. From here the leadframe is then sent to a machine called ‘Stacker’ to stack up the strips of leadframe. For this to be able to carry out, a conveyor system is necessary.

Whereas only occasional rollers along the work station are used to support the leadframe for the rest of the process. Since the leadframe is in a long strip and moving of the leadframe from one process to the other is done by a driver. So it does not need a conveyor system. Figure 2.4 shows a flow chart of the various types of work process for leadframe.
Figure 2.4 Work Process of Leadframes
Chapter 3

Objectives of the Project

The objectives of this project is to develop a custom made conveyor system to help in transferring the leadframe from the press machine to the stacker, whereby the leadframe will be nicely stacked up after being cut, without damage. It must link up well with the press and stacker machine. In addition, it must be able to separate the many strand of leadframes cut out by the press machine at a time to aid in the stacking process. This ultimate system will help to save a lot in the production process, time and cost.

The purpose of the project is also to conduct research studies on the various types of conveyors regarding its capabilities, materials used and work performances. Develop a custom made conveyor that is able to perform up to the highest standard and on top of that it must suit the kind of work processes required by semiconductor industry. It will generally help in the various aspects of the engineering productions.
Chapter 4

Methodology

Before starting on the project, a detail specification had to be prepared for the conveyor to be based on. So a meeting with the people involve is a must so that the project group can have a better understanding of the require system. Typically, the specification will contain information regarding the size, capacity, and layout of the conveyor system.

The peoples involve in the meeting include the customers, project managers, engineers, supervisors, technicians and even the operators from the related field.

4.1 Gathering of Information

Information regarding the project can be gathered through discussions and meetings. It is at this stage that a lot of matters have to be discussed. It is important that any issues regarding the project to be voiced out and discuss in order to have a clearer overview of what should be done. Below are the main areas.
4.1.1 Problems Encountered

Currently the present conveyor systems have a lot of problems. After checking, it was found that the systems cannot meet the new requirement and some of problems are due to wear. Below are the problems faced by the operators during production:
- Speed of the present conveyor is too slow and it cannot catch up with the outputs from the new press machine.
- It can only handle one piece of leadframe at a time.
- Conveyor belt gets loose easily. It does not have a proper tension.
- Black residue can be found around the bearings. It may due to wear.
- Conveyor belt tends to run and it is not in the center during operation.

4.1.2 Project Specifications

Specification of system is base on the customer requirement, so the system built must either meet the specification or exceeds the expectation. Below are some of the important areas:
- The different sizes of the leadframe which is to be run in the production.
- The speed range that the press machine has to be operated during production.
- The specific type of material that must be used for the system.
- The overall size of the whole system.
- The power rating for the electrical supply.
- The project schedule to let people.

4.1.3 Allocating of Task

Task allocating is important as it gives the people involved a clearer view of their responsibilities and their job scope. The type of task include:
- Overall in-charge of the project.
- The new concept design for the new stacker machine with the conveyor system.
- Mechanical installation for the whole unit.
- Electrical wiring and test run of the unit.

After the meeting with the persons involved, all the specifications and information is consolidated. Any changes to all these from the customer have to be discussed again and updated to everyone involved quickly. That is often why there are a few meetings to a project. The specifications and schedule for the project is tabulated and compiled in Appendix B and Appendix B respectively.

However customer must decide on their final requirements as soon as possible and a time limit to the changing of project specifications must be specified. If the specifications are to keep changing, designers will have a hard time in carrying out their design work. Because the designers have to change their designs according to the specifications. These make work difficult for them and are very time consuming. It will delay their work and as a result, it will affect the whole project schedule.

As this project is shared among a few people therefore communication and cooperation is important. Understanding of the peers’ work is vital especially when there is a linkage between each other designs. It is not uncommon to find that the design of one component hit the other part of the design if there is a communication breakdown between the project team members. Therefore teamwork is very important.

4.2 Development of Ideas

Design of the conveyor system takes time and it often involves a lot of research and experiments. Ideas can come from different sources.
Brainstorming is the best way but this requires a group of staffs, and the more the better. Often in this situation what you cannot think of, others can. So there are a lot of ideas generate from here. Consulting professional and experienced personnel can help too as they can give valuable advices. This can save us lots of trouble during the design stage. If not, studying the various existing conveyors and combine their best feature together into a design is also another way. However not every features can be implemented into a design as it depends on the limitations and their relevance to the work process.

After hearing advices from peers and supervisor and through observation of the existing conveyor in the production floor. I had decided to design the conveyor system base on belt conveyor type. Belt conveyor is the most suitable design as compare to the rest of the conveyor since the load is very light and it suits the application.

Figure 4.1 and Figure 4.2 show two top views of the preliminary designs.

Figure 4.1 uses four conveyors to transfer each of the leadframe to their destination. This is a very simple and direct design. However after studying, it is noticed that it is impossible to put the conveyor side by side as the width of the conveyor must be very small. It is very difficult to fabricate a small conveyor.

Moreover the different sizes of the conveyors have to be used when different sizes of the leadframe is been worked on. Time and cost is an important factor in production and we cannot waste time in changing the conveyors and it is ridiculous to have so many different sizes of conveyor. After the long strip of leadframe is been cut out, the four small pieces of leadframes are separated from each other by about 3-5 mm apart. As the gap between the leadframes is small, there may be a tendency that the leadframes will jam at the entrance of the conveyor prior to entering. So this design is not workable.
Let us now study Figure 4.2, the next design. A main conveyor is used to transfer the leadframes to their respective small conveyor with the aid of two separators. The separators are used to separate the leadframes further apart and they also prevent leadframes from jamming at the entrance of the small conveyors. The four small conveyors are not placed side by side; instead, they are located further from each other. In this way, they can be of bigger size to cater for all the different sizes of leadframe. For this design, the small conveyor does not have to change to run all the different sizes of leadframe. As such, there is no need to have so many sizes of conveyors. So this design is very much preferred.

Figure 4.1. Top View of 1st Design

Figure 4.2 Top View of 2nd Design
4.3 Finalisation of Design

After much simulation using the drawing software, AutoCAD, it was realised that the 1st design is definitely not workable. Since the gap between each leadframe is only 3-4 mm, it is impossible to have a side plate of the conveyor to be 2 mm if they are to be placed side by side. As mentioned earlier, the 2nd design is workable and the final design will base on this concept. This design is made up of one main conveyor, four sub-conveyors and two separators. This design actually incorporates both the powered material handling system and the nonpowered material handling system. The former being the conveyors and the latter refers to the separators. See Figure 4.3 for the final design.

4.3.1 Working Principle

There are basically two processes to the operation: The 1st stage and the 2nd stage.

1st Stage

After the long strip of leadframe is being cut out into four leadframes of smaller length and width, they are being transferred out of the press machine by the main conveyor to the 1st separator. Due to the offset of the centre of gravity, the two outermost leadframes will tilt to one side of the separator. Eventually the leadframes slide down the separator due to their own weight. When the leadframes reach the end of the separator, they will drop to the sub-conveyor and then transferred to the stacker unit to stack up. Refer to Figure 4.4 and Figure 4.5.

As for the two centre leadframes, they will start to slide down the plate to the bottom main conveyor when they, together with the two outermost leadframes, reached the end of the top main conveyor. They continue to travel along the main conveyor until they reach the 2nd separators. Refer to Figure 4.4 and Figure 4.6.

In short, 1st stage of the operation is to separate the two outermost leadframes from the four pieces of leadframes.
Figure 4.3 Plan View of Design
Step 1

4 Leadframes been cut out

Step 2

Step 3

Figure 4.4 Top View Showing How Outermost Leadframe are Separated (1\textsuperscript{st} Stage)
Figure 4.5. Side View Showing Outer Leadframe Sliding Down the Separator
Figure 4.6 Front View Showing Inner Leadframe Moving Along the Main Conveyor
2\textsuperscript{nd} Stage

When the two central leadframes reach the second separator, their centre of gravity is being offset. So they slide down to the other two sub-conveyors due to gravity. They are then transferred to the allocated stacker respectively for stacking up via the other two sub-conveyors. Refer to Figure 4.7 and Figure 4.8.

In short, the 2\textsuperscript{nd} stage of the process is to separate the final two central leadframes.

4.4 General Approach

After the concept of the design is out, it is then possible to choose the component parts. The selection for the component parts is discussed in Chapter 5.

With the size of all the component parts determined, a detailed assembly of all the parts is drawn out with the aid of AutoCAD software. At this stage, careful attention is needed or else one will encounter a lot of problems during the assembly of the parts. Designers must have a clear mind and be able to visualize any obstruction in fixing up the conveyor system.

After sizing is done and the parts drawing drawn, I need to source for the vendors and get a few quotations for all the parts needed. It is good to find as many vendors as possible during sourcing so that the prices and the lead time for the parts can be compared. Only then can I gauge which one is the most desirable.

If time is limited, I can distribute some parts out to different vendors to fabricate. But one thing I need to take note of is that for those parts to be fitted together, eg. bush and shaft, have them fabricated by the same vendor. So that they can control the tolerances of the parts and the situations whereby the parts unable to fit or too loose will not happen. Some of the general information for designing work can be found in Appendix D.1.
Step 1

2 Leadframes
From the 1st stage

Figure 4.7 Top View Showing How Inner Leadframes are Separated (2nd Stage)

Step 2

Step 3
Figure 4.8 Side View Showing How Inner Leadframes are Separated
The following factors should be observed during the design stage of a component or assembly to reduce corrosion to a minimum:

- The design should avoid crevices and corners where moisture may become trapped, and adequate ventilation should be provided.

- The design should allow for easy washing down and cleaning.

- Joints which are not continuously welded should be sealed, for example by the use of mastic compounds or impregnated tapes.

- Where dissimilar metals have to be joined, high strength epoxy adhesives should be considered since they insulate the metals from each other and prevent galvanic corrosion.

- Materials which are inherently corrosion resistant should be chosen or, if this is not possible, an anti-corrosive treatment should be specified.
Chapter 5

Selection of Components

A conveyor system is made up of several components. Each of these components plays an important part in the work performances of the conveyor system. Therefore special care should be given when selecting the components.

5.1 Conveyor Belts

The belt is the primary component of a belt conveyor system. It usually represents a substantial part of the initial cost of the system. Since it is such a large investment, proper selection is important to ensure long life. All other systems of a belt conveyor should be designed and built with the purpose of obtaining the longest possible belt life.

5.1.1 Components of a Conveyor Belt

A belt is composed of four main components. See Figure 5.1.
5.1.1.1 Carcass

The carcass performs all of the primary functions of the belt. It provides the tensile strength necessary to move the loaded belt and absorbs the impact forces of material being loaded onto the belt. It also provides lateral stiffness necessary to support the load between idlers and gives adequate strength for mechanical fasteners to hold on to. It is formed by bonding the piles of fabric together with a rubber or polymer skim coat.

5.1.1.2 Breaker

A breaker is a special fabric found on top of the fabric piles. It is used to increase the adhesion between the carcass and the top cover. It can also be designed to increase the impact, heating, and ripping resistance of a belt. Breaker can also increase lateral support.

5.1.1.3 Top Cover

The top cover protects carcass from the material being conveyed. It must absorb abrasive wear at loading and protect the carcass from any adverse property of the material being conveyed. The top cover must also be capable of withstanding any environmental condition it is exposed to.

5.1.1.4 Bottom Cover

The bottom cover is the lining on the bottom of the belt. Its purpose is to protect the carcass from possible wear from idlers and pulleys. It is usually thinner than the top cover.
In order to confirm the correct type of belt is being considered, it is necessary to have the following information:
- Types of items to be carried.
- Width of belt.
- Speed of conveyor.
- Total load on belt.
- Size and weight of the largest article.
- Adverse conditions such as the presence of oil, water, dirt and dust, and temperature variations.

5.1.2 Belt Material

Conveyor belt is constructed from a variety of natural and synthetic materials. The trend for the last fifty years has been moving away from natural fibres to the more dependable synthetic fibres. Below are some of the fibres used.

5.1.2.1 Nylon

Nylon is the first man-made fibre to be used in conveyor belts. It is constructed from polyamide fibres. It has high strength, high elongation, good resistance to abrasion, and excellent fatigue and impact resistance. Unfortunately it will absorb water. This gives it poor dimensional stability. However it is highly resistance to mildew.
5.1.2.2 Polyester

Polyester has high strength and exceptionally good abrasion and fatigue resistance. Unlike nylon, it has low moisture absorption, which gives it good dimensional stability. It is also not affected by mildew.

5.1.2.3 Polyurethane

Polyurethane is a unique material that offers the elasticity of rubber combined with the toughness and durability of metal. Polyurethane can reduce plant maintenance cost. Urethanes have better abrasion and tear resistance than rubbers, while offering higher load bearing capacity. Compared to plastics, urethanes offer superior impact resistance, while offering excellent wear properties and elastic memory.

5.1.3 Belt Splice Techniques

Conveyor belt is usually made endless onsite, by either vulcanizing or mechanical fasteners. Of the two techniques, vulcanizing provides the stronger splice. Back when natural fibres and nylon made up the majority of belt carcasses sold, vulcanizing sealed the carcass away from moisture and mildew, prolonging belt life. Mechanical fasteners leave edges exposed. The mechanical splice has gained popularity due to its low cost and ease of installation.

Vulcanizing is still the preferred choice of splice for initial installations and repairs on high-tension belts. For onsite repairs of low-tension belts, mechanical fasteners are more popular.

5.1.3.1 Vulcanized Splice

Vulcanizing can be done by either hot and cold method. In hot vulcanizing, the belt is cured and set in a vulcanizing press. This produces the strongest splice.
possible but requires trained personnel and large specialized equipment to be brought onsite. Cold splicing produces a fairly strong bond and is done using a liquid cement and hardener. This can be done by moderately trained personnel. See Figure 5.2.

**Step Splice**

This technique is normally used with conventional plied carcass construction. It is easily performed with moderately trained personnel using the cold vulcanizing technique.

**Skived Splice**

This technique must be used on the more complex straight warp or solid woven carcass. It is popular with PVC belting.

**Finger Splice**

This technique is also used on straight warp and solid woven carcasses. The fingers provide increased bonding area for a stronger splice.

**5.1.3.2 Mechanical Splice**

Although mechanical splices are not as strong as vulcanized splices, they are still very popular. They are commonly used in low-tension applications on short to mid length size conveyors. Mechanical splices do not have sufficient strength to hold high tension belts together but they are many times less expensive than vulcanized splices. They can be applied with simple tools in minutes, rather than hours, as with a vulcanized splice. Personnel installing mechanical splices do not require special skills. Belt does not have to be precleaned as compared to vulcanized splice, making them ideal for onsite installation. Below are the two main types of mechanical splice.
Figure 5.2 Types of Vulcanised Belt Splice Techniques

Hinged

Hinged splice can be installed in a shop and quickly joined onsite with the insertion of a hinge rod. The hinge rod can be removed, and one of the sides can be cut and reset. Hinged fasteners also offer the option of attaching a different thickness of belt to one another by hinging different size fasteners together. Hinged fasteners leave small openings that may allow fines to leak through the belt. This type of fastener is popular in mining as splices can be quickly separated or detached when extending the length of a conveyor. See Figure 5.3(a).

Solid plate

A solid plate fastener can handle higher tensions than its hinged counterpart. Since it has no moving parts, a longer service life can also be expected. This type of fastener also contains fine better. See Figure 5.3(b).
5.1.4 Belt Training

Training or tracking a belt is the process of adjusting various components of a belt system so the belt consistently runs centrally.

Initial setup and maintenance should ensure that all idlers are in line, square, and level transversely. All pulleys should be concentric with the pulley shafts. The pulley shafts should be perpendicular to the centre line of the belt.

Mechanical fasteners can be attached by staple, bolt, or rivet. Rivets are recommended because they damage the belt material the least.
If the pulleys are not properly aligned, the belt will run off-centre, so damaging its edges on the structure. Other factors which can cause a belt to wander are: belt not cut perfectly straight, conveyor structure out of line, pulleys not adequately crowned. Some or all of these possibilities make it essential to provide fine adjustment of the pulleys. The bearings or dead-eyes on each side of the pulley must be independently adjustable and should be securely locked in position after adjustment. Various methods are used to adjust roller mountings but the easiest is simply to slot all fixing holes.

For this project, polyurethane belt with finger splice is used. Additional properties like green colour is specified and the belt must be antistatic. The length of the belt is determined by using the AutoCAD software. The specification of the belt can be found in Appendix D.2.
5.2 Bearings

Bearings provide support for rotating shafts and allow smooth, low friction motion between two surfaces. Load is applied to these bearings in either a radial or axial direction, or in a combination of these. Radial loads act at right angles to the shaft axis of rotation. Sometimes this radial load is the result of a side load caused by a chain, belt, or gear, and sometimes it is due to gravity alone. Axial (or thrust) load is load applied along the axis of the shaft. If a load is supported by a vertical shaft, then the bearing will experience a thrust load.

Lubricant creates a low friction barrier between the rotating and stationary members, thus minimizing friction. Lubricant in the bearing isolates the shaft and sleeve, preventing metal-to-metal contact.

5.2.1 Parts of Bearing

Bearing usually consists of an outer ring, inner ring, rolling elements (balls or rollers), and a cage which positions the rolling elements at fixed intervals between the ring raceways. See Figure 5.4.

The outer ring, inner ring, and rolling elements of bearing are made with extremely tight tolerances, even to millionths of an inch, to assure good performance and long life. These elements are made from hardened steel and are ground and lapped to the design dimensions. Case-hardened steels are often used, with surfaces hardened to various depths. The cages and separators are usually made of brass or low-carbon steel and are usually formed by stamping. Many bearing failures are due to cage failures resulting from improper lubrication and overheating.
Rolling element bearings require sufficient lubrication to wet the rolling surfaces. Grease is used for most low speed applications. Seals and shields are often used to prevent loss of lubricant and to prevent dirt from getting into the bearing. Sealed bearings have lubrication included at assembly and are not relubricated. Less expensive unground bearings with much greater tolerances can be used for less demanding applications.

5.2.2 Types of Bearing

There are many different types of bearing available. Which is suitable will depends on their applications. Refer to Figure 5.5.
5.2.2.1 Ball Bearing

Ball bearing is the most popular of all the ball bearing types because it is available in a wide variety of seal, shield and snap-ring arrangements. It can sustain radial, axial, or composite loads and because of simple design, this bearing type can be produced to provide both high-running accuracy and high-speed operation.

5.2.2.2 Roller Bearing

Roller bearing is often used in high-speed applications. Because the inner ring, outer ring, and rollers are in line contact, this bearing type has a large radial load capacity. Since it supports axial loads as sliding action between the end of the rollers and flange faces axial loading is limited.

5.2.2.3 Self-Aligning Bearing

Self-aligning ball bearing is suitable for long shafts where accurate positioning of housing bores is difficult. Due to its special construction, it will tolerate a small angular misalignment from deflection or mounting error.

5.2.2.4 S-Bearing Unit

S-bearing unit is actually deep groove ball bearing with extended inner rings. It is manufactured in a number of designs. At one end of the inner ring the bearing is clamped to the shaft with an eccentric locking ring or with two setscrews. The outer diameter of the outer ring is as a rule ground spherically, so that the ring can align itself in a suitably designed housing if the bearing locations are misaligned.
After some thought, a flange bearing is used for the project. It is actually a combination of the ball bearing and the S-bearing unit. Just that it has a flange to it. Flange mounted bearings are used when a shaft axis is perpendicular to the bearing mounting surface. They are available in 2, 3, or 4-hole configurations. The one with 2-hole configuration will be used in this case. Refer to Appendix D.3 for its specification.
5.3 Motor and Gearhead

The two primary components of a drive unit are the motor and the gear head. A variety of ancillary equipment may also be required. These devices may provide such functions as speed control, soft starting capability, and overload protection. After having determined the type of conveyor, the next step is to select a drive system. Selection of the drive system is based on the following factors:

- Economics
- Space limitations
- Starting characteristics
- Ambient atmospheric conditions
- Single or variable speed requirements
- Type and voltage of power service available

When selecting a drive train, there is often a multitude of equipment choices and approaches. The difficulty lies in selecting the most appropriate system. Usually, economics is the deciding factor. But in some cases, special requirements or conditions will be the deciding factor.

5.3.1 Types of Motors

There are many types of motors in the market. Below are basically the few types.

5.3.1.1 Basic Motor

Continuous Operation (Induction Motor)

The speed of an induction motor varies with the load. It is used in applications where speed control is not required and within continuous uni-directional operation. This means that the direction of motor rotation can be changed just after bringing the motor to a stop.
Bi-directional Operation (Reversible Motor)

Reversible motors are capacitor-run induction motor and designed for applications where instantaneous reversal is required. By simple switching, the direction of motor rotation can be reversed frequently between CW and CCW rotation.

5.3.1.2 Brake Motor

If the applications require the motor to stop faster than the above mentioned, brake motor is recommended. With induction motor, it generally takes 30-40 revolution (at the motor shaft) before the motor comes to a complete stop after the switch is turned off. With reversible motor, it takes about 5-6 revolutions. But with brake motor, it is capable to reduce the overrun to just 1-1.5 revolutions. Some can even hold the load in position when the motor is stopped.

5.3.1.3 Speed Control Motor

The speed of the speed control motors can be easily set and adjust by the use of a potentiometer. The control system consists of a speed-feedback system, a motor, a control pack (or a driver) and a potentiometer. This motor is controlled by a closed-loop speed control system.

5.3.1.4 Linear Head Motor

Linear motion can be obtained by combining a rack-and pinion unit with motor. Linear head motor is designed especially for use with the AC standard motor coupled directly to the linear head, various type of movements are possible.
5.3.2 Selection Procedure

During the selection of a motor, there are fundamental criteria involved in the procedure. Below are the steps when selecting small size, standard AC motors such as induction motors and reversible motors:

- Determine the required specifications.
  First determine the basic required specification of mechanism and applications such as operating speed, load torque, power supply voltage and frequency.

- Calculate the operating speed and select gearhead.
  Induction and reversible motor speeds cannot be adjusted. Motor speed must be reduced with gearheads to match the required machine speed. It is therefore necessary to determine the correct gear reduction ratio.

- Calculate the required torque.
  Calculate the required torque and confirm the torque needed for the gearhead.

- Select a motor.
  Use the required torque and speed to select a motor and gearhead from the catalogue.

- Check with the starting torque of the motor/ Speed confirmation
  At the same time, confirm the starting torque of the motor and the maximum permissible torque of the gearhead. In a single-phase induction motor, starting torque is always lower than the rated torque. Therefore, to drive a frictional load, select the speed on the basic of starting torque. Check if speed meets up to actual requirements.
5.3.3 Sizing of Motor

Motor need to be carefully selected in order not to oversize or undersize it. Following the selection procedure as mentioned before, calculation of the correct size of motor and gearhead for the main conveyor and the sub conveyor is given as below.

5.3.3.1 Main Conveyor

According to the specification in Appendix, the output for the press machine is 25 to 55 leadframes/min. From this we can find the minimum and maximum belt speed required.

Belt speed is given as below.

\[ V = \frac{\text{Machine Output} \times \text{Leadframe Length}}{60} \text{ cm/sec} \]

\[ \therefore \text{Maximum belt speed, } V_1 = \frac{55 \times 25}{60} = 22.9 \text{ cm/sec} \]

\[ \therefore \text{Minimum belt speed, } V_2 = \frac{25 \times 25}{60} = 10.4 \text{ cm/sec} \]
Main conveyor specifications:

- Total weight, \( W \) = 3 kg
- Friction coefficient of sliding surface, \( \mu \) = 0.3
- Drum diameter, \( D \) = 3.2 cm
- Roller Efficiency, \( \eta \) = 0.9
- Angle of Inclination, \( \alpha \) = 0°
- Belt speed, \( V_1 \) = 22.9 cm/sec
  \( V_2 \) = 10.4 cm/sec
- Input voltage = 200 V/ 50 Hz
- Direction = uni-direction

\[ a) \quad \text{Calculation of speed at gear shaft.} \]

\[ N_{g1} = \frac{V_1 \times 60}{\pi \times D} \]
\[ = \frac{22.9 \times 60}{\pi \times 3.2} \]
\[ = 136.8 \text{ rpm} \]

\[ N_{g2} = \frac{V_1 \times 60}{\pi \times D} \]
\[ = \frac{14.6 \times 60}{\pi \times 3.2} \]
\[ = 62.1 \text{ rpm} \]

\[ b) \quad \text{Determination of gear ratio.} \]

With 50Hz power supply, torque of speed control motor is greatest at 1300rpm.

\[ i_1 = \frac{1300}{N_{g1}} \]
\[ = \frac{1300}{136.8} \]
\[ = 9.5 \]

\[ i_2 = \frac{1300}{N_{g2}} \]
\[ = \frac{1300}{62.1} \]
\[ = 20.9 \]

So to achieve both speed, smaller gear ratio must be taken.
Therefore gear ratio, $i$, of 9 is chosen.

\[
N_{M1} = N_{G1} x i \\
= 136.8 x 9 \\
= 1231.2 \text{ rpm}
\]

\[
N_{M2} = N_{G2} x i \\
= 87.1 x 6 \\
= 558.9 \text{ rpm}
\]

c) Calculation of required torque.

\[
F = F_a + W (\sin \alpha + \mu \cos \alpha) \\
= F_a^0 + 3 (\sin 0 + 0.3 \cos 0) \\
= 3 (0.3) \\
= 0.9 \text{ kg}
\]

Load torque at the gearhead shaft,

\[
T_L = \frac{(F \times D)}{(2 \eta)} \\
= 0.9 \times 3.2 / (2 \times 0.9) \\
= 1.6 \text{ kgfcm}
\]

Load torque at the motor shaft,

\[
T_m = \frac{T_L}{(i \times \eta_G)} \\
= 1.6 / (9 \times 0.73) \\
= 0.24 \text{ kgfcm}
\]

Considering the fluctuation of power supply, 200% tolerance in the calculation is given as below.

\[
T_m = 0.24 \times 2 \\
= 0.48 \text{ kgfcm}
\]

This required torque is applied to the motor constantly at any speed. Therefore the motor must have a greater torque than 0.48 kgfcm at low and high speed.
Based on the specification from Appendix D.4, speed control motor US560-502E is the best choice. Since the reduction ratio is 9, gearhead 5GU9KB is selected.

Then using both the minimum speed and the maximum speed of the speed control unit to determine whether the product selected meets the required specification.

\[
V_1 = \frac{N_{\text{max}} \times \pi \times D}{60 \times i} = \frac{1400 \times \pi \times 3.2}{60 \times 9} = 26.1 \text{ cm/sec}
\]

\[
V_2 = \frac{N_{\text{min}} \times \pi \times D}{60 \times i} = \frac{90 \times \pi \times 3.2}{60 \times 9} = 1.7 \text{ cm/sec}
\]

The selected motor can operate at a higher speed and a lower speed as compared to the required specification. Therefore the motor meets the requirement.

5.3.3.2 Sub Conveyor

Since the speed of the sub conveyor has to be faster than that of the main conveyor so a higher speed need to be assigned to it. Taking that the small conveyor needs to handle 35 to 80 lead frames/min. From this we can find the minimum and maximum belt speed required.

Belt speed is given as below.

\[
V = \frac{\text{Machine Output} \times \text{Leadframe Length}}{60} \text{ cm/sec}
\]

\[
\therefore \text{Maximum belt speed}, V_1 = \frac{80 \times 25}{60} = 33.3 \text{ cm/sec}
\]
\[ V_2 = \frac{35 \times 25}{60} \]
\[ = 14.6 \text{ cm/sec} \]

Small Conveyor specifications:

- Total weight, \( W \) = 0.85 kg
- Friction coefficient of sliding surface, \( \mu \) = 0.3
- Drum diameter, \( D \) = 3.2 cm
- Roller Efficiency, \( \eta \) = 0.9
- Angle of Inclination, \( \alpha \) = 0°
- Belt speed, \( V_1 \) = 33.3 cm/sec
- \( V_2 \) = 14.6 cm/sec
- Input voltage = 200 V / 50 Hz
- Direction = uni-direction

d) Calculation of speed at gear shaft.

\[ N_{g1} = \frac{V_1 \times 60}{\pi \times D} \]
\[ = \frac{33.3 \times 60}{\pi \times 3.2} \]
\[ = 198.7 \text{ rpm} \]

\[ N_{g2} = \frac{V_1 \times 60}{\pi \times D} \]
\[ = \frac{14.6 \times 60}{\pi \times 3.2} \]
\[ = 87.1 \text{ rpm} \]

e) Determination of gear ratio.

With 50Hz power supply, torque of speed control motor is greatest at 1300rpm.

\[ i_1 = \frac{1300}{N_{g1}} \]
\[ = \frac{1300}{198.7} \]
\[ = 6.5 \]

\[ i_2 = \frac{1300}{N_{g2}} \]
\[ = \frac{1300}{87.1} \]
\[ = 14.9 \]
So to achieve both speeds, smaller gear ratio must be taken. Therefore gear ratio, \( i \), of 6 is chosen.

\[
N_{M_1} = N_{G_1} \times i \\
= 198.7 \times 6 \\
= 1192.2 \text{ rpm}
\]

\[
N_{M_2} = N_{G_2} \times i \\
= 87.1 \times 6 \\
= 522.6 \text{ rpm}
\]

\text{f) Calculation of required torque.}

\[
F = F_a + W (\sin \alpha + \mu \cos \alpha) \\
= F_a + 0.85 (\sin 0 + 0.3 \cos 0) \\
= 0.85 (0.3) \\
= 0.26 \text{ kg}
\]

Load torque at the gearhead shaft,

\[
T_L = \frac{(F \times D)}{(2 \eta)} \\
= 0.26 \times 3.2 / (2 \times 0.9) \\
= 0.46 \text{ kgfcm}
\]

Load torque at the motor shaft,

\[
T_m = \frac{T_L}{(i \times \eta_G)} \\
= 0.46 / (6 \times 0.73) \\
= 0.11 \text{ kgfcm}
\]

Considering the fluctuation of power supply, 200\% tolerance in the calculation is given as below.

\[
T_m = 0.11 \times 2 \\
= 0.22 \text{ kgfcm}
\]
This required torque is applied to the motor constantly at any speed. Therefore the motor must have a greater torque than 0.22 kgfcm at low and high speed. Based on the specification from Appendix D.4, speed control motor **US425-402E** is the best choice. Since the reduction ratio is 6, gearhead **4GN6K** is selected.

Then using both the minimum speed and the maximum speed of the speed control unit to determine whether the product selected meets the required specification.

\[
V_1 = \frac{N_{\text{max}} \times \pi \times D}{60 \times i} = \frac{1400 \times \pi \times 3.2}{60 \times 6} = 39.1 \text{ cm/sec}
\]

\[
V_2 = \frac{N_{\text{min}} \times \pi \times D}{60 \times i} = \frac{90 \times \pi \times 3.2}{60 \times 6} = 2.5 \text{ cm/sec}
\]

The selected motor can operate at a higher speed and a lower speed as compared to the required specification. Therefore the motor meets the requirement.
5.4 Belt and Pulley

Belt drives provide an inexpensive means of transferring energy and motion from one rotating shaft to another. Belts are used when large distances between shafts make gears impractical or when the drive speed is too high for chain drives. Belt-drive systems include two shaft-mounted grooved pulleys, one on each shaft, and a belt loop.

Pulleys are used to transmit rotational energy to the various types of belts and they are generally made from steel or aluminium. Pulley width should be approximately 10% wider than the belt. Minimum pulley diameter should be at least 30 times the belt thickness. The shape of the pulley will often take the shape of the belt. This will minimize the slippage between the belt and the pulley.

Belt systems often include an idler pulley positioned to provide tension on the belt. Each pulley must be locked to its shaft. The drive pulley is mounted on the drive shaft, usually of an electric motor. The driven pulley is usually larger and has a lower rotational velocity. Figure 5.6 shows the assembly of a belt and pulley.

![Figure 5.6 Assembly of Belt and Pulley](image-url)
All belts except timing belts rely on friction between the pulley and the belt to transmit the force from the pulley to the belt. The force is exerted at the driven pulley to cause rotation, thereby transferring the force from one shaft to another. The distance the belt moves in a period of time, the belt velocity, multiplied by the force transferred produces the power supplied and received. Any differences in these quantities represent the inefficiency of the system.

5.4.1 Advantages and Disadvantages

The advantages of belt drives are that they do not require lubrication, they are low maintenance, they dampen and smooth out shock loads, and they provide quiet, smooth operation. Also pulleys are generally less expensive than drive sprockets.

The disadvantages of belt drives include load transfer limitations related to friction, a tendency for the belt to stretch, a tendency for the belt to jump from the pulley during shock loading, and inefficiency related to slippage.

![Figure 5.7 Features of Belt](image)
5.4.2 Problems with Belt

Problems which often related with belts include slip, stretch, and creep. Slip is caused by a loss of friction between the belt and pulley and is minimized by sufficient belt warp or arc of contact. If slip is prevalent, excessive belt temperature results. Stretch is minimized by internal reinforcement such as with polyester cord. Creep is the tendency of a belt to relax or stretch over time as it moves around the pulley while under load. Figure 5.7 shows the features of a belt.

5.4.3 Types of Belt

The many types of belt include flat, round, V-belt, and Timing belt. Refer to Figure 5.8.

5.4.3.1 Flat Belt

Flat belt was the original type of belt used to transfer power from line shafts operating above the factory floor to individual machines. Flat belts have the capability to provide torque transmission around a corner. This permits connection of nonparallel shafting. To provide necessary friction, flat belts require higher tension belts. Often a slight crown is applied to the pulleys to increase the tension on the belt. This crown also helps the belt stay centered on the pulley. But flat belts are not practical for timing applications where the angular orientation of one shaft relative to another is critical.

5.4.3.2 Round Belt

Endless round belt is specialized belts that can provide high speed but have limited force-transmitting capability. It often has 90° twists or a serpentine path. A round belt is simply a large O-ring.
5.4.3.2 V-Belt

V-belt is used in many industrial applications. Multiple V-belts with parallel belt strands are comparable to chain drives in carrying power. The name *V-belt* comes from its driving action, which occurs at the tapered sides of the belt rather than across the flat bottom. They generally contain polyester cords to add strength and retard stretching. The tension section carries the load while the compressed section wedges against the pulley groove.

5.4.3.2 Timing Belt

Timing belt is made with teeth molded into the rubber that mesh with teeth in the driving and driven pulleys, producing a positive no-slip drive system permitting timed operation. Steel reinforcement is used in the belt construction to eliminate belt stretch. Tooth shape is usually trapezoidal and many automobile engines use timing belts to synchronize the timing between the crank and the cam shafts of the engine. The primary disadvantage of this type of belt is that it is expensive.

If open-ended belts are used, the ends must be carefully spliced to assure that the belt stays together under load.

5.4.4 Speed Ratio

Speed ratio in belt systems is determined by the ratio of the effective diameters of each driven pulley to the drive pulley. Related to the speed of the belt system is the centrifugal force associated with the belt as it approaches the pulley. If the speed is sufficient, the belt will rise off the pulley, introducing substantial slip and perhaps disconnecting from the pulley. To counteract this effect, tension must be increased with the idler or by slightly increasing the distance between pulley centers.
Polyurethane timing belt and aluminium pulley are used in this project to transmit the power from the motor to the conveyor belt. The materials are chosen due to their better qualities than the others. The length of the belt is determined from the AutoCAD software. All the specification can be found in Appendix D.5 and Appendix D.6 respectively.

**Fig 5.8 Types of Pulley Belt**
5.5 Conveyor Structure

A conveyor is seldom a precision tool and its construction should be robust, and easy to install and maintain. Pressed steel sections are ideal for light duty but frames of standard rolled steel members are more suitable for heavy-duty work.

It is a common practice to mount the shaft in self-aligning ball bearings to allow for the tracking adjustments that must be provided.

5.5.1 Materials

Materials that are often use for building the structure for the conveyors are mild steel rectangular bar or aluminium profile. Conveyor frames should not be designed in a way that requires welding in two directions, i.e. along and across the conveyor.

In this project, aluminium profile is used for making the structure. The reasons are aluminium is light and it is flexible in terms of fixing up. Because of the grooves available on the profile, parts fixing on it can be adjusted freely. This gives it more flexibility in mounting. See Appendix D.7 for more details.

5.5.2 Importance of Flatness

Due to site level variations, uneven floors, inaccuracies in manufacture, it is almost inevitable that the person doing the installation work will want to adjust the structure on site. Person in charge needs to take note to vendor that there should not be any splatter or uneven surface. Especially those surfaces that come in contact with the conveyor unit, flatness of the surface is also a critical part that must take care of. For surface protection of the bar, undercoat and epoxy paint can be use.
Mounting of cell to structure, the mounting of the cell is done usually by using a plate that is joined to the base of the cell and screw tightly to the structure. Having a flange on the base usually does the tank mounting, as mounting holes are located at the flange.

It is necessary to ensure that the edges of side members at joints are well radiused. If lining materials are used, these too must have radiused or chamfered edges, and all fixing bolts must be well countersunk.

On the whole, we should practice standardizing. Standardizing is the practices of using only one make of equipment and maybe only one or two sizes of that make. This is not always possible in every situation, particularly when custom-made equipment is required. A standard model is chosen based on past successes of certain makes, or the more deliberate approach of experimenting with different manufacturers’ products.

There are numerous advantages to standardizing. For one, spare parts stocking are simplified. The plant need only stock a few spare parts for all the conveyors of the specific make. There is also an advantage in terms of maintenance. The plant personnel become familiar with repair routines, replacement, and lubrication schedules.

Standardizing should be approached cautiously and it should never be implemented at the expense of adequate equipment performance. Bear in mind no one conveyor can be applied to every situation. That is why there are so many different types.
Chapter 6

Safety Aspects

Safety measures are very important during the installation and operation of the conveyor system. They must be strongly adhere to in the prevention of incidents.

6.1 Areas to Take Note

Below are some of the areas which I had take note prior to design the conveyor system.

6.1.1 Electricity

Voltage supplies to motor in order for the conveyor to operate.

Problems : - Possibilities of people getting electrocuted if wires not connected properly.

Actions : - Check that wire connections are not exposed.
- Make sure the wire is well insulated.
- Cover up the speed controller so that the places near the joints of the connection wires are not accessible.
- Stick warning signs for high voltage supply at places near the speed controller.
6.1.2 Belt and Pulley

Using of pulleys and belts to transmit power from the motor to conveyors.

Problems : - Hands get caught by the pulleys and belts when motor is running.
            May cause serious fracture.

Actions : - Attached safety covers to the exposed belts and pulleys.
          - Stick warning signs to warn operators of the moving parts.

6.1.3 Motor

Prolong usage of conveyors, especially during 24 hrs shift work.

Problems : - Motors get very hot. Hands will get burnt when they are accidentally touched.

Actions : - Attached safety covers with holes for ventilation purpose.
          - Stick warning signs to warn operators of the moving parts.
          - Arrange to run production in an air-conditioned room to cool down the motors faster.
          - Stick warning signs to warn operators of the hot parts.

6.1.4 Structure

Prolong usage of conveyors, especially during 24 hrs shift work.

Problems : - Sharp edges and corners of the metal parts can cut people if they are not careful.

Actions : - State in drawing that all sharp edges and corners to be chamfered or rounded.
          - Stick warning signs to warn operators of the moving parts.
          - Minimize small angles at the corners or edges of the conveyors parts during design stage, as they are sharp.
6.2 General Guidelines

The person in charge must have a thorough knowledge of the following precautions and shall aim for zero incident operations.

In the precaution, the term "Person in charge" refers not only to the person who operates or supervises this system but also engaging directly in production activities; it includes people who maintain and inspect the equipment and all people engaged in work relating to the equipment.

6.2.1 Safety Acts for Assembly and Installation

- Be sure to put on safety equipment like safety shoe and etc.

- When performing assembly and installation, be sure that the parts are clean without any oil stain as it may dirty the products.

- Before performing any works, signboard "Work In Progress" should be put up at the most prominent area where every person can see.

- Before performing any works, secure all doors on the control panel or operating panel.

- Before performing any works, set the main switch to "OFF" position and lock the key, or place a sign saying "DO NOT SWITCH ON" on the main panel.

- If changing of system wiring is necessary, be sure to shut off the power supply. Performing wiring work with the power supply turned on, is danger of electrical shock.

- Electrician should take extra care when performing electrical wiring connection and disconnection on the primary power supply.
- Assembly and installation, either on electrical or mechanical work, must be done by skilled worker with electrical or mechanical equipment assembly and installation knowledge.

- Inspect the work area surrounding. All unsafe points must take extra measure to ensure safety. In particular, if there are places where footing is inadequate, there is a risk of human injury due to falling.

- Never use gloves if there is a danger of being wound into the rotating parts etc.

- Distinguish component storage location and passageway; do not place things in passageways. There is a risk of injury if people trip over them.

6.2.2 Safety Precaution for Operation Procedures

6.2.2.1 Before Operation

- Check that there are no people go near the rotating mechanism or high temperature parts.

- Never touch any electrical switches with wet hands.

- Cooperative work is required, be sure to signal your partner when starting any operation system

- Do not operate the system with the equipment safety cover removed.

- Carefully check the position and function of switches, buttons and keys before operating any system operation.

- Check power supply's cable and wire insulation. If damage, risk of fire and electrical shock is high.
- Keep the floor around the equipment organized and clean.

- Do not place any foreign objects on any of the movable mechanism.

- Secured all control or operating panel doors.

- When performing adjustment work, check for one or two completed revolution on all rotating mechanism by hands, to ensure they are not jammed either by foreign metal or driving mechanism itself.

- Remove obstruction around the system

- Check all fasteners are properly tightened.

6.2.2.2 During Operation

- First signal anyone around, before starting the operation.

- Always be alert of any abnormal vibration and noise. Stopped the operation immediately and remedy the fault.

- Do not touch the rotating mechanism when it is running.

6.2.2.3 After Operation

- Do not touch any equipment even when power shut off, some internal parts may still remain charged or temperature may be high. Work only when discharging and equipment temperature is low.
6.2.3 Emergency Act

- Press the emergency stop switch on touch screen panel.

- Follow the checklist stated in general precaution before operation.

- Never operate the system again before any fault is found and remedied.

- If the problems cannot be determined, seek specialist for assistance.
Chapter 7

Project Performance

After the conveyor system is installed on the stacker machine, several testing is done on the machine itself. Different sizes of leadframe are used for the testing purposes. The samples include the smallest and the largest leadframe that is to be processed during any time of the production and some of the sizes in between the range. The speed of the conveyor is adjusted according to the speed of the stamping machine. For the test run, the speed of the press machine is being put to the low side before the speed is being gradually increase. This is to prevent any serious damage to the machine if the punching tools are not aligned properly.

To start of with the test run, the coil of leadframe need to be prepared and set up in the machine. Every aspect of the machine must be adjusted and set to the required width of the leadframe. A number of things have to be adjusted before the transferring process is smooth. The separator has to be adjusted to cater for the width of the leadframe. By loosen the screws, the top part of the separator holder can be moved to either widen the gap or to narrow it. See Figure 7.1.
As for the sliding of the two outer most leadframe, the orientation of the separator can be adjusted to give the best sliding action. It will prevent the leadframe from sliding too fast and damage the edges. It can also prevent leadframe from not sliding down due to not enough tilting angle.

For the 2 middle leadframe, the plate is used as a platform for them to slide to the bottom main conveyor. The position and tilting angle of the plate can be adjusted to aid the sliding action. See Figure 7.2.

Tapping and downsetting process is carried out before the leadframe is passed to the press machine for cutting. After cutting, the leadframe is then transferred out of the press machine by the conveyor system. It was found that the speed of the conveyor has to be faster than that of the press machine if not the conveyor will not be able to catch up with the press.
7.1 Test Result

A speed of the minimum and the maximum is being tested and leadframes of various width were used for the testing. The testing was conducted for more than six hours. During this period, all the models of the leadframe that is to be run were tested. From the test run, it can be said that the machine is working fine. The test result for all the models tested is tabulated in Table 7.1.

From the result, we can see that the conveyor system is able to accommodate the various kind of leadframe models. It is able to achieve the cycle time without fail. However, it seems like the wider the width of the leadframe and the faster the conveyor runs, the likelihood that defects will occur. This is because as the conveyor runs fast, the momentum of the leadframe will be more and causes the leadframe to slide down the separator even faster. Since the force is too great, it slides down and hit the side of the conveyor and get dented.
<table>
<thead>
<tr>
<th>No.</th>
<th>Model</th>
<th>Testing Time (min)</th>
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<th>No. of Defects</th>
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<td>1A</td>
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<td>25</td>
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<td>30</td>
<td>55</td>
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</table>

Table 7.1 Test Result for the Conveyor System

To solve the problem, the tilting angle of the separator is changed to reduce the sliding force. Another way is to place a rubber padding at the side of the conveyor. This will act as a cushion for the leadframe.

7.1 Comparison Test

To further outline the advantages of this new conveyor system, an experiment on two production lines are conducted. The difference of the lines is that one of it uses the new conveyor system while the other uses manpower to collect the products. This experiment was continued for four months. The outcomes of both results were plotted in graphs shown in Figure 7.1 and Figure 7.2.

From Figure 7.1, we can see that the number of defective parts for manual collecting is far greater than that of the conveyor system. So it shows that the conveyor system is more reliable and it gives lower production cost.
Figure 7.1 Test Result for the Conveyor System

Figure 7.2 Monthly Yield Results
In Figure 7.2, due to the reliability of the conveyor system, the yield is much higher than that of manual operation. As the conveyor system is able to operate at high speed, therefore the output is also greater.

7.3 Aspect of Sustainability

For the case of my project, the resources that I use are commonly found in the market. Even if the parts are to be replaced due to wear and tear, they can still be recycled. These contribute a lot in reducing waste production and therefore act as a measure towards protection of the environment.

What I feel that is needed to accommodate in my design in the aspect of environmental protection are: minimization in air, noise and waste pollution. It must be environmental friendly. Currently the earth is under lots of destructive damages and the situation is alarming. It is necessary for us to save it and bring back the pleasant habitat it used to be.

Regarding the impact of my project work in global scale, I can foresee that for those companies who are my competitors, they will find this conveyor system attractive. They will like to acquire one if they do not have any. But in the future it is not unusual if people are trying to improve my design to make it a better system. They may feel that the one I make will not be good enough for future use. Since technology keeps advancing so the system has to constantly upgrade to meet the demand.

However, I think most people will still feel comfortable with my work. Since it is easy to operate and environmental friendly. As such, there are no environmental or pollution cost incur during production. This will help to save the production cost.
This project is mainly for improvement purpose. It is consider successful since the performance level had increased a few notch. In this case, operators do not need to attend to the machine so often and they can have more time for other works like inspection of work quality. There is even a possibility that one worker attending to 2 machines simultaneously instead of just one. As workforce is abundant, the management will have to retrench some workers to save labour cost. So indirectly this will cost some of the operators their rice bowls. This is indeed a sad situation.

Well, it is really an honour if my work is been recognized by other people in the world, especially in those developed countries. It will reflect that my work is of some standard. What I am certain is that this conveyor system is very user friendly as most people will be able to handle it without fail. It does not require an expert to operate. I am sure people from undeveloped countries are able to operate the systems too.

**7.4 Ethical Responsibility**

I personally feel that this system is quite safe and it will not bring any harm to the people if it is not misuse. Other than the lost of the operators’ job, the rest are benefits to the users. Maybe people will comment that usage of the motor is very dangerous because of the voltage supply, people can get electrocuted if the connection of the wire is not done properly. Or people can get hurt if their hands get caught in the pulley and belt. But if the safety measures are done properly and rules are strictly follow, I do not think that anyone will get hurt so easily.
Chapter 8

Conclusion

In the semiconductor industry, manufacturers deal with changes every year: shorter device product lifecycles, rapid technology changes, and market demand volatility. There are no hard and fast rules for predicting effective lifecycles for semiconductor equipment. Manufacturers must have the flexibility to react quickly and effectively to market and technology changes.

In an age of market skepticism and consolidation, bringing a new idea or product is increasingly difficult. An innovation must demonstrate that it solves an existing or future problem, can be cost effective and can meet ever-increasing requirements of production. In the future, new technologies and roadmap milestones promise to present even greater challenges.

The rewards for overcoming these barriers and having an innovation incorporated into a production process can be substantial for a product that meets a critical need.
8.1 Achievement of Project Objectives

In view of the performance, the conveyor system has achieved its objectives that are stated in Chapter 3.

It links up well with the press machine and the stacker unit. It is able to separate the four strand of leadframes and transfer them to their respective stacker unit which the present conveyor system is not able to. The new design allows for greater production output since it is able to operate at a higher speed. The number of defects is very low as compared to manual operation. It is cost saving, efficient and has greatly improved the operation process.

From these, I conclude that this project is a success. Though it may need some improvement, it can still perform up to the required expectations.

8.2 Further Work

Usually the initial design is not the final one as it needs improvement in order to make the whole system runs better.

Although the idea of adjusting the sliding plate to various angles and different height is good, there are some problems in the adjusting. The workers have difficulty aligning the plates due to its weight and it is hard to get it straight. So time is often wasted in getting the sliding plates to its correct position.

So to solve the problems, grooves can be implemented in the adjusting plates so that movement of the plate is restricted to only one axis at a time. The operators can now adjust the sliding plates at ease.

Another area to improve on is the mounting blocks for the flange bearing. The fabrication cost can be reduced further by simplifying the design. A flat plate with mounting holes is good enough.
References


Face: Mechanical Standard Components for Factory Automation 2003, Misimi Corporation, FA Mechanical Division, Tokyo.


Appendix A

Project Specification
University of Southern Queensland  
Faculty of Engineering and surveying  

ENG 4111/2 Research Project  
Project Specification

FOR: Lim Doou Gie  
TOPIC: Design & Development of Conveyor System for Semiconductor Industry  
SUPERVISOR: Dr. Harry Ku  
ASSOCIATE SUPERVISOR: Dr. Yan Wenyi  
LOCAL SUPERVISOR: Mr. Tan Say Keong

SPONSORSHIP: SUMITOMO METAL MINING ASIA PACIFIC PTE LTD

PROJECT AIM: The aim of the project is to conduct research studies on the various types of conveyors regarding its capabilities, materials used and work performances. Develop a customer made conveyor that is able to perform the same criteria as those types of conveyor and on top of that it must suit the kind of work processes required by semiconductor industry. It will generally help in the various aspects of the engineering productions.

PROGRAMME: Issue A, 15th March 2004

1. Research background information on different processes in a semiconductor industry. (By mid April)
2. Study on the conveyors used and other types of conveyor available in the market. (By end March)
3. Analyse on the problems faced in the present conveyor
4. Study on the requirements of a good conveyor system. (By end April)
5. Design & development of the conveyor system. (By end April)
6. Detailed drawing of conveyor system using AutoCAD software. (By end May)
7. Liaise with vendors on the fabrication of the conveyor system. (By end June)
8. Assembly of the conveyor system by the company set-up team. (By end July)
9. Testing on the work performance of the conveyor system. (By end July)
10. Comparison of the new conveyor system with the old system. (By end July)
11. Conclusion on the conveyor system. (By end August)
12. Discussion with the supervisor on the project writes out. (By end August)
13. Initial drafting of the project and show to the supervisor. (By end September)
14. Final drafting of the project which includes modifications suggested by supervisor. (By end September)
15. Complete of the report. (By end October)

If time permits:
16. Implement new improvements to the conveyor system. (By end October)

Agreed by Student: Lim Doou Gie Date: 02 / 04 / 04
Agreed by Supervisors: ____________ Date: ___ / ___ / ___
Agreed by Associate Supervisors: ____________ Date: ___ / ___ / ___
Appendix B

Project Information
## B.1 Parts Specifications

### Leadframe & Standard Parts Specifications

<table>
<thead>
<tr>
<th>S/no</th>
<th>Items</th>
<th>Descriptions</th>
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<tr>
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<td>Single, Dual or 4 Strand</td>
<td>4 Strand Stacker units kyoshin press (20 ton)</td>
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<td>2</td>
<td>Interleaf</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Output: min &amp; max</td>
<td>25 ~ 55 leadframes/minute</td>
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<td>4</td>
<td>Material of leadframe</td>
<td>A42 / Cu Alloy etched &amp; stamped</td>
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<td>5</td>
<td>Thickness of leadframe</td>
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<td>6</td>
<td>Leadframe Width : min &amp; max</td>
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<tr>
<td>7</td>
<td>Leadframe Length : min &amp; max</td>
<td>150 ~ 250 mm</td>
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<td>8</td>
<td>Stacking height</td>
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<td>3 ~ 5 stack (Base on leadframe width)</td>
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<td>10</td>
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<td>Anti-static green belt</td>
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<tr>
<td>11</td>
<td>Type of belt of stack conveyor &amp; colour</td>
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<td>12</td>
<td>Type of cushion of leadframe datum</td>
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<td>Hopper pusher material</td>
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### General Machine Specification

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<td>3</td>
<td>Power condition</td>
<td>200V 3 phase</td>
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<td>4</td>
<td>Compress air</td>
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<td>15</td>
<td>Pneumatic system</td>
<td>SMC or Koganei</td>
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<td>16</td>
<td>All belts / transmission with safety cover</td>
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<tr>
<td>17</td>
<td>Facility failure detector for no air</td>
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Person-in-charge: Tan Say Keong  
Mechanical design: Edmund Poon/ Roy Lim  
Electrical design: Edmund Koh  
Mechanical installation: Teo Tian Lai/ Jason Zhao  
Electrical wiring: Azli
## PROJECT SCHEDULE

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<tr>
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Appendix C

Assembly Drawings
C.3 Pictures

**Figure C.1** Top View of Conveyor System

**Figure C.2** Isometric View of Conveyor System
Figure C.3 Front View of Conveyor System

Figure C.4 Setting Up of Conveyor System in Production Floor
Appendix D

Data Sheets
D.1 General

1. Shape and Dimension of Parallel Key and Key Groove

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Note: Applicable shaft diameters should be derived from the torque that corresponds to the key strength. Shown here, therefore, are reference for general usage.

When the key size is appropriate for the transmission torque, a shaft larger than the applicable shaft diameter may be used. In that case, it is recommended to adjust h and t so that the key side uniformly contacts the shaft and hub. This does not apply to shafts smaller than the applicable shaft diameter.

Reference: Size codes in ( ) are not stipulated in the corresponding international standards and should not be used in new designs.
Retaining Rings (External) JIS B 2804

**Groove Dimension**

**d₀ Clearance Diameter**

---

**STW-rings can be supplied in tape wrapped or banded.**

**Size No. 36 through 125 tape wrapped or banded.**

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Unit: mm
## TOLERANCE SYSTEM - HOLE BASIS

### EXTRA FINE TOLERANCE FIT
- **H6**: EXTRA FINE HOLE
  - g5: Close running fit
  - h5: Slide fit
  - j5: Push fit
  - k5: Light keying fit
  - m5: Medium drive fit
  - n5: Heavy drive fit
  - p5: Force fit

### FINE TOLERANCE FIT
- **H7**: FINE HOLE
  - e8: Slack running fit
  - f7: Normal running fit
  - g5: Close running fit
  - h6: Slide fit
  - j8: Push fit
  - k6: Light keying fit
  - m6: Medium keying fit
  - n6: Heavy keying fit
  - p6: Force fit

### MEDIUM TOLERANCE FIT
- **H8**: MEDIUM HOLE
  - d9: Extra slack running fit
  - e9: Slack running fit
  - f8: Normal running fit
  - h7: Slide fit

### COARSE TOLERANCE FIT
- **H9**: COARSE HOLE
  - c9: Extra slack running fit
  - d8: Loose running fit
  - e8: Slack running fit
  - h8: Slide fit

### DESCRIPTION OF PREFERRED FIT

#### CLEARANCE FITS

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<td>Close running fit for running on accurate machines and for accurate location at moderate speeds and journal pressures.</td>
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<td>Sliding fit not intended to run freely but to move and turn freely and locate accurately.</td>
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<td>Locational clearance fit provides snug fit for locating stationary parts; but can be freely assembled and disassembled.</td>
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</table>

#### TRANSITION FITS

| H7 / k6    | K7 / h6     | Locational transition fit for accurate location, a compromise between clearance and interference. |
| H7 / m6    | N7 / h6     | Locational transition fit for more accurate location where greater interference is permissible. |

#### INTERFERENCE FIT

| H7 / p6*   | P7 / h6     | Locational interference fit for parts requiring rigidity and alignment with prime accuracy of location but without special bore pressure requirements. |
| H7 / s6    | S7 / h6     | Medium drive fit for ordinary steel parts or shrink fits on light sections, the tightest fit usable with cast iron. |
| H7 / u6    | U7 / h6     | Force fit suitable for parts which can be highly stressed or shrink fits where the heavy pressing forces required are impractical. |
### Tolerances of Commonly Used Hole Fits

#### Deviations of holes to be used in commonly used fits

**Basic size class (mm)**

<table>
<thead>
<tr>
<th>Basic size</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
</tr>
</tbody>
</table>

**Tolerance zone class of hole**

| Zone | Tolerance | Unit: μ M
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<thead>
<tr>
<th></th>
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<tr>
<td>A</td>
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<td>±16</td>
</tr>
<tr>
<td>B</td>
<td>+30 -30</td>
<td>±30</td>
</tr>
<tr>
<td>C</td>
<td>+30 -40</td>
<td>±50</td>
</tr>
<tr>
<td>D</td>
<td>+30 -50</td>
<td>±80</td>
</tr>
<tr>
<td>E</td>
<td>+30 -65</td>
<td>±120</td>
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<td>F</td>
<td>+30 -90</td>
<td>±200</td>
</tr>
<tr>
<td>G</td>
<td>+30 -120</td>
<td>±300</td>
</tr>
<tr>
<td>H</td>
<td>+30 -180</td>
<td>±450</td>
</tr>
<tr>
<td>I</td>
<td>+30 -240</td>
<td>±600</td>
</tr>
<tr>
<td>J</td>
<td>+30 -360</td>
<td>±900</td>
</tr>
<tr>
<td>K</td>
<td>+30 -480</td>
<td>±1200</td>
</tr>
</tbody>
</table>

**Note:** This table shows that the upper figures in each zone are the values given for the lower limit of the range.
<table>
<thead>
<tr>
<th>B/R</th>
<th>b8</th>
<th>c8</th>
<th>d8</th>
<th>d6</th>
<th>d5</th>
<th>d4</th>
<th>d3</th>
<th>d2</th>
<th>d1</th>
<th>c1</th>
<th>c0</th>
<th>b1</th>
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<tbody>
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<td>50</td>
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</tbody>
</table>

---

**Tolerance zone class of shaft**

Unit: \( \mu \)m

---

**Technical data:** The material of this chart is referenced from "SHAFT FITS and SHAFT BOres" in 1960.
1. Dimensions of counterboring and bolt hole for the socket head cap screws

<table>
<thead>
<tr>
<th>Nominal of screws (d)</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M14</th>
<th>M16</th>
<th>M18</th>
<th>M20</th>
<th>M22</th>
<th>M24</th>
<th>M27</th>
<th>M30</th>
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<tbody>
<tr>
<td>- d'</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>24</td>
<td>26</td>
<td>28</td>
</tr>
<tr>
<td>d'</td>
<td>3.4</td>
<td>4.5</td>
<td>5.3</td>
<td>6.6</td>
<td>9</td>
<td>11</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>24</td>
<td>26</td>
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</tr>
<tr>
<td>H</td>
<td>2.7</td>
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<tr>
<td>d₂</td>
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</table>

2. Dimensions of counterboring and bolt hole with spring washers or flat washers

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<th>Nominal of screws (d)</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M8</th>
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<th>M18</th>
<th>M20</th>
<th>M22</th>
<th>M24</th>
<th>M27</th>
<th>M30</th>
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<tr>
<td>t₂</td>
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<td>1</td>
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<td>1.6</td>
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<td>2.3</td>
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</tbody>
</table>
D.2 Conveyor Belt

---

**Flat Belts**  
*For general use / Transfer electronic parts*

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>L(m)</th>
<th>Unit Price</th>
<th>Endless Machining fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBLT 15</td>
<td>1.45</td>
<td>720</td>
<td>1,830</td>
</tr>
<tr>
<td>HBLT 10</td>
<td>1.45</td>
<td>720</td>
<td>1,830</td>
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<tr>
<td>HBLT 1</td>
<td>1.45</td>
<td>720</td>
<td>1,830</td>
</tr>
</tbody>
</table>

**Features of HBLT**

- **Electricity resistance of type**
  - 10-10^12
- **Voltage of the traveling belt**
  - 10-20
- **Vibration control**
  - 5-10

**Safety Precautions**

- **Note for Storage**
  - Keep away from direct sunlight.
  - Store in a clean, dry place.
- **Note for Use**
  - Avoid exposure to chemical fumes or extreme temperatures.
  - Do not use in areas with high humidity.

**Examples of Price Calculation**

- 
  \[ \text{Total price} = \text{Unit price} \times \text{Length} + \text{Endless machining fee} \]
  
**Criteria for Endurance of HBLT against Chemicals and Other Substances**

**Not damaged by**

- Acids, Alkalies, Oxidizing and Reducing Agents, Solvents
- Alcohol, Ether, Petroleum
- Water, Steam

**Damaged by**

- Sodium Hydroxide, Calcium Hydroxide
- Ammonium Hydroxide
- Mercury

---

**Type**

- **Belt Characteristics**
- **Belt Construction**
- **Appropriate Range**

<table>
<thead>
<tr>
<th>Type</th>
<th>Driving Pulley</th>
<th>Min. Pulley</th>
<th>Length</th>
<th>Weight (g)</th>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
<th>Length (m)</th>
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</thead>
<tbody>
<tr>
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<td>1.45</td>
<td>1.0</td>
<td>4.0</td>
<td>0.2/O</td>
<td>100</td>
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<td>25</td>
<td>1.45</td>
<td>0.7</td>
<td>3.0</td>
<td>0.1/O</td>
<td>100</td>
</tr>
</tbody>
</table>

---

- **Volume Discount Rate**
  - Quantity 1: 8% 2-4: 10% 5-19: 15% 20 and above: 20%
- **Expiry Date**
  - 300 days

---

- **Conveyor Belt DHLT**
- **For transfer electronic parts**

---

- **Production Time**
  - 5 days
- **Price**
  - 10,000 yen

---

- **Catalog No.**
  - L

---

- **Order Example**
  - HBLT 15 1.45

---

- **Note**
  - Specifications and designs are subject to change without notice.
  - The above information is for reference only and is not a guarantee.

---

- **CAD Data Folder Name:** Timing_Files

---

- **Date:**
  - 14.5

---

- **Example of Price Calculation**
  - DHLT 15 = 15
  - (Unit price) = 720 yen
  - (Endless machining fee) = 1,830 yen
  - Total price = 12,030 yen

---

- **Example of Price Calculation**
  - HBLT 15 = 15
  - (Unit price) = 720 yen
  - (Endless machining fee) = 1,830 yen
  - Total price = 12,030 yen

---

- **Example of Price Calculation**
  - HBLT 15 = 15
  - (Unit price) = 720 yen
  - (Endless machining fee) = 1,830 yen
  - Total price = 12,030 yen

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- **Example of Price Calculation**
  - HBLT 15 = 15
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- **Example of Price Calculation**
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- **Example of Price Calculation**
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- **Example of Price Calculation**
  - HBLT 15 = 15
  - (Unit price) = 720 yen
  - (Endless machining fee) = 1,830 yen
  - Total price = 12,030 yen

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- **Example of Price Calculation**
  - HBLT 15 = 15
  - (Unit price) = 720 yen
  - (Endless machining fee) = 1,830 yen
  - Total price = 12,030 yen
D.3 Bearing

### FLANGE UNITS

#### STANDARD

- **UNIT NO.**
  - UFLLOD
  - UFLLODOC
  - UFLLODOD
  - UFLLOD2
  - UFLLODOC
  - UFLLODOD2
  - UFLLO2
  - UFLLODOC
  - UFLLODOD2

- **DIMENSIONS (mm)**
  - D
  - H
  - J
  - A
  - A'
  - A
  - L
  - L
  - B
  - S
  - S
  - A
  - A

- **BOLT SIZE**
  - M6
  - M8

- **LOAD RATING**
  - CR (kN)
  - CO (kN)

- **HOLDING NO.**

#### UFLO SERIES

- **UNIT NO.**
  - UFL006
  - UFL006C
  - UFL006DC
  - UFL006D

- **DIMENSIONS (mm)**
  - D
  - H
  - J
  - A
  - A
  - A
  - L
  - L
  - B
  - S
  - S
  - A
  - A

- **BOLT SIZE**
  - M4

- **LOAD RATING**
  - CR (kN)
  - CO (kN)

- **HOLDING NO.**

#### WITH END COVERS

- **UNIT NO.**
  - UFL006
  - UFL006C
  - UFL006DC
  - UFL006D

- **DIMENSIONS (mm)**
  - D
  - H
  - J
  - A
  - A
  - A
  - L
  - L
  - B
  - S
  - S
  - A
  - A

- **BOLT SIZE**
  - M4

- **LOAD RATING**
  - CR (kN)
  - CO (kN)

- **HOLDING NO.**

---

**Notes:**

- Dimensions may vary slightly.

**Units:**

- mm

**Temperature Range:**

- 0°C to 60°C
D.4 Motor and Gearhead

The **US** series combines a separate-type control unit and a speed control motor. Connection between motor and control unit is simplified by a one-touch connector. The series is optimal for applications where remote control is required (Instantaneous stop function is not equipped).

### Features

- **Easy Connection**
  The operation is possible just by connecting the control unit into the power supply after connecting the motor and control unit through one-touch connector.

- **Easy Operation**
  The speed can be set easily with a potentiometer on the front panel of the control unit.

- **Approved by Safety Standards**
  The **US** series is recognized by UL/CSA standards and conforms to EN standard (EN certifications are scheduled). CE marking is used in accordance with low voltage directive.

### Safety Standards and CE Marking

<table>
<thead>
<tr>
<th>Standards</th>
<th>Certification Body</th>
<th>Standards File No.</th>
<th>CE Marking</th>
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</thead>
<tbody>
<tr>
<td>UL1904</td>
<td>UL</td>
<td>E4193 (6W type)</td>
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</tr>
<tr>
<td>UL2111</td>
<td></td>
<td>E4197 (15W - 90W type)</td>
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<tr>
<td>CSA C22.2 No.100</td>
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<tr>
<td>CSA C22.2 No.77</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Motor**
  - EN60034-1
  - EN60034-9
  - IEC60034-11 (15W - 90W type)

- **Control Unit**
  - UL508
  - CSA C22.2 No.14
  - EN9560
  - EN9578

- Recognized name and certified name of each safety standards are motor model name and control unit name.
- List of Motor and Control Unit Combinations = Page A-173
- For installations for EN/IEC standards = Page F-2
### System Configuration

- **Motor Mounting Brackets** (Sold separately) ([Page A-206])
- **Flexible Couplings** (Sold separately) ([Page A-201])
- **Motor Speed Indicator** (Sold separately) (Not a standard certified product) ([Page A-206])
- **Extension Cables** (Sold separately) ([Page A-206])

- **Motor**
- **Gearheads** (Sold separately)
- **Capacitor** (Included) ([Page A-206])
- **Capacitor Cap** (Included) ([Page A-206])

**Example of System Configuration**

**US Series**

<table>
<thead>
<tr>
<th>Variant</th>
<th>Motor Mounting Brackets</th>
<th>Flexible Couplings</th>
<th>Gearheads</th>
<th>Capacitor</th>
<th>Capacitor Cap</th>
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<tbody>
<tr>
<td>US560-501U</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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- ☐: Required under this system.
- ☐: Selectable according to necessity. Oriental Motor provides.

### Product Number Code

**US 560 - 50 1U**

<table>
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<tr>
<th>Parameter</th>
<th>Code</th>
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<td>560 (Series)</td>
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<tr>
<td>5</td>
<td>25mm</td>
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</table>

- **Motor Shaft Type**
  - 0: Round Shaft
  - 2: Right Angle (with G1 type gearhead)
  - 8: Right Angle (with G2 type gearhead)

- **Power Supply Voltage**
  - 1W: Single-Phase 110V/110V
  - 14: Single-Phase 100V/100V

Product Number Code of the Gearheads = Page A-18

For the model names, refer to the specifications on the next page.
## Specifications

1. The product are impedance protected.
2. The product contains a built-in thermal protector. When a motor overheats for any reason, the thermal protector is opened and the motor stops. When the motor temperature drops, the thermal protector closes and the motor restarts. Be sure to turn off the power before inspecting.

<table>
<thead>
<tr>
<th>Model</th>
<th>Maximum Output Power W</th>
<th>Voltage V</th>
<th>Frequency Hz</th>
<th>Variable Speed Range (RPM)</th>
<th>Torque 120V (Nm)</th>
<th>Torque 80V (Nm)</th>
<th>Torque 50V (Nm)</th>
<th>Starting Torque 120V (Nm)</th>
<th>Starting Torque 80V (Nm)</th>
<th>Current A</th>
<th>Power Consumption W</th>
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The variable speed ranges shown are under no load condition.
### Single-Phase 220V/230V

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</tr>
</tbody>
</table>

- Gearheads and decimal gearheads are sold separately.
- Enter the gear ratio in the box [ ] within the model number.
- A colored background indicates gear shaft rotation in the same direction as the motor shaft; a white background indicates rotation in the opposite direction.

### Gearmotor—Torque Table when Right-Angle Gearhead is Attached

A right-angle gearhead can be attached to US425, US540, US560 and US590 type.

- Page A-263

### Permissible Overhung Load and Permissible Thrust Load

Motor (Round Shaft Type) ~ Page A-14

Gearhead ~ Page A-14

### Permissible Load Inertia J (GD²) for Gearhead

- Page A-15
Motor/Gearhead

US560-501U, US560-502E (Pinion Shaft Type)
Motor: USM560-501W, USM560-502W
Mass: 2.8kg
Gearhead: SGU-KB
Mass: 1.5kg

Shaft Section of Round Shaft Type

US560-001U, US560-002E (Round Shaft Type)
Motor: USM560-001W, USM560-002W
Mass: 2.8kg

Key and Key Slot (Included with the gearheads, common to SGU-KB and SGU-K)

Decimal Gearhead
(Can be connected to GU pinion shaft type)
SGU10XKB (for SGU-KB), SGU10XX (for SGU-K)
Mass: 0.6kg

Flange Mounting Type Gearheads
(Can be connected to GU pinion shaft type)
SGU-K
Mass: 1.5kg

The figure in parenthesis indicates the dimension of SGU10XKB.
Key and Key Slot (Included with the gearheads)

Motor/Gearhead
US425-401U, US425-402E (Pinion Shaft Type)
Motor: USM425-401W, USM425-402W
Mass: 1.8kg
Gearhead: 4GN10XK
Mass: 0.65kg

Shaft Section of Round Shaft Type
US425-001U, US425-002E (Round Shaft Type)
Motor: USM425-001W, USM425-002W
Mass: 1.8kg

Decimal Gearhead
(Can be connected to GN pinion shaft type)
3GN10XK
Mass: 0.6kg

Key and Key Slot (Included with the gearheads)
C Control Unit
USP206-1U/USP206-2E
USP315-1U/USP315-2E
USP425-1U/USP425-2E
USP540-1U/USP540-2E
Mass: 0.45kg

Common to US560 and US590 type
USP560-1U/USP560-2E
USP590-1U/USP590-2E
Mass: 0.6kg

Panel Cut-Out for Control Unit
Installation Method by Opening a Square Hole

Capacitor (Included with the motor)

Capacitor Dimensions (mm)

- Capacitor cap is provided with the capacitor.
Connection and Operation

Names and Functions of Control Unit Parts

Front of Control Unit

Wiring Diagrams

Continuous Rotation:

Motor Speed Indicator
SOMAPPO
Pin number

Power Supply

Specifications: AC250V Inductive Load 5A minimum

US560, US590 type
Continuous Rotation:

Motor Speed Indicator
SOMAPPO
Pin number

Power Supply

In the diagram above, the motor shaft rotates in the clockwise direction. When changed to the dotted line position, the motor shaft rotates in the counterclockwise direction.

Bi-directional Rotation:

Specifications: AC250V Inductive Load 5A minimum

- An extension between the motor and control unit is required, an extension cable can be used (sold separately). Using the longest cord, the distance can be extended up to 4.75m. Extension Cables → Page A-309

Inner Wiring Diagram for 4-Terminal Capacitor

Terminals of the capacitor are connected as shown in the figure. For lead wire connection, use one lead wire for each individual terminal.

Operation Method


Rotation

Connect the motor lead wire connectors to the control unit. Then connect the AC power cord to the AC power supply. When the RUN/STAND-BY switch of the control unit is flipped to RUN, the motor rotates in the clockwise direction as seen from the motor shaft. (Control units are set for clockwise rotation at shipment. The direction of rotation for the gearhead output shaft may be the reverse of the direction of the motor shaft depending on the gear ratio.)

- US560 and US590 types
Connect the motor connector to the control unit. Then connect the AC power cord to the AC power supply. When the RUN/STAND-BY switch of the control unit is flipped to RUN, the motor rotates in the clockwise direction as seen from the motor shaft. (Control units are set for clockwise rotation at shipment. The direction of rotation for the gearhead output shaft may be the reverse of the direction of the motor shaft depending on the gear ratio.)
Changing Speed
When the potentiometer located on the front surface of the control unit is turned in the clockwise direction, motor speed increases; when turned in the opposite direction, motor speed decreases.
Motor speed can be set and adjusted over a range of 90/min—1400/min at 50Hz, 90/min—1600/min at 60Hz.

Stopping
When the RUN/STAND-BY switch on the control unit is set to STAND-BY, the motor stops. This switch is not a power ON/OFF switch. When the motor is to be stopped for a long time, a separate power ON/OFF switch should be installed.

Changing the Direction of Rotation
- US206, US315, US425 and US540 types (Capacitor is attached to the control unit.)
Continuous Rotation:
When the direction of motor rotation needs to be reversed for reasons relating to transmission mechanisms such as gearheads, change the terminal used for attaching the power cord, located at the back of control unit, from terminal N (CW) to terminal N (CCW).
The power cord connections are located at terminals L and N (CW) when shipping.
(The should always be done with the power OFF.)
Bi-directional Rotation:
Install an additional power switch and CW/CCW switch as shown in the diagram to the left, and use these switches to change the direction of rotation.
(Motor cannot be reversed instantaneously. Turn SW1 off and wait until the motor has come to a complete stop before switching SW2.)
Connecting the Speed Indicator:
Connect the terminals ① and ③ of the SDM496 (a speed indicator) to the SPEED OUT terminals of control unit.

- US560, US590 types (Connection of capacitor is necessary.)
Un-directional Rotation:
After turning the power off, change the lead wire used for attaching the power cord located at the back of the control unit, from N(CW)-N(COM) to N(CCM)-N(CCW). (The lead wire is set at N(CW)-N(COM) when shipping.)
Bi-directional Rotation:
Install an additional power switch and CW/CCW switch as shown in the diagram on page A-172, and use these switches to change the direction of rotation. (Motor cannot be reversed instantaneously. Turn SW1 off and wait until the motor has come to a complete stop before switching SW2.)
Connecting the Speed Indicator:
Connect the terminals ① and ③ of the SDM496 (a speed indicator) to the SPEED OUT terminals of control unit.

List of Motor and Control Unit Combinations
Model numbers for motor/control unit combinations are shown below.

### Single-Phase 110V/115V

<table>
<thead>
<tr>
<th>Input Power</th>
<th>Motor Model</th>
<th>Control Unit Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>6W</td>
<td>US206-40IU</td>
<td>USP206-1U</td>
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<td>US206-00IU</td>
<td>USP206-01U</td>
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<td>US315-40IU</td>
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<td>USP425-01U</td>
</tr>
<tr>
<td></td>
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<td>US560-50IU</td>
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### Single-Phase 220V/230V

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<th>Motor Model</th>
<th>Control Unit Model</th>
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<tbody>
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<td>US206-402E</td>
<td>USP206-2E</td>
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<td>US206-002E</td>
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<td>US315-402E</td>
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<td></td>
<td>US425-402E</td>
<td>USP425-2E</td>
</tr>
<tr>
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<td>US425-002E</td>
<td>USP425-002E</td>
</tr>
<tr>
<td></td>
<td>US540-402E</td>
<td>USP540-2E</td>
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<td>US540-002E</td>
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<td>US560-502E</td>
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<td>US590-502E</td>
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<tr>
<td></td>
<td>US590-002E</td>
<td>USP590-002E</td>
</tr>
</tbody>
</table>
D.5 Timing Belt

**Synchronous Belts**

**Model:** TSN (Rubber)

**Materials:**
- Rubber
- Polyurethane

**Dimensions:**
- Pitch: 45° (L = 1.4, H = 1.1)
- Width: 0.4 to 4.6 (L = 1.4, H = 1.1)
- No. of Teeth: 80 - 400

**Order Example:**
- TSN 210 XL 050
- TBN 210 L 050

**Price:**
- Volume Discount Rates
  - 1 - 4: 5%
  - 5 - 19: 10%
  - 20 - 49: 15%
  - 50 - 99: 20%
  - 100 - 249: 25%
  - 250 - 499: 30%
  - 500+: 35%

**Production Time:**
- Type TBN (MXL, XL, L): 3 Days
- Type TBN (H), TUN: 5 Days

**Notes:**
- Note that the number of teeth has different meanings depending on their types.
- The pitch is represented by the surface on the tooth for MXL and the tangential length for XL, L, and H.

**Type MXL:**
- Pitch: 2.033 mm

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---

- **Catalog No.**
- **Type:**
- **Belt No.:**
- **Width:**
- **Unit Price:**

---
### Type XL (Pitch: 0.808mm)

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Unit Price</th>
<th>No. of Belt Width</th>
<th>Belt Width</th>
</tr>
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<tbody>
<tr>
<td>182XL</td>
<td>911.46</td>
<td>(574, 579)</td>
<td>010</td>
</tr>
<tr>
<td>183XL</td>
<td>902.47</td>
<td>(574, 579)</td>
<td>060</td>
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<tr>
<td>184XL</td>
<td>901.48</td>
<td>(574, 579)</td>
<td>110</td>
</tr>
<tr>
<td>185XL</td>
<td>891.49</td>
<td>(574, 579)</td>
<td>160</td>
</tr>
<tr>
<td>186XL</td>
<td>881.50</td>
<td>(574, 579)</td>
<td>210</td>
</tr>
<tr>
<td>187XL</td>
<td>871.51</td>
<td>(574, 579)</td>
<td>260</td>
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<tr>
<td>188XL</td>
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</tr>
<tr>
<td>189XL</td>
<td>851.53</td>
<td>(574, 579)</td>
<td>360</td>
</tr>
<tr>
<td>190XL</td>
<td>841.54</td>
<td>(574, 579)</td>
<td>410</td>
</tr>
</tbody>
</table>

### Type L (Pitch: 0.925mm)

<table>
<thead>
<tr>
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<th>Unit Price</th>
<th>No. of Belt Width</th>
<th>Belt Width</th>
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<tbody>
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<td>110</td>
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### Type H (Pitch: 1.279mm)

<table>
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<td>231XL</td>
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<tr>
<td>232XL</td>
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<td>(654, 659)</td>
<td>410</td>
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**Volume Discount Rate**

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<th>5</th>
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<th>25</th>
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<td>20%</td>
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<td>75%</td>
<td>100%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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**Price**

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**Volume Discount Rate**

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<th>Quantity</th>
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<td>50%</td>
<td>60%</td>
<td>75%</td>
<td>100%</td>
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**Price**

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<td>(624, 629)</td>
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**Volume Discount Rate**

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**Price**

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<td>302.64</td>
<td>(654, 659)</td>
<td>410</td>
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</tbody>
</table>
D.6 Pulley

**Synchronous Belt Pulleys — XL type —**

![Image of synchronous belt pulleys]

- **Catalog No.**
- **Type**
- **No. of Teeth**
- **Shape**
- **H-P.N-C Hole**
- **B Hole**
- **Z**
- **J**
- **P.D.**
- **O.D.**
- **F**
- **E**

**Table 1: Selection Table for Shear Force and Spec.**

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Pulley Shape</th>
<th>Shaft Hole Spec.</th>
<th>Type</th>
<th>P.D.</th>
<th>O.D.</th>
<th>F</th>
<th>E</th>
<th>Z</th>
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<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
</tr>
</tbody>
</table>

**Order Example**

- **ATPXL037**
- **B**
- **V19**

**Production Time**

- **3 Days**

**Notes:**
- For applicable synchronous belt drive belts, refer to P.983.
- When shaft hole specifications is V, then Z=22.

---

- **106**
D.7 Structure

Profile / Profiles / Profils

40x80L
40x120L
40x160L

LE 1 x L = ... mm
3 842 993 130
M12
3 842 993 131
M10 M12
3 842 993 132
D17 L 3 D17
3 842 993 135
D17 L 3 D17
3 842 993 136
D12 + D17
3 842 993 137

LE 12 x L = 6070 mm
3 842 529 341

LE 1 x L = ... mm
3 842 993 139
M12
3 842 993 140
M10 M12
3 842 993 141
D17 L 3 D17
3 842 993 142
D12 + D17
3 842 993 144

30 mm ≤ L ≤ 6000 mm

LE 12 x L = 6070 mm
3 842 529 343

LE 6 x L = 6070 mm
3 842 529 345

Endenbearbeitung M12 an gekennzeichneten Zentralbohrung.
End finishing M12 at marked central bore.
Usinage des extrémités M12 dans la cannelure centrale marquée à cet effet.

* Endenbearbeitung D17 an gekennzeichneten Nut.
* End finishing D17 at marked groove.
* Usinage des extrémités D17 dans la rainure marquée à cet effet.