UNDERSTANDING of

HP vs. TORQUE APPLIED TO MACHINE TOOLS SPINDLES

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WSM TECHNOLOGIES APRIL 22, 2017

SHORTEST DEFINITION OF HP

- What does the unit HP measures?

HP = RATE AT WHICH WORK IS DONE

(DIFFERENT WORK WILL HAVE DIFFERENT CALCULATION BASIS HENCE DIFFERENT UNITS MIGHT BE USED

(OTHER UNITS DEFINING THE RATE OF WORK ARE:

WATT, JOULES, BTU.

SHORTEST DEFINITION OF HP

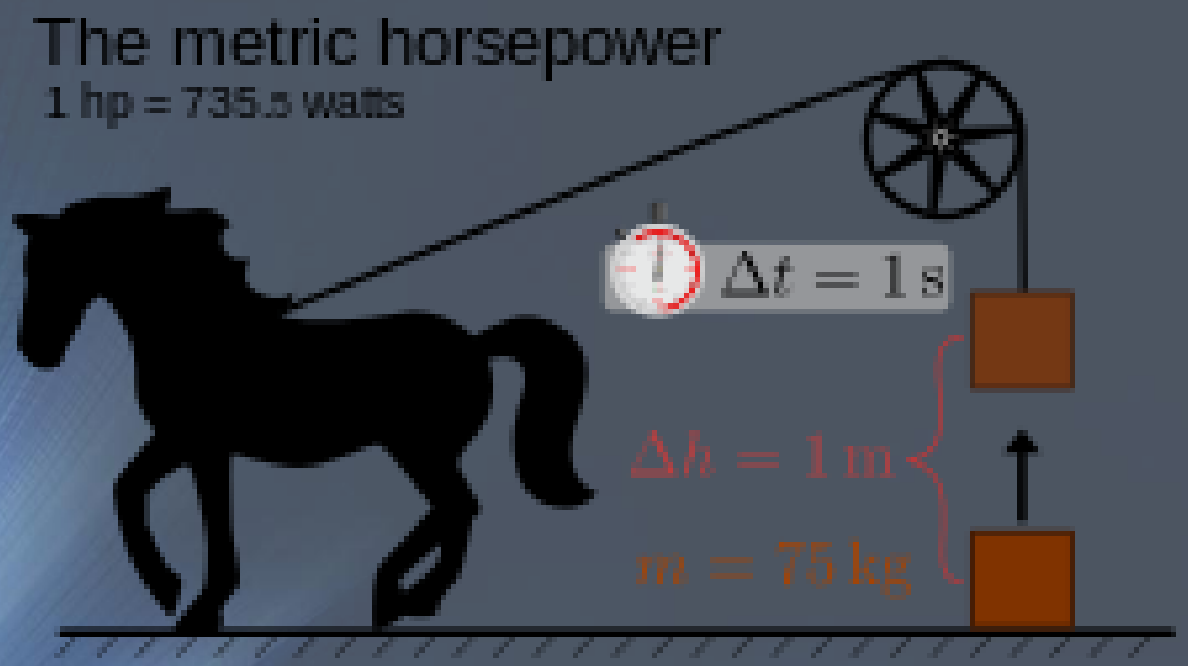
HOW TO MEASURE MECHANICAL WORK?

BY MEASURING THE ABILITY TO LIFT A GIVEN WEIGHT

TO A GIVEN HEIGHT IN A GIVEN TIME.

SHORTEST DEFINITION OF HP

- What does the unit Mechanical HP measures?



Original Imperial Horsepower

1HP = 550 foot lbs per second

NOTE:
TIME IS AS IMPORTANT AS THE FORCE OR THE DISTANCE.
THIS WILL BE KEY ALSO FOR LATER CONSIDERATION.

HP HISTORY. ENGINE HP (ROTATION)

- The development of the Steam Engine provided a reason to compare the output of horses with that of the engines that will replace them.
- James Watt developed the notion of HP in engine to compare the rate of work of horses vs steam engine.

HP HISTORY. ENGINE HP. JAMES WATT

- JAMES WATT METHOD WILL DEFINE
- RATE OF WORK OF A HORSE WITH A ROTARY SYTEM

- 1 HORSE COULD TURN A MILL WHEEL 144 TIMES IN ONE HR. (2.4 rpm)
- THE WHEEL WAS 24ft IN DIAM. (12ft radius)
- Horse therefore travelled: $2.4 \times 2\pi \times 12$
- HORSE COULD PULL ALL DAY LONG WITH A FORCE OF 180 POUNDS

HP HISTORY. ENGINE HP. JAMES WATT

- JAMES WATT RATE FORMULA TO QUANTIFY THE WORK OF A HORSE

- $P(hp) = \frac{W}{t} = \frac{Fd}{t} = \frac{180lbfx2.4x2\pi x12ft}{1min} = 32{,}572\frac{ft\ lbf}{min}$

- **1hp =** $32{,}572\frac{ft\ lbf}{min}$ typically was rounded to $\mathbf{33{,}000}\frac{\boldsymbol{ft\ lbf}}{\boldsymbol{min}}$

HP HISTORY. ENGINE HP. JAMES WATT

Calculating Horse Power

- When Torque "T" is in pound-foot units, rotational speed "N" is in rpm and power required is in horsepower
- $$P(hp) = \frac{T(ft \cdot lbf) x N(rpm)}{5252}$$
- The constant 5252 is the rounded value of $(33{,}000\ ft \cdot lbf/\min)/(2\pi\ rad./rev)$

SIMPLE AND INTERESTING COMPARISON

- What can we, human do in hp

- Hussein Bolt ran the 100m in this example in 9.83 sec
- What can a horse do in hp
  - Note that TIME is always part of MAX. HP rating.

MEN	HP cont.	HP max
Normal men	0.1	1.2 2 sec
Athlete	0.3	2.5 2sec
Hussein Bolt	100m dash	3.5 .89 sec

Horse	HP Cont.	HP Max
County Fair (1929)	1	14.9 3sec

KEY NUMBERS REVIEW

- **HP = RATE AT WHICH WORK IS**

1 hp

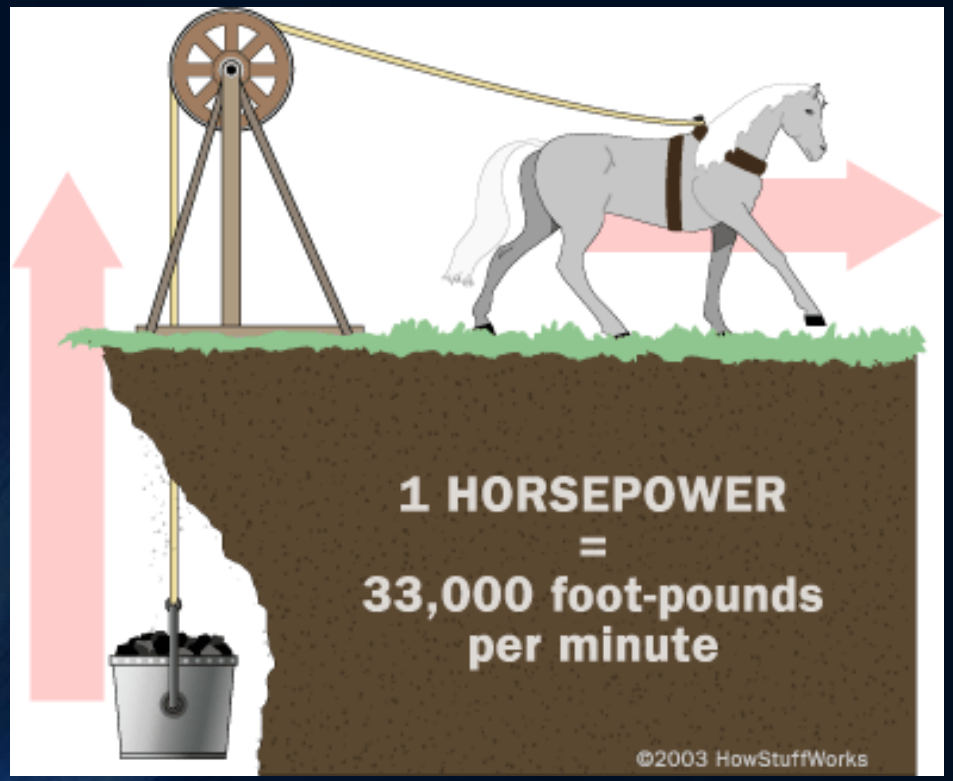
Factor

- **33,000 ft· lbf / min**

- to find hp when you have torque and rpm

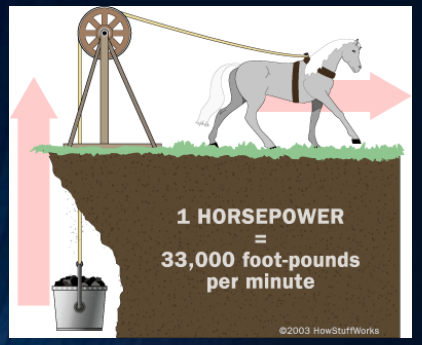
5,252

1 hp = 1 hp = 1hp. BUT, are all hp really equal ?



$$1\text{hp} = 33{,}000lb * 1ft\ in\ 1\ min$$
$$1\text{hp} = 330\ lbs\ *\ 100ft\ in\ 1\ min$$
$$1\text{hp} = 165\ lbs\ *\ 200ft\ in\ 1\ min$$
$$1\text{hp} = 16.5\ lbs\ *\ 2000ft\ in\ 1\ min$$

1 hp = 1 hp = 1hp. BUT, are all hp really equal?



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$1\text{hp} = 165\ lbs * 200ft\ in\ 1\ min$

$1\text{hp} = 8.25\ lbs * 4000ft\ in\ 1\ min$

1. **IMPOSSIBLE TO HEAVY**
2. **MAY BE**
3. **FOR SURE** (ALMOST WATT EXPERIMENT)
4. **IMPOSSIBLE HORSE IS TOO SLOW**

1. Horse running speed needed in this example 45.48 mph
2. Typical horse run 25- 30 mph

1 hp = 1 hp = 1hp. BUT, are all hp really equal?

YES OF COURSE ALL MECHANICAL HP ARE EQUAL.
THE MEANS TO REACH THE DESIRED HP ARE DIFFERENT.

THEREFORE MACHINES INDEPENDANTLY FROM HORSEPOWER NEED DIFFERENT DESIGN TO ACCOMPLISH DIFFERENT OUTCOME.

1 hp = 1 hp = 1hp. BUT, are all hp really equal?

1hp= $33{,}000lb\ 1ft\ in\ 1\ min$	1	NEED MORE FORCE NOT SPEED
1hp= $330\ lbs\ 100ft\ in\ 1\ min$	1	MAY BE, MAY BE NOT, BUT NOT ALL DAY
1hp= $165\ lbs\ 200ft\ in\ 1\ min$	2	FOR SURE, ALL DAY (Almost Watt experiment)
1hp= $8.25\ lbs\ 4000ft\ in\ 1\ min$	3	NEED MORE SPEED NOT FORCE

NOTE1: IN FIRST EXAMPLE , MORE FORCE TO MOVE THE WEIGHT not more horses, ONLY 1 HP
Note 2: IN FIRST EXAMPLE I ASK FOR MORE FORCE NOT TORQUE BECAUSE THE HORSE IS PULLING STRAIGHT FORWARD

Note 3 ALL DAY = CONTINUOUS

HORSE POWER IS NOT SUFFICIENT TO DESIGN ADEQUATE MACHINES FOR EACH SITUATION.

HP = UNIT TO MEASURE THE RATE AT WHICH WORK IS DONE
FORCE= MASS * GRAVITY (Newton LAW) F=m* a

When movement is linear , what is needed to create motion is a Force.

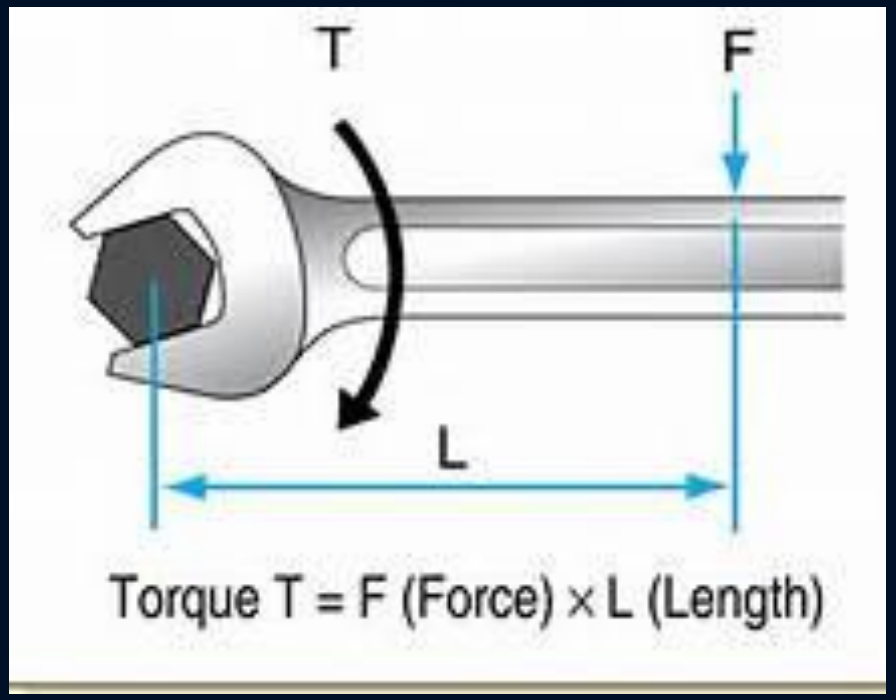
When movement is rotating, what is need to create motion is Torque

NEW NOTION COMING INTO PLAY WITH MOTORS:

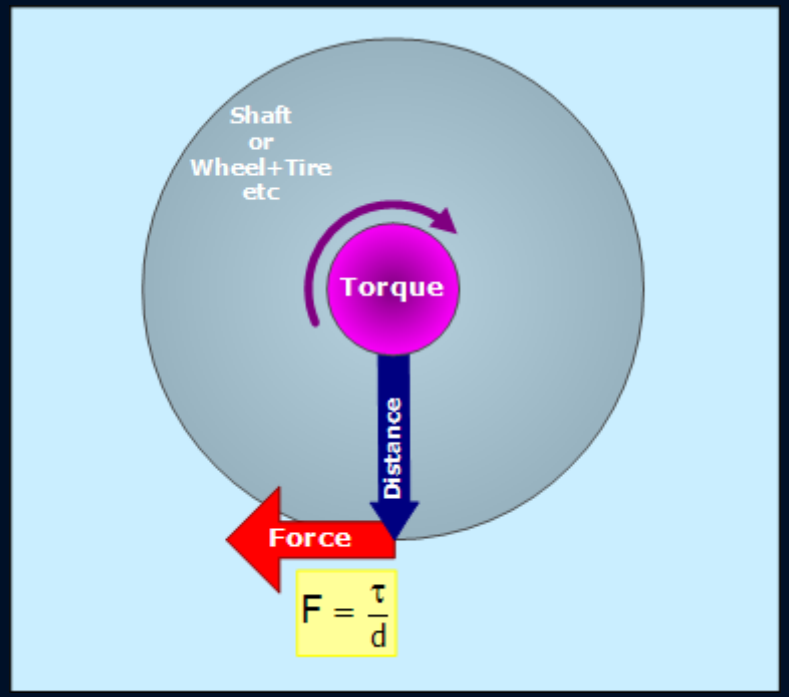
TORQUE

TORQUE

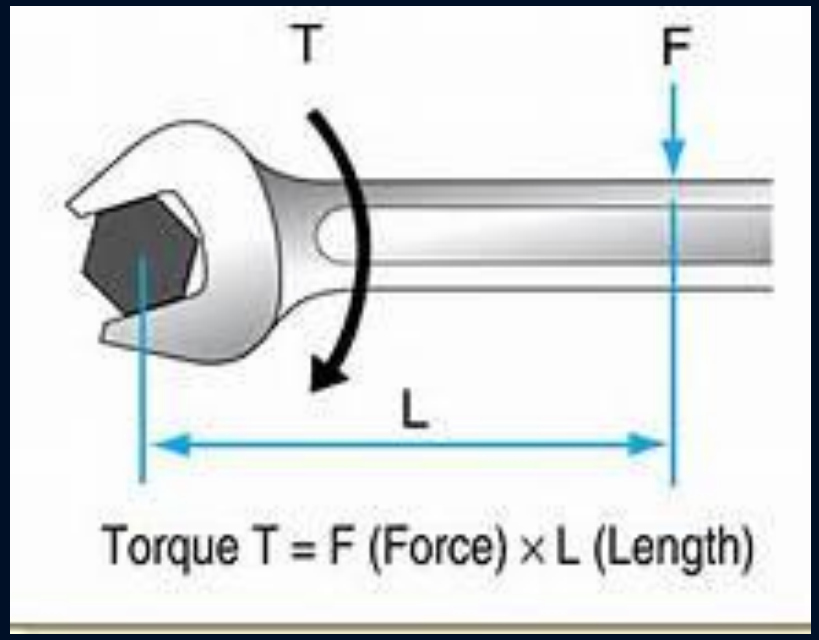
Simplest Mechanical Torque



Simplest Torque Example with motor



TORQUE UNIT



$T = L \cdot F$

$T = ft \cdot lbf$

TORQUE

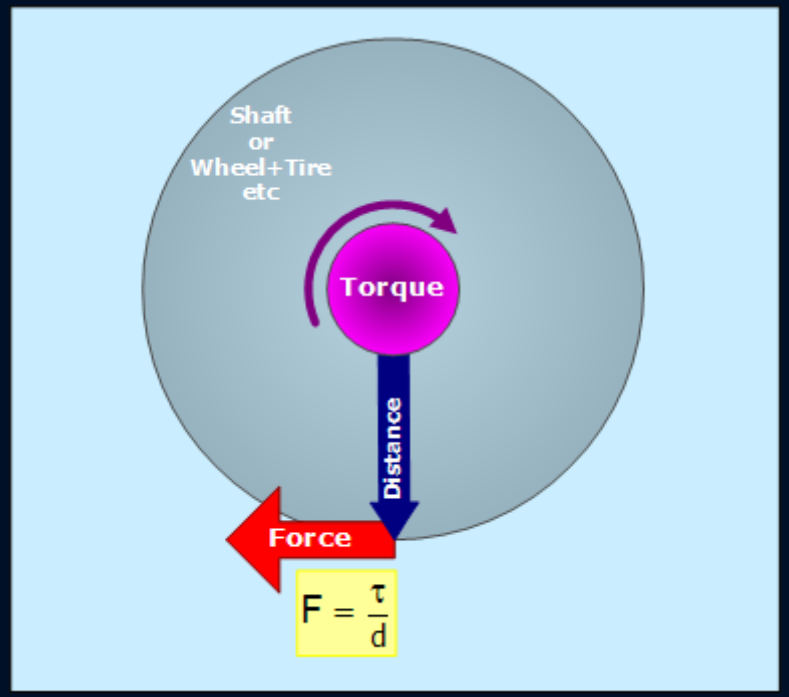
F=force (lbf)
T= Torque (ft· lbf)
d=Diameter spinning (ft)

$$F = \frac{T}{d}$$

$$T = F \cdot d$$

Unit: $\text{lbf} \cdot ft = \text{lb}f \cdot \text{ft}$

Simplest Torque Example



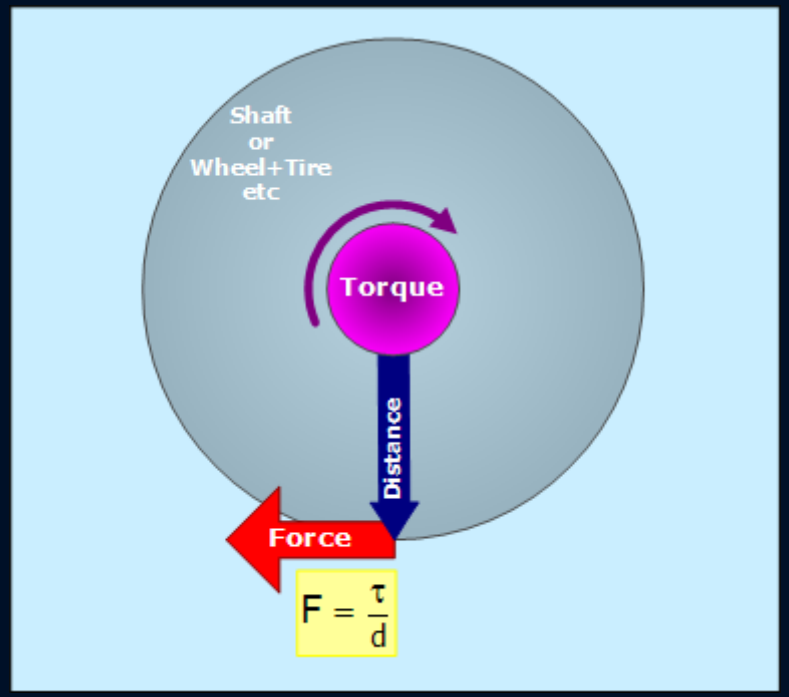
POWER &TORQUE

P= power (hp)
T=Torque (ft· lbf)
N=rpm
5252=constant

$$P = \frac{T * N}{5252}$$

$$P(hp) = \frac{T(ft \cdot lbf) * N(rpm)}{5252}$$

Simplest Torque Example with Motor



TORQUE & POWER

P= power (hp)
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$$T = \frac{P * 5252}{N}$$

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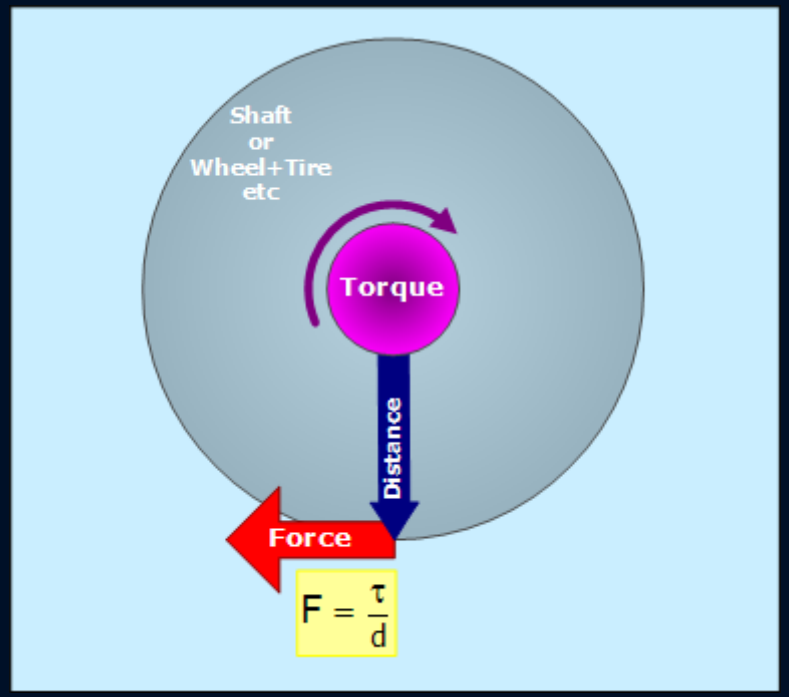
Simplest Torque Example with Motor

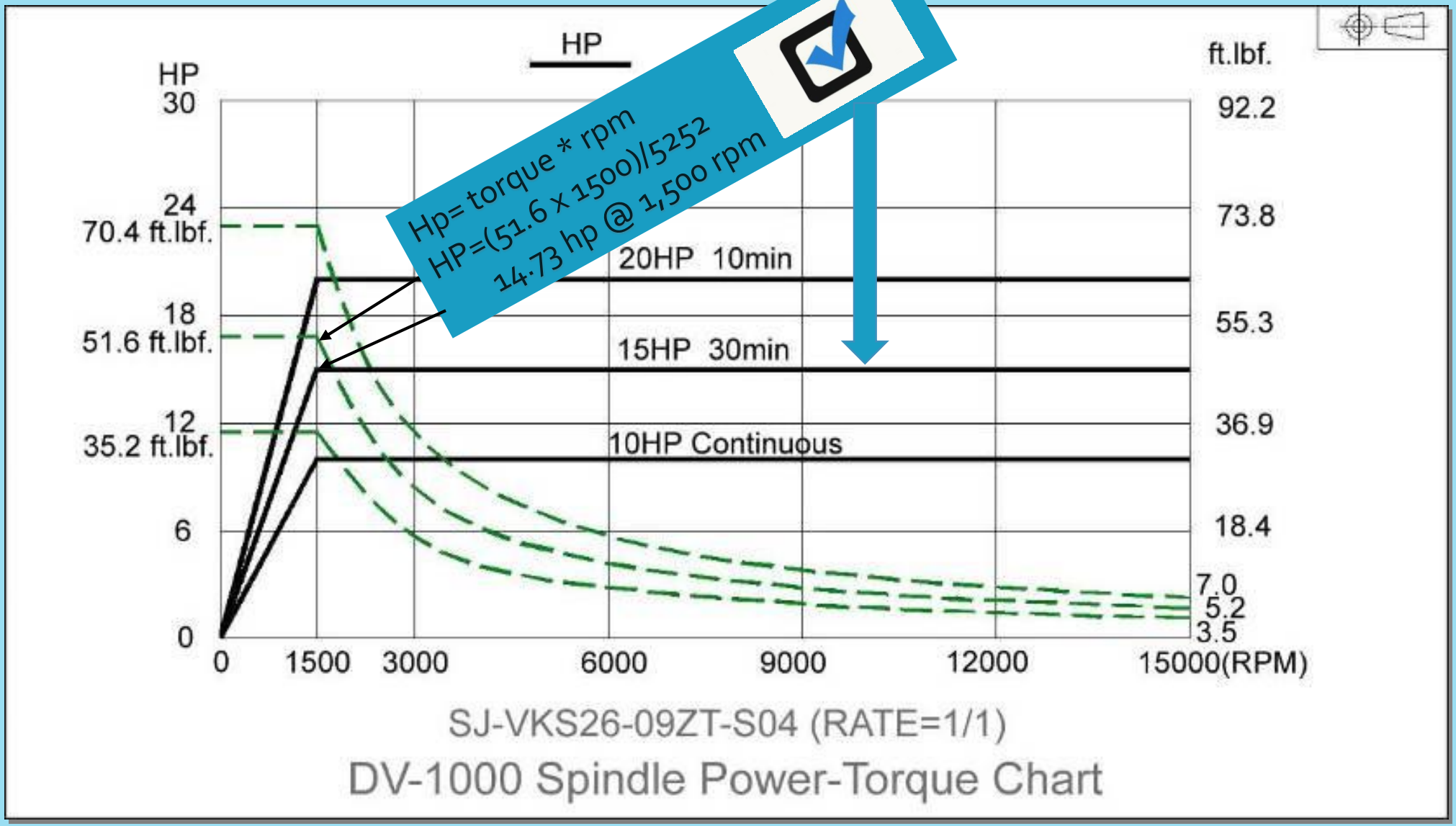


RECAP WITH A MOVIE APPLYING PRINCIPLE OF FORCE AND TORQUE WITH A CAR ENGINE

EXACT SAME PRINCIPLE AS WITH OUR SPINDLE

- https://video.search.yahoo.com/search/video;_ylt=A0LEVxfbxv9Yv4sAWphXNyoA;_ylu=X3oDMTByMDgyYjJiBGNvbG8DYmYxBHBvcwMyBHZ0aWQDBHNlYwNzYw--?p=horsepower+vs+torque&fr=mcafee#id=5&vid=0a9429acfd43f7c1644184aabb987f65&action=view

Horse Power, Torque, RPM Charts



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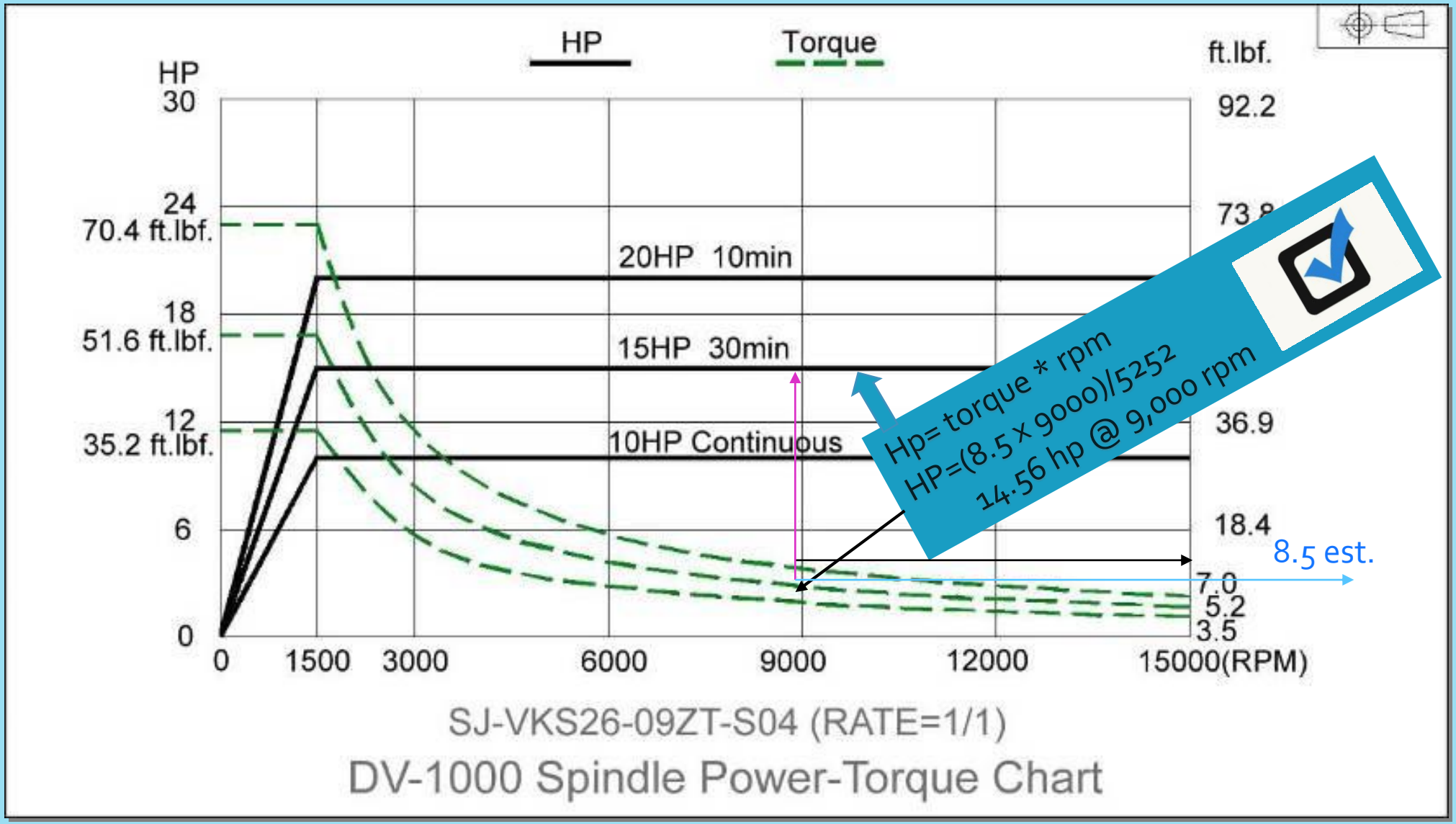
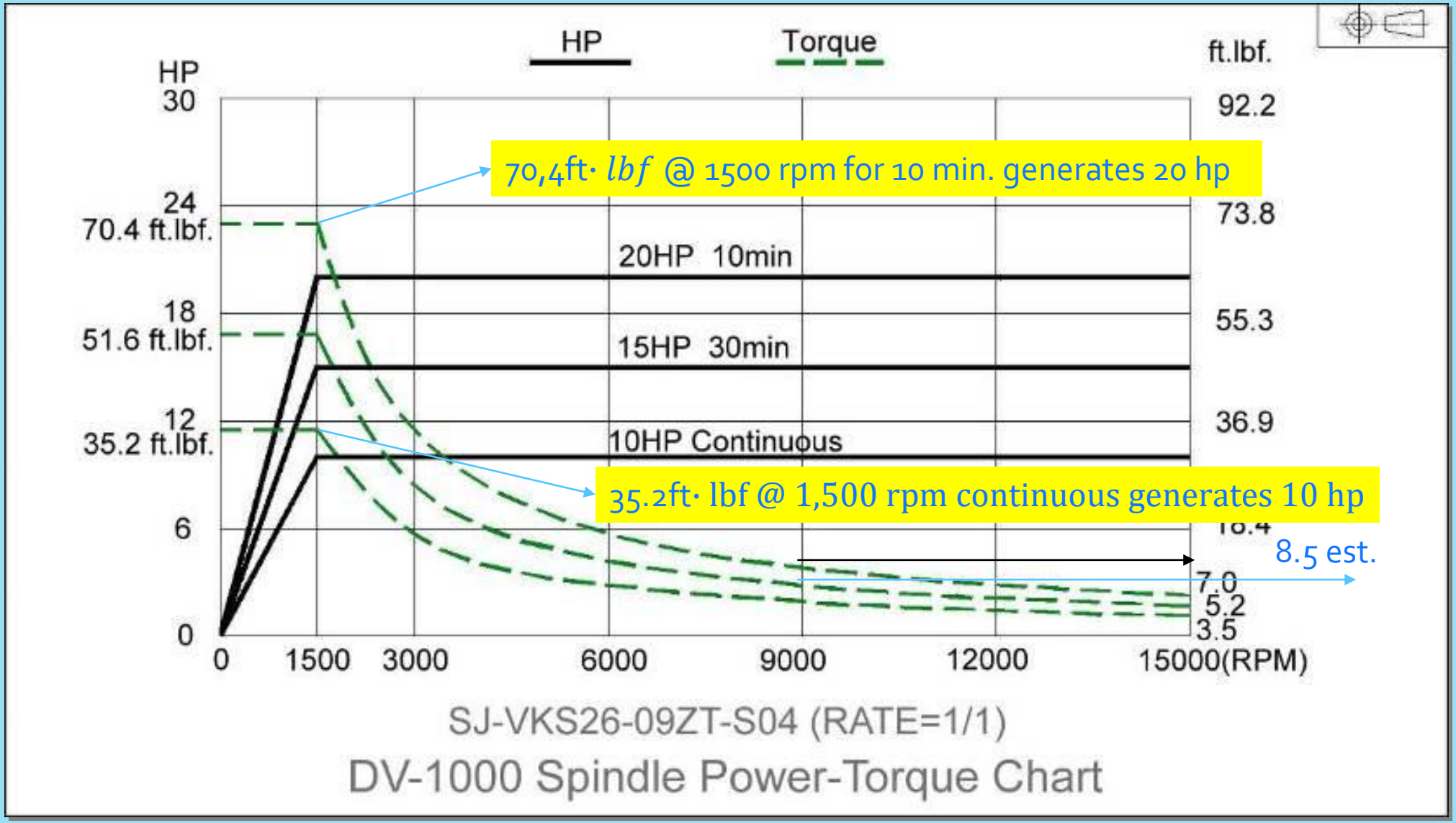


Horse Power, Torque, RPM Charts



Horse Power, Torque, RPM Charts
SO WHAT?

70,4ft· lbf @ 1500 rpm for 10 min. generates 20 hp

35.2ft· lbf @ 1,500 rpm continuous generates 10 hp

=

What does this mean for the prospect interested in the machine?

1. In continuous mode he can do the same <u>amount of work but</u> in **double the time** than the with the max. rated 20 hp as long as the job takes 20 min or less, **the longer the job the better for the 10hp.**

2. Any job taking **more than 10 min** with the max torque (twice as productive as 10 hp) will have to be **dialed down** to preserve the spindle.

3. Slowing the machine down **might not be the customer main goal, The 10 min. rating is not that great…..**

Horse Power, Torque, RPM

What does this mean for the **prospect** interested in the machine?

70,4ft· *lbf* @ 1500 rpm for 10 min. generates 20 hp

35.2ft· lbf @ 1,500 rpm continuous generates 10 hp

=

1. What Torque is needed in ft· lbf @ what rpm to use a given tool?

2. The point above does matter to maximize the productivity of the machine but does **not matter as to rather the job can be done or not** because **it can always be done,** just at a different/ lower rate of work and therefore will take more time. Lower hp need more time for the same work.

3. **However this should matter if the Prospect is also the OWNER.**

Horse Power, Torque, RPM

What does this mean for the owner interested in the machine?

70,4ft· *lbf* @ 1500 rpm for 10 min. generates 20 hp

35.2ft· lbf @ 1,500 rpm continuous generates 10 hp

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Previous page.....

1. *...does not matter, as to rather the job can be done or not, because it can always be done, just at a different/ lower rate of work hence taking more time.*

   lower hp need more time for the same work.

1. THIS IS HOW HAAS WON THE DAY!

Horse Power, Torque, RPM

What does this mean for the owner interested in the machine?

70,4ft· *lbf* @ 1500 rpm for 10 min. generates 20 hp

35.2ft· lbf @ 1,500 rpm continuous generates 10 hp

HYUNDAI ≠ PORSCHE STUTTGART

1. THIS IS HOW HAAS WON THE DAY!

The consequence of this realization by HAAS are phenomenal in terms of the cost to build machines because the Lower Forces and Stresses Involved throughout the machines in a low continued HP machine utilization are so much less significants.
A lot less Forces and Stress enables them to design the machine with components not as strong (smaller, lesser in material quality and craftsmanship) to do the job:
Just not quite as fast.

How important is this when most shops work only 1 shift and the machines are producing for a fraction of that shift?

Horse Power, Torque, RPM

What does this mean for the owner interested in the machine?

70,4ft· lbf @ 1500 rpm for 10 min. generates 20 hp

35.2ft· lbf @ 1,500 rpm continuous generates 10 hp

Mercedes-Benz

$$P(hp) = \frac{T(ft \cdot lbf) * N(rpm)}{5252}$$

1. **So now we understand why better machines are typically involved in tough, demanding production environments especially with multiple shifts 24hr/day.**

2. **These machines always produce work at a better rate of work (HP) because of more horsepower due to the highest level of torque @ rpm ratio requiring stronger design, better components and materials for superior durability which translate to:**

HIGHER AND MORE PRODUCTIVE UP TIME….ALL DAY LONG.

Horse Power, Torque, RPM

What does this mean for the owner interested in the machine?

70,4ft· lbf @ 1500 rpm for 10 min. generates 20 hp

35.2ft·
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≠

1. Weaker competitors are reacting by increasing horsepower at unrealistic spindle load (MORE THAN 100%??) for shorter and shorter period of time of operation. (S..rating).
    1. Their HP is also reached at impractical torque rpm ratio.

2. **These "DECEPTIVE" HP ratings are designed to change the prospect perception but not the reality of the productivity capability of the machine he is considering.**

1. By changing the STD of HP publication to increase the perceived performance,

you are further handicapping your performance, because of the technology in cutting tools . These tools are designed for CONSTANT HP, therefore in many instances you will not be able to use the tool as effectively as their design allowed for, resulting in lower material removal rate and very importantly lesser tool life for higher cost.

Horse Power, Torque, RPM Charts

What does this mean for the owner interested in the machine? Confusion… back to how much 

70,4ft· lbf @ 1500 rpm for 10 min. generates 20 hp

Why not ?

105.6 ft· lbf @ 1500 rpm for 5 min. generates 30 hp

Remember Original performance target was ➡ 35.2ft· lbf @ 1,500 rpm continuous generates 10 hp

3 X

1. The prospects believes that the machines are more equal to better machines in their ability to produce work at an equal rate because of similar HP, while the time to produce work at the indicated rate (hp) is extremely limited.

2.Furthermore because the machine Forces and Stresses involved are so limited in time, the machine design does not need to be BETTER THAN BEFORE the new high HP ratings. Now we understand why HAAS can make inexpensive/ cheap machines that suffice for many shops.

Horse Power, Torque, RPM Charts

What does this mean for the owner interested in the machine? Confusion… back to how much

1. The best prospects based on their performance and stats have the best contracts. It does not mean that the new team will know how to integrate this piece in the team and make them successful. Many will make their owner a lot of money

1. Most players do not make a lot of money and often for not very long (SOUNDS FAMILIAR) They enable the game to be played for the best to shine and make a lot of money.

Horse Power, Torque how to invest?

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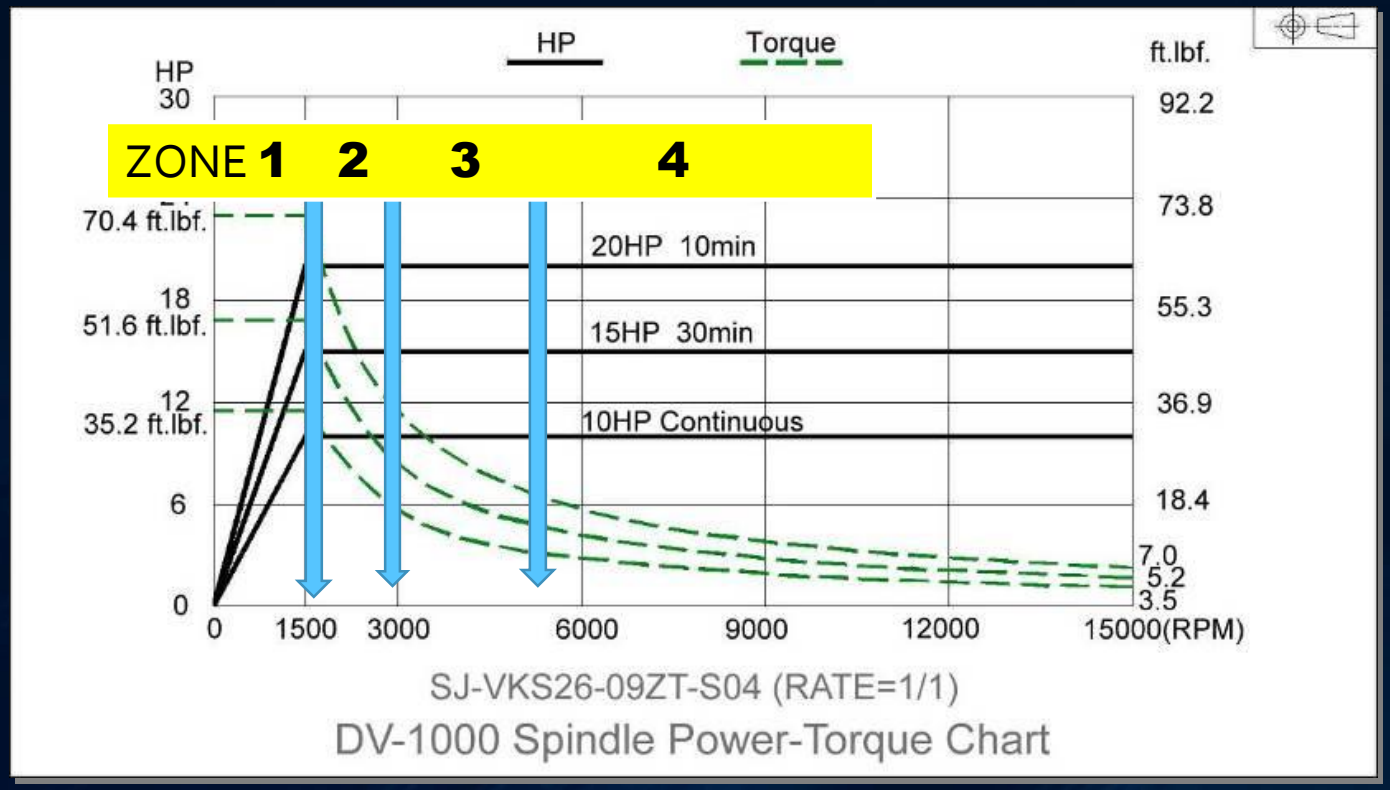
NFL OWNERS TAKE A GAMBLE .
SHOPS OWNERS DO NOT HAVE TO. IT IS OUR JOB TO EDUCATE THEM AS TO WHY FASTER IS BETTER??? SEEMS EVIDENT…
THE INVESTMENT **DIFFERENCE** HAS TYPICALLY NO RISK!

NEXT STEP? APPLICATION WITH CUTTING TOOLS



1. UNDERSTANDING THE DIFFERENT ZONE 1,2,3,4 TO DIFFERENTIATE FROM MACHINE TO MACHINE WHICH MACHINE/ SPINDLE IS THE MOST PRODUCTIVE FOR A GIVEN TOOL, WHAT TECHNIQUE TO USE ETC.

2. Spindle design/ Efficiency

3. Spindle rating “S”

4. Also consider HP of axis motor??? Tricky…

http://ijirae.com/images/downloads/vol1issue6/JYME10089.54.pdf