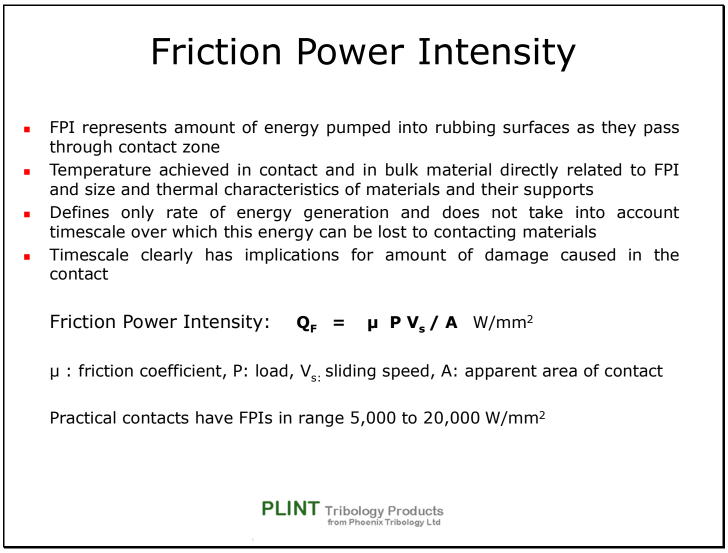
Guidance – Friction Power Intensity & Energy Pulse

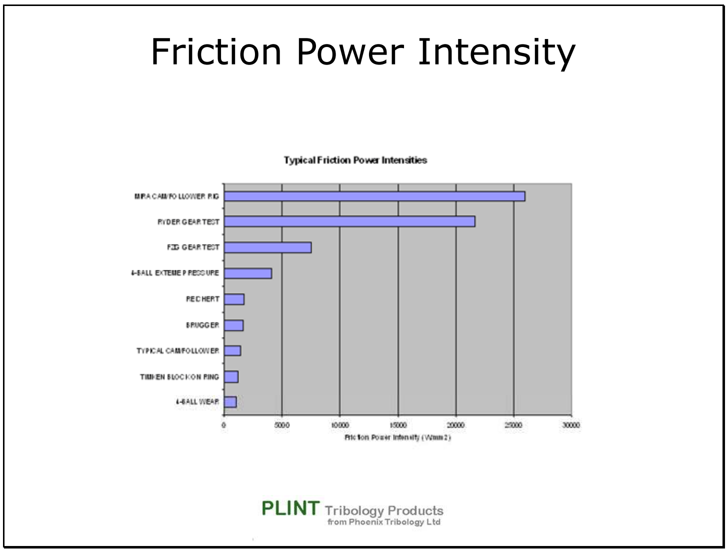
Extract from:

https://www.phoenix-tribology.com/wp-content/uploads/products/guidance/Tutorial-Tribology-Testing.pdf



The friction power intensity (Matveevsky) is simply defined as the amount of energy pumped into the rubbing surfaces as they pass through the contact zone. The temperature achieved in the contact and in the bulk material is directly related to the FPI and the size and thermal characteristics of the materials and their supports.

The FPI defines only the rate of energy generation and does not take into account the timescale over which this energy can be lost to the contacting materials. This timescale clearly has implications for the amount of damage caused in the contact.



Practical contacts have FPIs in the range 5,000 to 20,000 W/mm^2.

The bar charts shows the FPIs for a number of different sliding and sliding-rolling test machines. It will be noted that the pure sliding machines, the continuous energy pulse machines, have much lower FPIs than the machines in which the point of contact moves on both surfaces.

Friction Power Intensity

It should be noted that Friction Power Intensity (FPI) has the same dimensions as PV.

PV: Pa ms^{-1} $\quad \dfrac{ML}{T^2} \cdot \dfrac{1}{L^2} \cdot \dfrac{L}{T} = \dfrac{M}{T^3}$

FPI: W/mm^2 $\quad \dfrac{ML}{T^2} \cdot \dfrac{L}{T} \cdot \dfrac{1}{L^2} = \dfrac{M}{T^3}$

The FPI is equivalent to the PV limit multiplied by the friction coefficient.

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The Pressure-Velocity (PV) Limit is a commonly used measure for defining the performance limits of polymers. This limit is in effect the melting point of the material. Thermal collapse limits the contact at high velocity, whereas mechanical strength limits the contact at high pressure.

Note that Friction Power Intensity (FPI) has the same dimensions as PV.

The FPI is equivalent to the PV limit multiplied by the friction coefficient.

Energy Pulse

Product of FPI and contact transit time, EP takes into account length of time during which material is subjected to energy input during its transit of contact zone, where t_t is transit time in seconds

Energy Pulse: $E_P = \mu P V_s t_t / A$ $\quad$ J/mm^2

EP is analogous to Archard Wear Law, however, it uses the friction force rather than applied load, which is perhaps more logical as it takes into account the rubbing conditions (but assumes that the friction coefficient can be measured)

Archard Wear Law: $\Delta V = k P V_s t_t / A$ $\quad$ mm^3

EP can be regarded as an incremental contribution to wear or surface damage in contact. Sum of EPs can be used as a measure of total wear

Correct analysis of EP in real contact and subsequent modelling in experimental design significantly enhances probability of achieving a satisfactory emulation

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The Energy Pulse is the product of the FPI and the contact transit time. The EP therefore takes into account the length of time during which the material is subjected to energy input during its transit of the contact zone.

The Energy Pulse is analogous to the Archard Wear Law, however, the Energy Pulse equation uses the friction force rather than the applied load. This is perhaps more logical as it takes into account the work done in the contact.

Each Energy Pulse can be regarded as an incremental contribution to wear or surface damage in the contact. The sum of the Energy Pulses can be used as a measure of the total wear.

Energy Pulse

$$\mathbf{EP} = \mu\, \mathbf{P\ Vs\ t_t / A} \quad \mathrm{Jmm^{-2}}$$

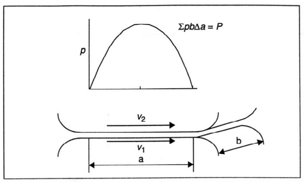
where

μ	=	friction coefficient	
P	=	applied load	N
Vs	=	relative sliding velocity	ms^{-1}
A	=	area of contact	mm^2
t_t	=	transit time	s

The transit times for the contact are:

Upper body: $t_t = a / v_2$

Lower body: $t_t = a / v_1$



Correct analysis of the EP in the real contact and subsequent modelling in the experimental design significantly enhances the chances of achieving a satisfactory emulation of sliding and combined sliding and rolling contacts.

It is important to note that in many machine components there can be very high FPIs but, because the contact durations are short, the EP is low and hence the incremental damage is low.