



# What is the most advanced mechanical system?

Introduction to Mechanical Design  
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## 1. JUSTIFICATION: Why is this important?

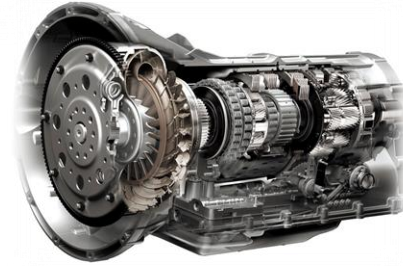
- ✓ The requirements of the engineer who wants to take part in modern industrial field is that recognizing a trends in the development of high-tech machines.
- ✓ To understand an one system, a detailed understanding of the specific elements that make up the system is required.

## 2. Outline of content

System: **Auto  
mobile**



Sub system: **transmission**



Key element: **clutch**



Why is this a key element? :  
Efficiency, stability

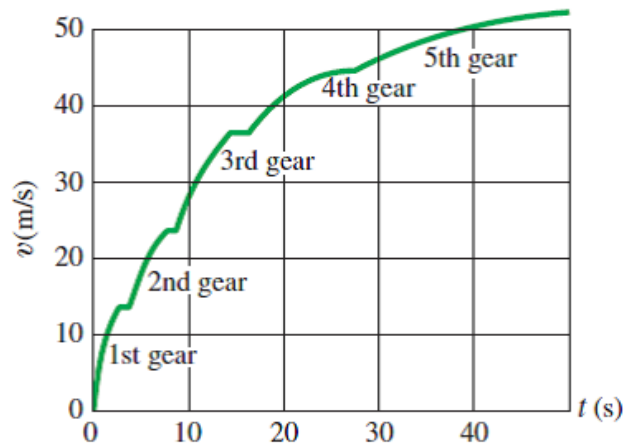
How to improve transmission  
system's efficiency? : **clutch disc**



How to design a clutch disc



## 3.1 Technical content – System: Automobile



*“Transmission makes a car’s shift(gear change).”*

Automobiles are general transportation in modern times.

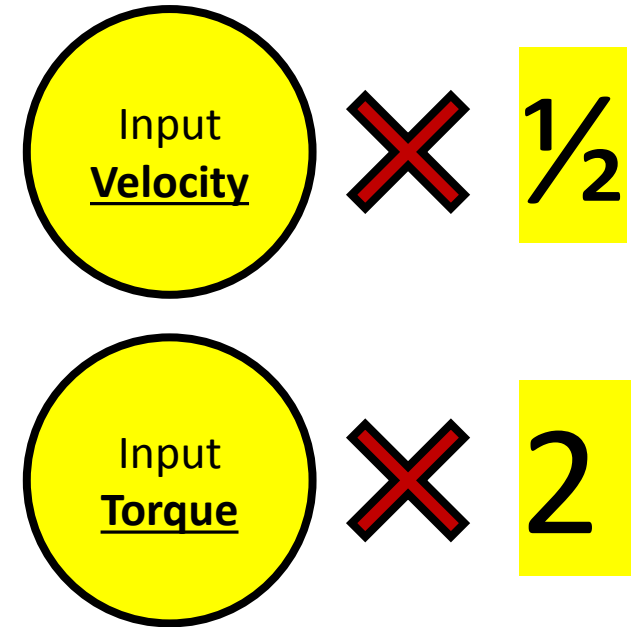
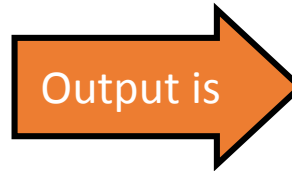
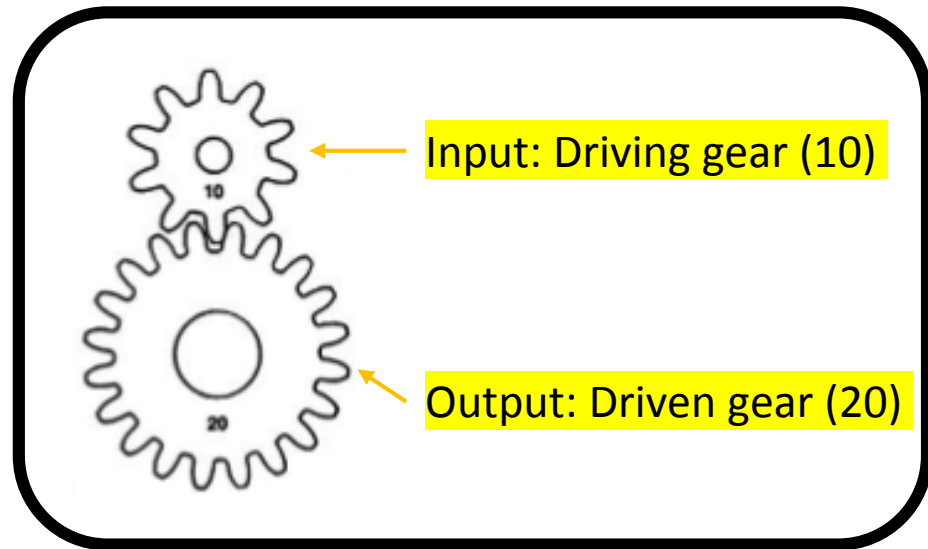
In that, automobile is the major subject that would be applied variety advanced technologies firstly.

Among them, the technologies of transmission is very important to experience more comfortable and exciting drive.

When a car is accelerated, we could experience to recet speed change.

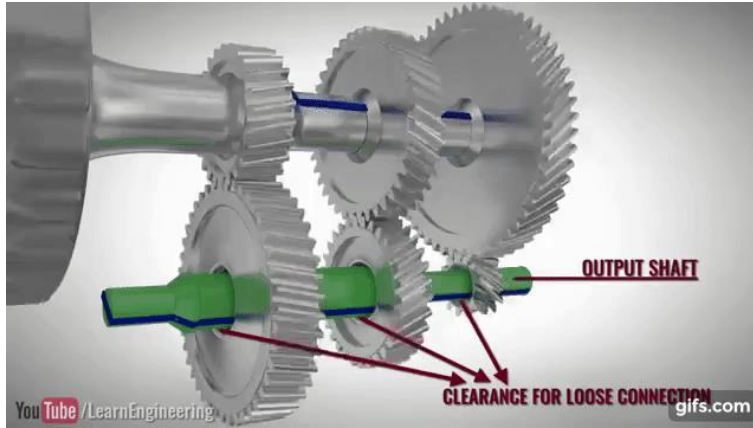
To understand this, we have to study the principle of transmission.

## 3.2 Technical content – Sub-system: transmission

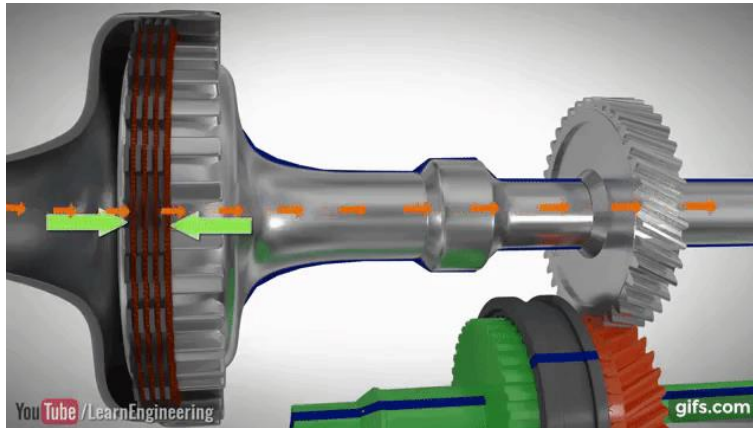


if the **number of teeth** of the driving gear and driven gear is a ratio of one to two, the **speed** of the driven gears is cut in half, and the **torque** is doubled.

## 3.2 Technical content – Sub-system: transmission



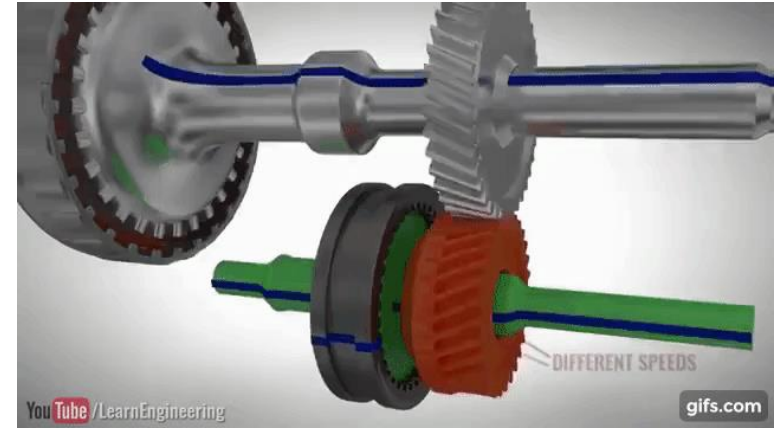
(1) The **output gears** are loosely connected to the **shaft**.



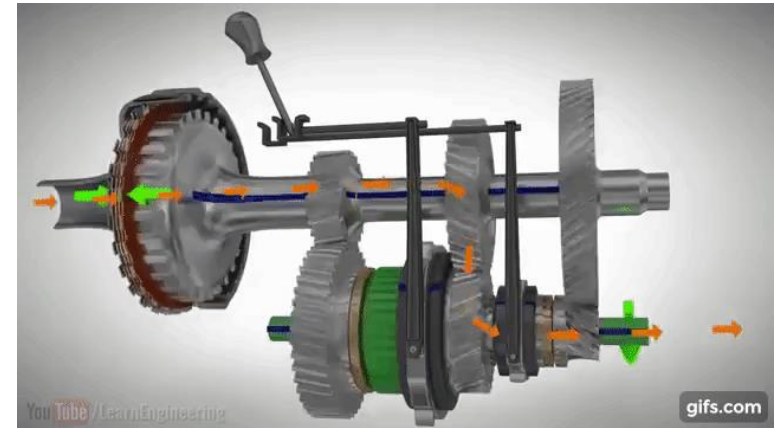
(3) To achieve a **speed match**, it is essential to **disconnect** the power flow to the transmission by **clutch**.

Upper gear  
= Input gear  
= driving gear  
(power comes from the engine)

Lower gear  
= Output gear  
= driven gear  
(power is transmitted to the wheels)



(2) the **sleeve** (black) and **gear** (orange) will be rotating at **different speeds** during the transmission operation.

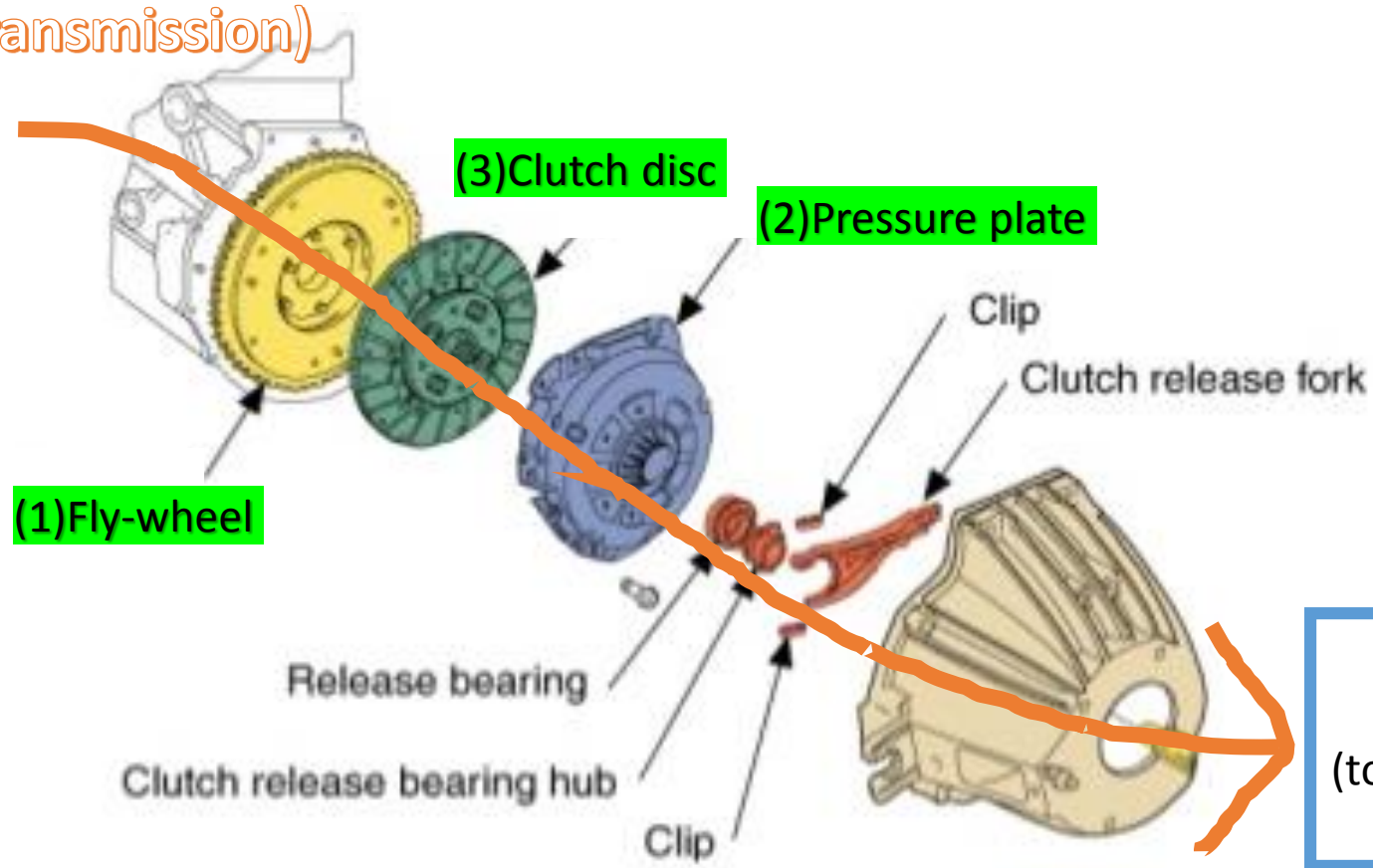


(4) when **clutch plate is pressed** the frictional force it can discontinue the power flow and achieve a **speed match**.

### 3.3 Technical content – Key element: Clutch

the **clutch** is a device for disconnecting and connecting rotating shafts.

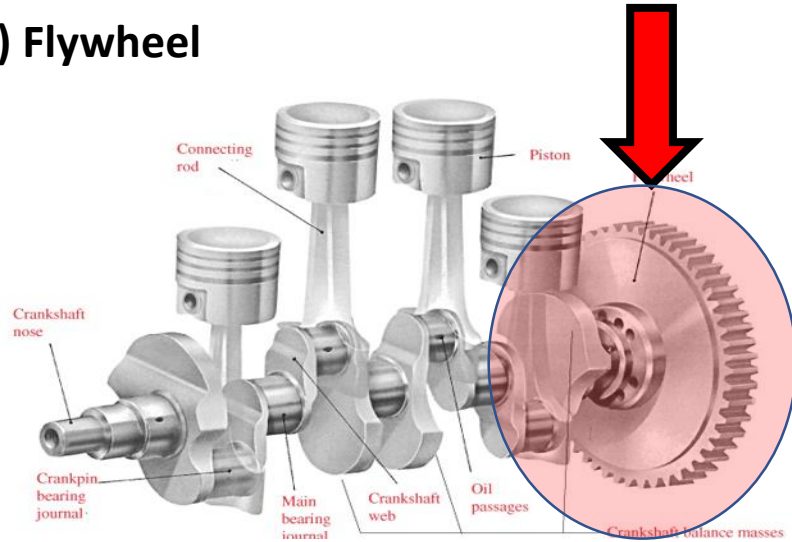
(Power transmission)  
Engine  
+crank shaft



Transmission  
(toward to wheel)

## 3.3 Technical content – Key element: Clutch

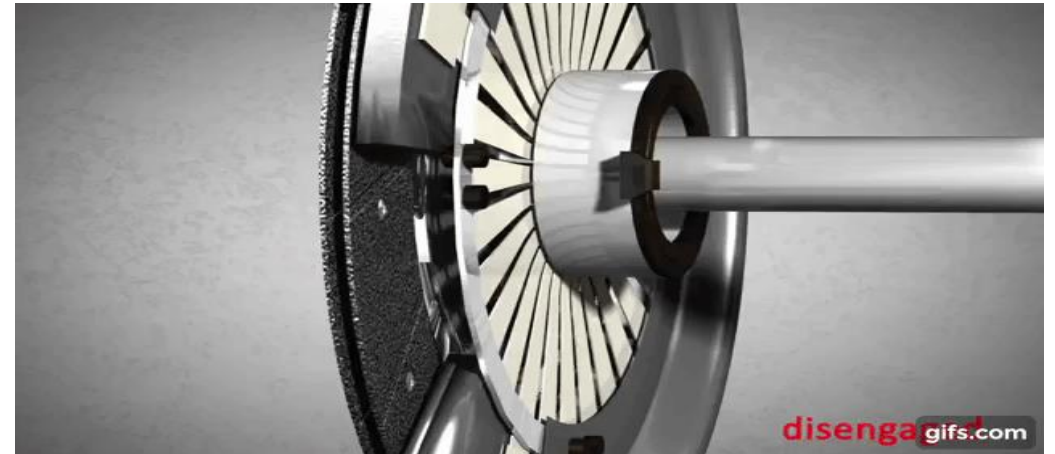
### (1) Flywheel



The flywheel is connected to the crankshaft on the engine and is located between the engine and the clutch disc.

The **inertia** provided by the **flywheel** mass tends to keep crankshaft speed more constant.

### (2) Pressure plate



The **pressure plate** is used to efficiently transfer the engine torque between the flywheel and the clutch disc.

To do so, the pressure plate **pushes the clutch disc** with sufficient force to contact the flywheel.



## 3.4 Technical content – Why is this a key element?: efficiency & stability

When all of these conditions are satisfied, the **driving efficiency and stability** of the car will undoubtedly increase.



### (1) Requirement of clutch

1. Torque from the **engine** is delivered to the **transmission** effectively.

The clutch must transmit to the transmission the torque required under all driving conditions, over the full range of effective rotational speeds of the engine.

2. **Connect and disconnect** the **power** from the **engines**

To synchronize the gear parts to be transferred, the power transfer between the engine and manual transmission must be cut off.

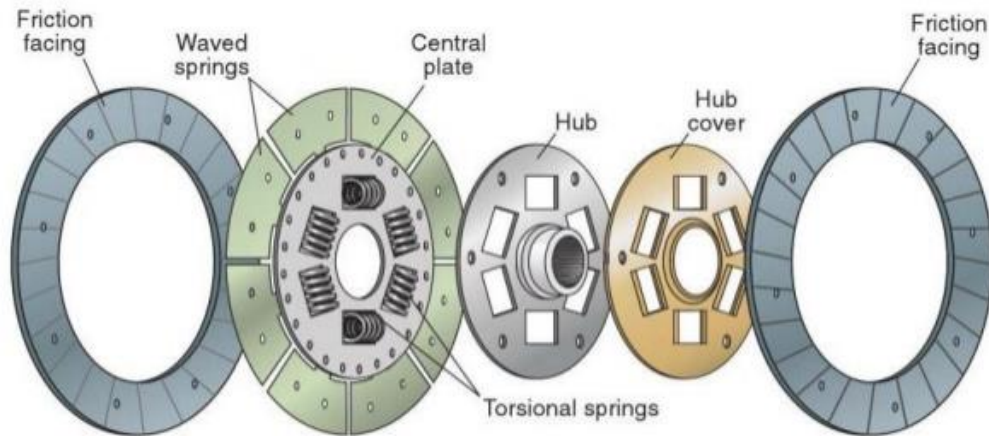
3. **Reduce** the **torsional vibration**.

As the explosion stroke is repeated periodically, a torsional vibration occurs on the crankshaft. The torsional attenuator on the clutch disk reduces this torsional vibration. This minimizes transmission noise, e.g., rattling noise.

4. **The engines and components** protected from **overload**.

Excessive torque transmission is prevented by slipping the clutch.

## 3.5 Technical content – how to improve clutch's efficiency & stability: clutch disk



the **clutch disc** has the friction material needed to **transmit** engine torque from the flywheel and pressure plate to the input shaft of the transmission.



(1) this **spring hub arrangement** dampens **torsional vibrations** from the engine.



(2) **Friction facing** is riveted to both sides of the clutch disc.

## 3.6 Technical content – How to design Clutch disk

### Physical properties of clutch disc

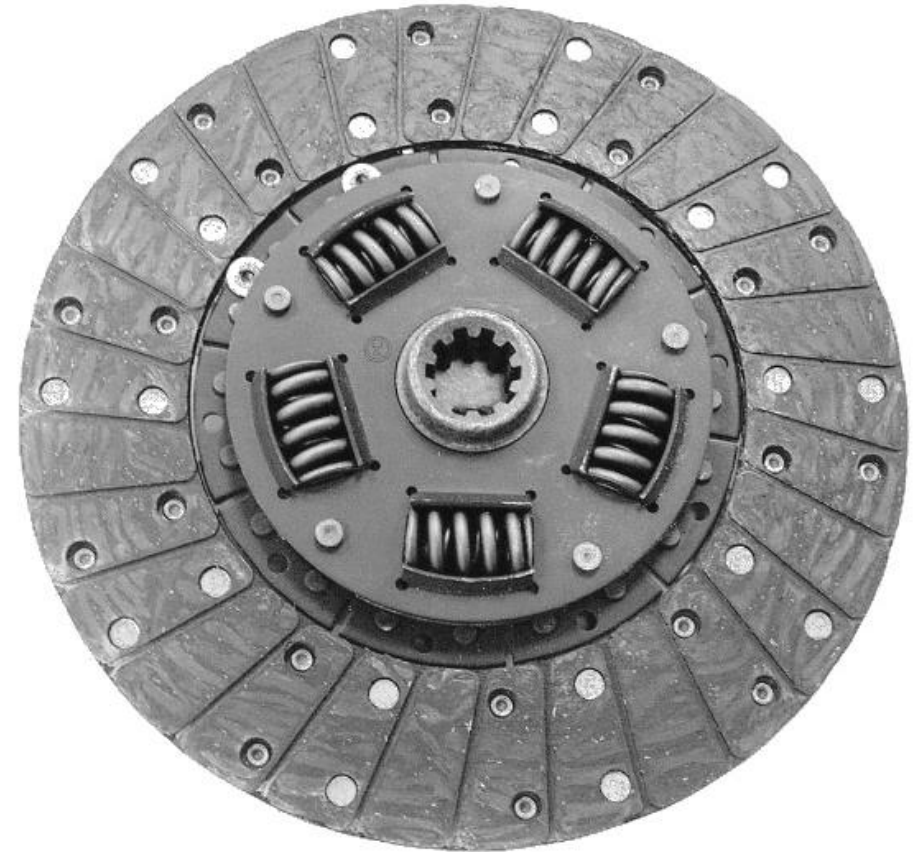
The most important thing in designing a part is to understand the **physical properties** to perform its role well.

- ⊖ good **heat resistance**
- ⊖ high **resistance to wear**
- ⊗ high **coefficient of friction**

: With good thermal conductivity, a constant high coefficient of friction shall be maintained over the widest possible temperature range.

- ④ **surface bonding strength**

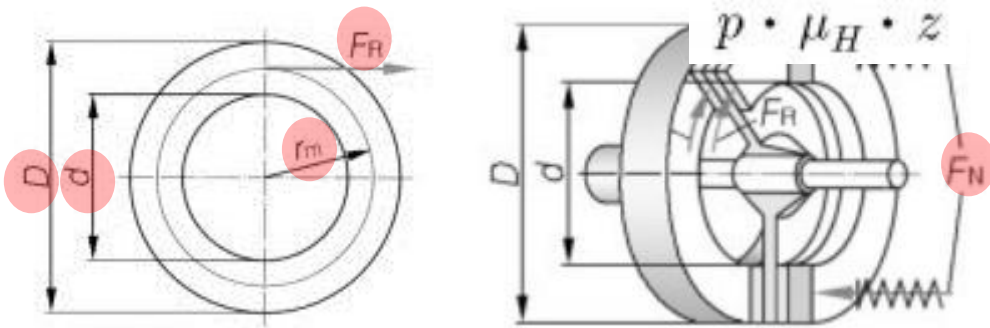
: To prevent the surface from being ripped off, a large amount of triple-flange should be created.



## 3.6 Technical content – How to design Clutch disk

$$p \cdot \mu_H \cdot z \cdot 2 \cdot A \cdot r_m = M_K$$

**(Key Formula for Design of a clutch disc)**



**<Measurement of clutch-disc and the others>**

$D$  : outer diameter of disc[cm]

$d$  : inner diameter of disc[cm]

$A$  : cross section of facing[cm<sup>2</sup>]

$p$  : surface pressure[N/cm<sup>2</sup>]

$M_K$  : Total deliverable torque

$r_m$  : significant radius of torque

$z$  : Number of clutches

$F_R$  : friction on one side of the facing[N]

$F_N$  : compression force  
(sum of the clutch spring tension)[N]

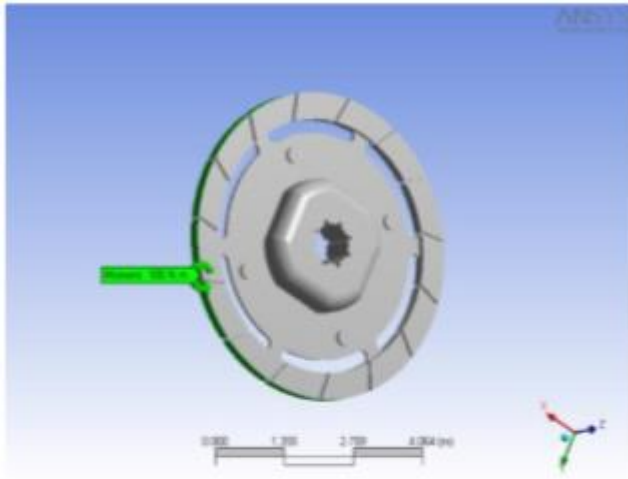
$\mu_H$  : coefficient of static friction

$\mu_K$  : coefficient of sliding friction

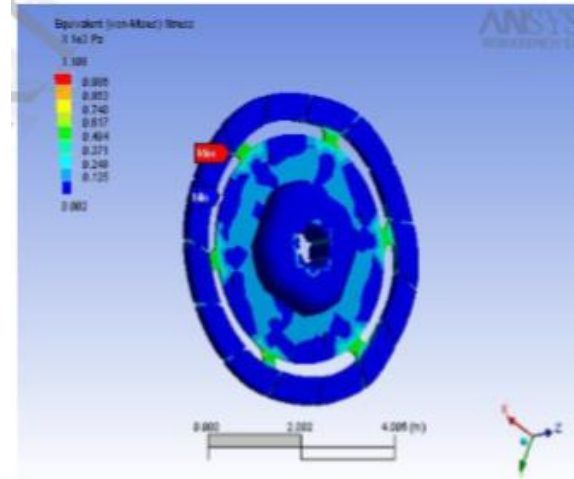


## 3.6 Technical content – How to design Clutch disk

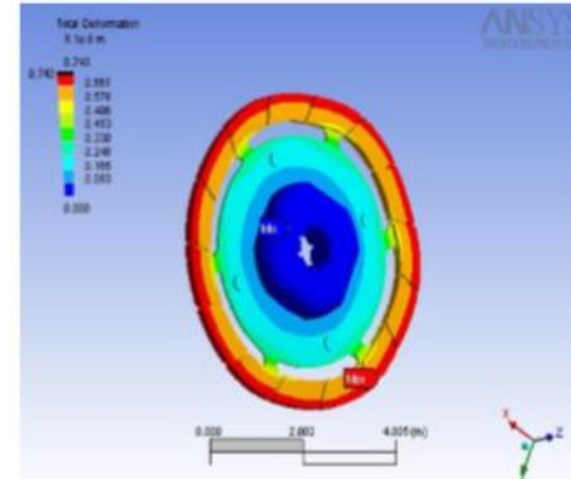
### Result in ANSYS



(1) Moment on plate



(2) Equivalent stress



(3) Total deformation

- At end of the design, it is necessary to analyze them by several programs like ANSYS

- We can get the values that we've learned in materials mechanics.

Table 1. Properties of Structural steel

Name	Value
Compressive Ultimate Strength	0.0 Pa
Compressive Yield Strength	$2.5 \times 10^8$ Pa
Density	7,850.0 kg/m <sup>3</sup>
Ductility	0.2
Poisson's Ratio	0.3
Tensile Yield Strength	$2.5 \times 10^8$ Pa
Tensile Ultimate Strength	$4.6 \times 10^8$ Pa
Young's Modulus	$2.0 \times 10^{11}$ Pa
Thermal Expansion	$1.2 \times 10^{-5}$ 1/°C
Specific Heat	434.0 J/kg·°C
Relative Permeability	10,000.0
Resistivity	$1.7 \times 10^{-7}$ Ohm·m

## 4. Conclusion: What was learned?



- ✓ Many improvements in technology have been developed over the years, and will continue to be developed even in the smallest parts. And we found that they were fraught with the hard work and sweat of countless senior engineers.
- ✓ We learned the roles of variety sub-systems that we thought which are not important.
- ✓ An organic link between the small detail parts is required for one high-tech machine system to operate.

## 5. The road ahead: what you propose to do next or recommend others to do (learn more)



- At the first phase preparing this presentation, We were trying to study a gear. However, the depth of the knowledge for designing gears was so deep that we had to give up. It seems difficult to study in time.

We want to study more about the gears through some professor's class.

- We wanted to explain the (**Key Formula for Design of a clutch disc**) in detail over about three pages. But since we are running out of time, It could not be. We should practice making our presentation more effectively in a short time.

- Since the design takes into account the various characteristics of the material, we should study materials in depth.

## 6. Support material: references (ASME style)

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**(Question and Answer)**

**Thank you for listening to my presentation.**