AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

DEPT OF ENERGY & AUTOMOTIVE ENGINEERING

# PLATES TORQUE DECAY OF MULTIPLATE

## FRICTION CLUTCH
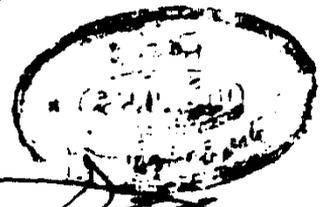
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by

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## SUMMARY

The torque capacity of friction clutch decreases during its service-life down to a value at which the clutch fails to transmit the applied torque.

The reliability of the clutch can be improved from the knowledge of the torque decay function i.e reducing the number of clutch failures.

The prediction of the torque decay shape function for the elements of the multiplate clutch pack is achieved by the help of the reliability theory and the field failure data.

To arrive at the torque decay shape function theoretically, three shape functions (parabolic ,straight line and exponential shape functions ) have been tried.

A field study is done on a multiplate friction clutch of a heavy vehicle to obtain the distribution function of covered kilometers by the vehicle to the failure of the clutch . The comparison of the practical and the theoretical results which are based on the three shape functions, shows that the suitable torque decay shape function is a compound function . This function composes of a straight line to about 70% of the service-life of the clutch plate, and parabolic function to the end of life .

This compound function gives results in acceptance with the practical results at confidence level of 99% .

A     Effective area of a friction surface.

$A_j$     Friction work done during the $j^{th}$ cycle.

a     Ratio of internal and external radii of a friction surface.

B     Constant.

$C_i^{ns}$     Combination of i out of ns .

$E(.)$     Expected value (arithmatic mean).

$F(j)$     Difference between summation of hazard functions when there are j failures in the system.

F     Friction force.

$f(x)$     Probability density function of the stress.

G     Geometry factor .

$g(Y)$     Probability density function of the strength.

$h_j(.)$     Hazard function of the $j^{th}$ element.

$h_j^n$     Hazard function of the $j^{th}$ element when there are n failures in the system .

$I_1$     Rotating inertia belongs to a power unit.

$I_2$     Rotating inertia belongs to a working unit.

$KE$     Covered kilometers to joint point of straight line shape function and parabolic one.

$K^{'}$     Coefficient of proportionality.

k     Covered kilometers .

$k_f$     Covered kilometers to failure.

$k_i$     Covered kilometers to failure of the $i^{th}$ vehicle.

$k^{''}$     Proportionality factor.

l     Real numbers 1,2,3 and 4 .

| | |
|---|---|
| z | standard variate. |
| $x_i$ | total number of tested vehicles in th horn- arized sample. |
| $\alpha_j$ | Fraction of probabilities with indices i indicates the number of failed elements the index of elements in the system. |
| $\beta_o$ | Mean number of occurences per unit time. |
| $\beta, \beta_1$ | Dynamic factor considering and neglecting spline friction. |
| $\beta_2$ | Shape parameter of Weibull distribution. |
| $\gamma$ | Location parameter of Weibull distribution. |
| $\gamma_1$ | Coefficient shows how the 1- shape function is near to the ideal case. |
| $\eta$ | Scale parameter of Weibull distribution. |
| $\theta$ | Value corresponds to number of occurences. |
| $\theta_1$ | Mean angle between normal force on tooh of rotor plate and tangent to curcumference. |
| $\theta_2$ | Mean angle between normal force on tooth of stator plate and tangent to curcumference. |
| $\omega_N(t)$ | Probability of N occurences in o to t time. |
| $\mu$ | Coefficient of friction between plates. |
| $\mu_2$ | Coefficient of friction between rotor plate and splines. |
| $\mu_3$ | Coefficient of friction between stator plate and splines. |
| $\sigma_{..}$ | Square root deviation of.. |
| $\sigma_1$ | Square root deviation of the torque capacity of the pair of friction surfaces. |
| $\sigma_2$ | Square root deviation of the applied torque on the pair of friction surfaces. |

## INTRODUCTION :

The torque capacity of friction clutch decreases
during its service - life down to a value at which
the clutch is unable to transmit the applied torque.
In this case the clutch is said to be failed.

Determination of the form of the torque decay
shape function helps to improve the clutch reliability
( reduce the number of failures ).

The prediction of the torque decay shape function
of the elements of the multiplate pack of the clutch
enables the designer to have the reliability equation
as a function of design parameters. Then a parametric
study can be made for minimization of the number of
failures .

The design parameters are the coefficient of
friction between plates, the coefficient of friction
between the plates and splines, compressive  force
on plates, number of plates , dynamic factor , and
dimensions of the plates.

This work concentrates on the prediction of the
torque decay shape function for the elements of the
multiplate clutch pack .

This is achieved by the help of reliability
theory and field failure data .
Fig.(1)shows the method of fulfilment the task .

eliability i the probability that a system can
perform its function correctly in a given period of
time under the given operating conditions. Reliability
evaluation is derived by practical or theoretical
means. ractical evaluation needs especial technique
of testing, to process the data collected, and to
interpret the information in a meaningful fashion ,
or to collect appropriate data from field of exper-
ience. Theoretical evaluation of reliability needs
to formulate a reliability mathematical model which
is an adequate representation of the component (ag-
gregate) being considered. Thus involving the tech-
niques of probability theory, mathematical modelling
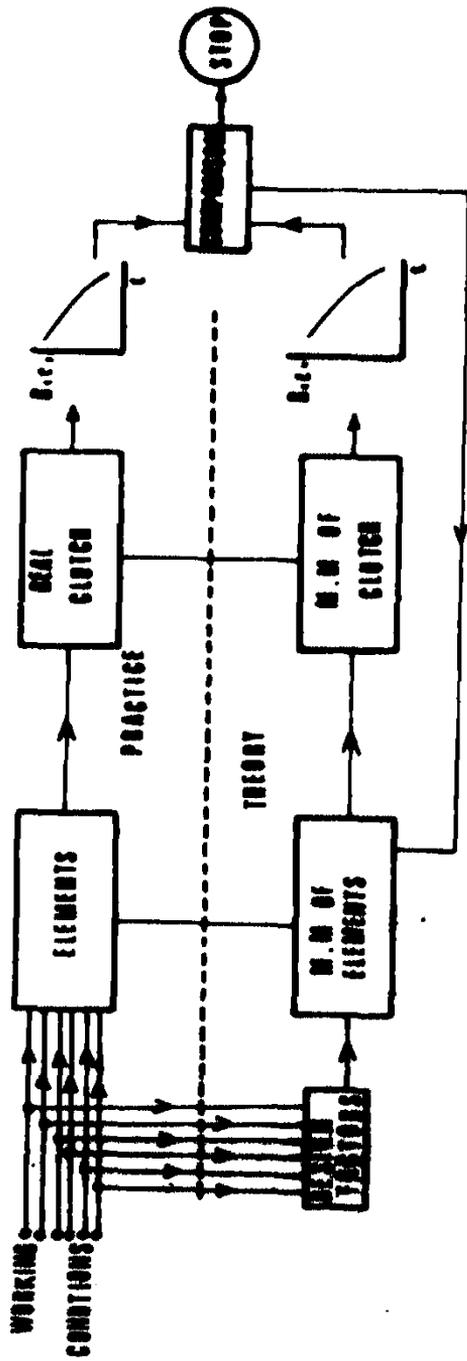and various especialized mathematical concepts.

Fig.(1) PROCEDURE OF ESTIMATION OF PLATE TORQUE DECAY

R(t)........ Reliability function of time t

M.M......... Mathematical model

CHAPTER ONE : FACTORS AFFECTING SERVICE-LIFE OF
FRICTION CLUTCHES :

The friction clutch Fig.(1.1)consists of driving
parts, driven parts and release mechanism . It is
better to study the function of the friction clutch
before dealing with the factors affecting the serv-
ice-life.

## 1.1 Function of Friction Clutches [1]* :

The clutch transmits power from a power source
to a stationary or moving component until the two
are moving at the same speed, that is ; until there
is no relative angular velocity between driving and
driven parts. Consider two rotating inertias $I_1$ and
$I_2$ rotate with unequal angular velocities $W_1$ and $W_2$
at time two and $w_1$ and $w_2$ at any instant. Let $I_1$
belongs to a power source giving a torque Md and $I_2$
belongs to a working unit having a resisting load
torque $T_2^+$ . Furthermore, let the clutch transmits
a torque T .

The function of the clutch-according to Fig.
(1.2)- is as follows :

(1) Let the engagement of the clutch starts at time
    t = o , the clutch torque T increases up to
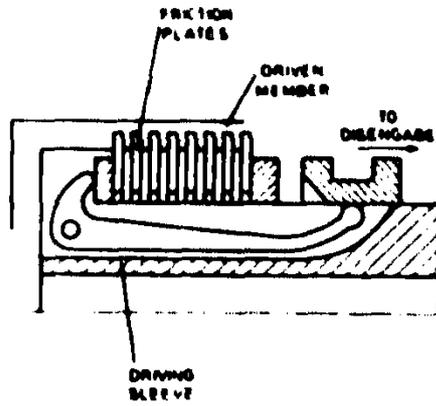
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\* Number of reference

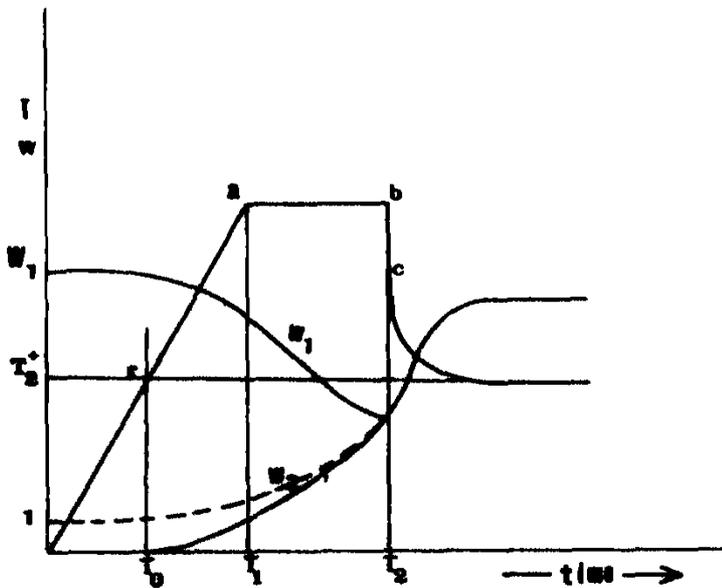Fig.1 1 Design of multi-plate clutch [6]



Fig.1.2. Function of the clutch

the value of the resisting torque $T_2'$ at the point r. The driven parts begin to move at time $t_o$ .

(2) After full engaging the clutch torque becomes maximum (point a) . The angular velocity of driven parts increases during the time $(t_o-t_1)$.

(3) During the time $t_1$ to $t_2$, even the clutch is fully engaged, it goes on slipping . The value of $w_2$ increases and the value of $w_1$ decreases. The tourque T is constant during this period.

(4) At time $t_2$ , the clutch will rotate as one solid body $(w_1=w_2)$ .

(5) For vehicles, if $M_d$ is the torque of the engine, and $T_2^+$ is the resisting torque transfered to driven shaft of the clutch, the diagram repre-sents the starting of the motion of the vehicle.

(6) If the angular velocity of the driven parts of the clutch varies from zero (point 1), then the diagram shows the shift to higher gear.

## 1.2 Design Factors :

It is meant by the design factor that one defin-ed by the designer as dimensions , number of plates (n+1), coefficient of friction between surfaces $\mu$ compressive force P and dynamic factor $\beta$. The rela-tions between some parameters will be studied .