MATERIAL CONSERVATION in BELTS & PULLEY Drives, LEADS to ENERGY CONSERVATION

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The industry is facing energy losses in each of their machine in the motor-to-machine power transmission. This is happening due to oversized pulleys meant for V belts, existed in the decades-old running machine. Now since the Energy Efficiency route is taking over the Energy conservation route, it is time to think of reducing the weight of Rotating component and increase the size of conducting component in a system. Similar to the road traffic, where our vehicles reduced their size and weight, to improve the fuel economy and we have broadened the roads to ensure smooth, speedy & choke-free traffic. Our Railways slogan – 'Less Luggage & More Comfort' and let us walk the talk of Energy Conservation in our industry now. Material conservation is the first thing to tried by the OEM in their new & old products supplied long years back; and to be tried by the user industry to achieve energy conservation in their decade-old running machines, as they are paying excess energy bills.

Any industry segment will have this system of motor-coupled-to-machine by belts in majority of their machines. Here, the machine OEMs in each segment do take extra care of their product safety first and then only focused its running cost. That is why the Govt. suggested going for 5 STAR rated products with the slogan, "More the Stars, More the Energy savings in that product". This paper showcases the case studies of few industry segments, where we find the energy loss in the power transmission from the Motor to Machine, by the Belts & Pulley drives. Especially the pulley drives are not replaced by the industry, for its total machine life. These "Dished Out" pulleys increase the energy loss in power transmission. Also pulley needs to be undersized to match to the new compact and Power saving belts and here raw cogged belts now.

These heavy weight pulleys consume 10 % more power when transferring from the motor to machine in some of our case studies and this is an Eye-Opener. The loss % may vary, but it needs to be focused now, immediately. So the user industry is suggested to revisit TODAY, to study energy breakup analysis of his motor –to-machine power transmission, generically and horizontally deploy this instantly-applicable-exercise to all his other machines.

Instead of investing on industry's proposed swap from his decade old standard motor to the latest IE3 motor now, first he must try to find the ways to reduce energy demanded by the machine & links from the Motor end. And by implementing this immediately, the user can reduce his energy loss from TODAY and this paves way for more productivity from each of his machines at less power consumption, and the Simple Payback Period is in the order of few weeks to months now. After energy demand reduction achieved first in the motor only, then the user has to replace with the optimum-sized IE3 motor.

EXISTING ENERGY LOSSES EXISTED IN OLD PULLEY DRIVES:-

The symptoms of energy losses can be seen in belts due to the looseness, worn-out belts, that is visibly observed, but what is not NOTICED, is that the worn-out pulley which is ignored by the user. Because he assumes that the pulley is part of the equipment meant to serve for the life time of the machine. The existing running pulley grooves look with glossy finish in most of grooves. They need to have rough surface with matt finish. Rough surfaced grooves only can grip the belt better and they were over-designed till date. Grooves inside pulley have been **dished out** of Differential Driving of belts over grooves. Over five years of 24 x 7 hours of usage, that pulley had gripped many old & new belts, hence this pulley is a consumable based on its condition.

Driven Machine	Driving unit / Motor					
	Max power ≦ 300% of rated power			Max power > 300% of rated power		
	AC motors, single-and three-phase with star-delta start, DC shunt-wound motors, Multiple cylinder internal combustion engines.			AC motors, single and three-phase, series wound, slip-ring motors with direct start, DC motors, series and compound wound, Single cylinder internal combustion engines.		
	Running time (hrs./day)			Running time (hrs./day)		
	3 ~ 5	8 ~ 12	16 ~ 24	3 ~ 5	8 ~ 12	16 ~ 24
● Agitator for liquid ● Small centrifugal blower ● Fan up to 7.5 kW ● Light-duty conveyor	1.0	1.1	1.2	1.1	1.2	1.3
● Belt conveyor (for sand, grain, etc.) ● Dough mixer ● Fan over 7.5 kW ● Generator ● Machine tool ● Punching machine ● Pressing machine ● Shearing machine ● Printing machine ● Positive displacement rotary pump ● Vibrating and rotary screen	1.1	1.2	1.3	1.2	1.3	1.4
● Brick-making machinery ● Bucket elevator ● Piston compressor ● Screw conveyor ● Hammer mill ● Hollander ● Piston pump ● Positive displacement blower ● Crusher ● Woodworking machinery ● Textile machinery	1.2	1.3	1.4	1.4	1.5	1.6
● Gyratory and jaw-roll crusher ● Mill (ball/rod) ● Hoist (heavy load) ● Rolling mill, calender etc. for the rubber and plastic industry	1.3	1.4	1.5	1.5	1.6	1.8

REVISIT to basics of your Motor-to-Machine Power Transmission TODAY to monitor to target Energy losses now.

The user has to have a mindset to change his pulley costing few thousand Rs after few years. This is the need of the hour now because, when switching over to REC belts from V belts, the pulley can be undersized in size and weight due to reduction in groove numbers says three grooves in new pulley instead of six grooves in the old multi-groove pulley.

ENERGY EFFICIENCY IMPROVED DUE TO REC BELTS & PULLEYS NOW:-

Thanks to old Energy efficient concepts in belts and the industry conveniently switched over to Raw Edged cogged REC belts in the past decade. We suggest swapping for cogged belts now, due to the additional factors of Correction Power Rating, Speed Ratio, Belt length Correction Factor, and Arc of Contact Correction Factor. These factors aid in optimizing the pulley drive for cogged belts. This REC belt swap is taken because of its superiority over V belts as mentioned under:-

1. **The cogged belts by design, is having 30 % power carrying capacity for the same classical V belt weight now.**
2. **The cogged belts run cooler, run say, 50 % more longer hours, and occupy less space in pulley.**
3. **The narrow & cogged belts operate higher speed ratios using smaller diameter pulleys.**
4. **Hence this needs the existing pulley to be replaced with say 20 % around, less-dimensioned pulley.**
5. **Being cogged on the pulley side the belt has a better grip with the pulley, to sustain the RPM drop better.**
6. **Better grip and higher coefficient of friction reduces slippage to near negligible & improves its efficiency.**
7. **Cogs on the inner surface of the belt increase air flow and facilitate cool running.**
8. **Very high flexibility due to moulded cogs allows the use of smaller sized pulleys to save on initial cost.**

Motor starting problems prevented by:-
types of selection of starting – Pros & Cons.
Courtesy – ABB SOFT START HAND BOOK

Problem prevented

Type of problem	Type of starting method			
	Direct on line	Star-Delta start	Drives	Softstarter
Slipping belts and heavy wear on bearings	No	Medium	Yes	Yes
High inrush current	No	Yes	Yes	Yes
Heavy wear and tear on gear boxes	No	No (at loaded start)	Yes	Yes
Damaged goods / products during stop	No	No	Yes	Yes
Water hammering in pipe system when stopping	No	No	Yes	Yes (Eliminated with Torque control Reduced with voltage ramp)
Transmission peaks	No	No	Yes	Yes
Estimated average installation cost	1	3	> 12	6

Details	V Belt drive - 4 Drives SPC	Cog belt Drive - 3 Drives - XPB	Cog Belt drive - 2 Drives - XPB
Motor HP	75	75	75
Motor KW	55	55	55
Motor Pulley Dia	258	245	245
Machine Pulley Dia	425	406	406
Actual RPM	898	890	888
Actual KW	38.27	34.67	33.96
Kw savings with Cog belt drives		3.6	4.31
Savings attained in %		9.4	12.4
Kit Investment cost		21746	19600
Expected savings /Year		192207	230115
Payback in Months		1.4	1.2

Motor starting duty from "Soft to Heavy" decides the belt & pulley sizing / Waste collection blower in Textile mill.

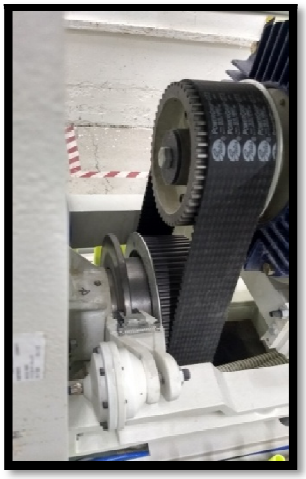
For any industry application of motor to machine belt transmission, here we find the Motor OEM sizes his motor to suit to the machine demanded load. And the machine OEM manufactures his efficient machine taking utmost care to reduce his manufacturing cost and as well he sees to it, that his machine consumes optimum energy as running cost.

Motor drive transmission efficiency –
Visible losses seen in Belt Losses from motor to load

The efficiency of mechanical power transmission depends on grip between pulley and belt, further depends on μ (Co-efficient of friction) and strength (Tensile) of the belt. In case of

Table 3.4: Losses in V Belts

Sr. no.	Motor HP	Losses %
1	2	8-15
2	3	7-13
3	4	6-12
4	6	5.5-10
5	8	5-9
6	10	4.5-8.2
7	20	3.5-7
8	30	3.2-6
9	40	3-5.5
10	60	2.8-5
11	80	2.5-4.5
12	100	2.5-4.5



BEE Guidelines of Losses % in the V belts / Excess heat loss in pulley / Excess weighted Belt & Timed Pulley loading.
Condition monitor your RPM in motor & machine pulley routinely and plan for Less-weight & Efficient Transmission.

Here, for the sake of not losing RPM, we are implementing the timing belt & matched pulley. This increases the power of transmission here. Take ambient at 40 *C, if the belts are hotter by 20 *C above the ambient, say at 60 *C and above, then the belt life reduces by 50 % that is noticeable. This hotter belt in turn reduces the pulley life and dishes out pulley more, but not noticed by us. Soft belt also by continuous rubbing the hard pulley, can elongate the pulley inside dimensions.

While discussing about the motor to machine transmission, the machine OEM wants to play it safe to go in for stronger belt (at least for him, his belt must not fail during his warranty period prematurely). So to accommodate his strong belt, he plans for stronger pulley to withstand the belt, and the tangential stress from the motor to machine. By this, he makes his pulley size that of a flywheel and that acts as Heavy Tare load to the motor, consuming more of Tare KW, during idle loading.

ENERGY STUDY - RICE MILL CLUSTER			
MACHINE DETAILS Rice Polishing Machine	Before Changing Pulleys and Belts		After changing Pulleys and Belts
Motor HP/KW	40/30		40/30
Motor RPM	1470		1470
Type of Motor drive	Star Delta		Star Delta
Motor Pulley Dia. In mm	285		230
Machine Pulley dia. In mm	505		406
Belt Specification	B 112		SPB 2720
No of Belts	6		3
Machine Pulley RPM - Motor spec.	830		830
Motor Pulley weight in Kgs	28.22		12.4
Machine Pulley weight in Kgs	55.4		27.82
Belt weight in Kgs	3.12		1.7
Total weight of drive syatem in Kgs	86.74		41.92
Reduction in weight in Kgs			44.82
Reduction in weight in %			52
Amperes at Load Average I	19		17.9
Average Line Votage - V	375		376
Power Factor PF	0.78		0.69
Power consumption per Hr. Kw	9.62		8.03
Savings in Energy in KW			1.59
Savings in Energy in %			16.51

Rice Polisher machine pulley drives / Energy Study shows Excess weight in pulleys created loss of 16 % all along.

The industry conveniently ignored the swap of old to new pulley as that involved more of additional labour in erection and alignment of new pulley in place of old pulley. Here the industry need to understand only one concept that "Energy saving is fully possible & achievable in a healthy power transmission system by fine tuning and optimization." If the same system is unhealthy by way of old oversized worn-out pulleys, then this will result in mis-match of new belts in old pulleys and energy savings is achieved meager, compared to better energy savings achievable.

WHAT HAPPENS WHEN YOU DON'T' REPLACE YOUR EXISTING WORNOUT OVERSIZED PULLEY?

The V belt are designed for motor at full load rating and in 7 out of 10 cases, over belting is designed. The motor and blower pulley are heavy mass when designed and this adds more to Tare-load consumption of 'motor + belt + pulley' upto the load, thus increasing unproductive load on the motor power. Because of overweighing-belting, the pulley sizes, belt width and the number of belts go up to increase power demand to motor. The motor is always not running to the designed full power ratings. It is ideal to use the actual running KW as the motor load now applied to the belt as the transmission power. Study over a period, and measure the running KW / min and max power drawn by the motor and average out the running KW. But the industry commonly use the Motor Rated power KW as the transmission power for the calculation purposes.

Minimum pulley datum diameter Unit : mm Table 2-4

Belt type	Z	A	B	C	D	E
For wrapped type	45	71	112	180	315	450
For raw edge cogged type	40	63	90	140	-	-

TYPES OF PRIME MOVER	
'Soft' Starts	'Heavy' Starts
AC electric motors – star / delta start – synchronous – split wound – inverter control DC electric motors – shunt wound – stepper motors	AC electric motors – DOL start – single phase – slip ring DC electric motors – series wound – compound – servo motors
I/C engines with 4 or more cylinders. Prime movers with centrifugal clutches or fluid couplings.	I/C engines with < 4 cylinders

MITSUBOSHI Belts details on V & cogged belts / FENNER Belts details on Hard & Soft Motor Starts.

You have changed your motor starting from Harsh DOL, Star Delta starting to smooth VFD starting now and so now your belt & pulley also needs to under-sized to withstand only slow & soft ramp of VFD starting current. The origin of In-

efficiency is due to the over-design of belt & pulley drive transmission starts from the OEM at the Design Maximum only. When designed, this REC belt was not focused before and priority towards Energy conservation was not there, previously. The efficiency of the mechanical power transmission depends on grip between pulley & belt, further depends on the co-efficient of friction and tensile strength of the belt transmission.

This Thermal Image of belt & pulley will show how much your KW input to motor is un-wantedly heating up the belts & pulley drives. You will also find rubber burnt smell and screeching sound when blower is started and these are the signs of wear-out, happening now.

Energy Conservation in Excess Belts and Pulleys. Further can be conserved by opting for IE 3 undersized motor, VFD

ENERGY STUDY at GRANITE INDUSTRY

DATA	EXISTING	New EE Belt & Pulley
MOTOR	30 KW	30 KW
RPM	960	960
MOTOR PULLY DIA	125	150
MACHINE PULLEY	610	710
MACHINE RPM	200	200
BELTS	B 125	SPB 3450
TYPE	CLASSICAL	WEDGE
DESIGN POWER	45 KW	45 KW
NO OF PULLEY GROOVES	10	6
NO OF BELTS	10	6
AMPERE	25	20
POWER CONSUMPTION PER HOUR	13.8 units / hr	11.5 units / hr
POWER SAVINGS		17%

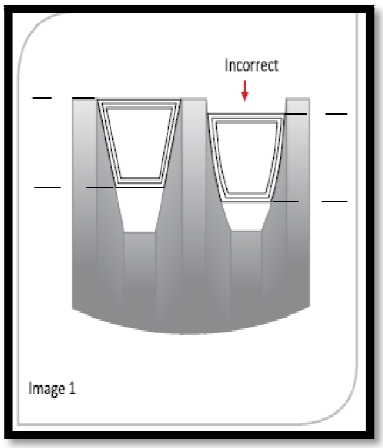


Image 1

Both - Excess weighted Pulleys / Differential Driving leads Dished-out Grooves / Glossy Heavy weight pulley loses grip.

You, the industry need to be aware that your pulley (also due to this cyclic belt movement under harsh conditions) needs to be replaced around 5 years duration, based on the loading nature and thermal imager inputs on pulley. Now we always demand the industry after our energy audit, to replace belts & pulleys, and optimize power in their pulley. After thermal imaging and measuring the slippage losses, we the Energy Auditors now suggest to the user, to replace both belts & pulley from V belt to cogged belt now. Citing the above factors, let the user first re-size the pulley, discuss with the belt & machine OEM to achieve the same RPM or the desired RPM after reduced slip, possible now due to this cogged belt.

CONCLUSION:-

Material conservation is the first thing to tried by the OEM to achieve energy conservation in their products. Motor OEM is reducing the overall weight, but improves the material composition and in its MOC, the Material of Construction. In the load ends like pump or fan or compressor, the OEMs are innovating to reduce the weight of rotating wetted parts inside the housing. So here too, the user industry is suggested to follow, what the OEM is doing now to improve their machine efficiency.

Plan to revisit TODAY to the power transmission areas in your decades-old machines and analyze what is the CUP-to-LIP energy losses happening in between due to the rotation of the heavy bulk weight of the pulleys especially now, since you are replacing the belts only Routinely till date. Consult your Belt & Pulley Specialist or the Machine OEM TODAY and ask him what can be done now to reduce the energy losses in there. Understand that their responsibility ends there within the machine's warranty period, and now it is your turn to reduce the hot spots in mechanical power transmission that happened due to Accelerated Ageing till date.

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The Objective:- SHARING KNOWLEDGE TO SAVE OUR ENERGY!

CONSERVING OUR ENERGY IS OUR COLLECTIVE RESPONSIBILITY TODAY, FOR A BETTER TOMORROW!