**Belt-Tension and its effects:**

1. In general how belt tension affects the conveyor belt based transport system:  
   Too low Belt tension causes:  
        -  the belt to slip  
        -  loss of conveyance   
        -  leads to wear and tear of the drive pulley  
   Too high belt tension causes:  
       - excessive wear on parts such as bearings and shafts  
      - uneven belt wear   
      - excessive stress on the lacing of the belt and it can eventually pull apart causing immediate breakdowns  
       - Also affects the life of the driver motor
2. Nominal belt tension is necessary for a smooth transfer of components/raw material between workstations of a discrete manufacturing settings or to transport bulk material to different production sites of a processing plant. Improper belt tension causes the above-mentioned issues which causes the unexpected production breakdown, equipment wear (not only belts but other components also affected) etc.

**Conveyor belts used in FASTory line:**

Our line uses **OPTIMAX HF** flat belts, having dimensions 1800\*50\*1 in mm. These are small belts for handling small loads. For more details see page 129 in the user manual, attached with this email.

In this manual manufacturer provides technical details about belts and formulas for calculating belt and drive parameters including belt tension. For calculating the belt tension they discuss two methods (page 135 ),

**method 1** uses "OptimaxTT" <https://www.youtube.com/watch?v=koVxVsn6v88> and

**method 2** uses elongation constant and belt surface length. Unfortunately, the manufacturer does not provide any information about optimal belt tension and expected lifetime of these belts.

**Optimal Belt tension**:  Based on the research for "optimal belt tension" I found that it is the minimum belt tension for which there is no belt slack, belt slip, and mistracing in the conveyor belt setup.  
There are some methods to calculate belt tension without measuring stress by using the "mark to mark method", please watch this short tutorial <https://www.youtube.com/watch?v=2O7e_LA5KAM> . on the other hand, "the length addition value" method may be used for calculating the belt tension as mentioned in the OPTIMAX technical manual (attached with this mail). As far as I understand the optimal belt tension is dependent on the application i.e. in which environment, we want to use that conveyor, what and how much material we want to transport, nature of conveyance path etc.  For our case, we are just moving pieces of paper with pallets and each pallet weighs approximately 1600-1700g which is low as compared to the real scenario  as far as concerned with industrial conveyor belts we have belt models, resistance and friction parameters and formulas for calculating optimal belt tension for conveyor system which hands the transportation of bulk material provided by

CEMA (<https://www.cemanet.org/wpcontent/uploads/2012/06/BBChangePages1stPrinting.pdf>) and DIN (<https://www.din.de/en/about-standards/din-standards>) conveyor belt standards for designing an optimal.

**Belt Tension Predictor Model:**

As tension of a conveyor belt has significant impact on material transportation, equipment health as well as its own health. The deterioration of belt tension does not happen at once, but it is a gradual process and continues without any notice until belt slip, mistracing or an equipment breakdown occurs. Workers check belt tension at regular time intervals like bi-weekly or once in a month (preventive maintenance). During this regular preventive maintenance schedule production plant or assembly line needs to be stopped, weather preventive maintenance needed or not, which causes unnecessary delay in production because you need to stop whole plan regularly.

With the help of a belt tension predictor model this preventive maintenance can be transformed to a predictive maintenance, do maintenance when you need it before any equipment damage occurs.

As told before the losing of nominal tension in the conveyor belt is a gradual process and goes undetected util some serious thing happens with instruments, but the signatures/signals attached to driver motor for example speed, temperature, vibration, power consumption etc., starts varying as soon as belt tension deteriorates from nominal value.(We do not have any sensors to measure motor temperature, speed etc.)

Belt tension and load have a direct relation with power consumed by driver pully/motor as driver pully needs to provide certain amount of power which is necessary to overcome resistance and frictional forces of conveyance path to maintain constant speed.

To find the effect of belt tension and load on the power consumption of the driver pully a set of experiments were conducted for both “static and dynamic case” under different belt tension and load on conveyor belt. Static case experiments were conducted to find the belt tension lower and upper thresholds. From static case the lower (0-70%) and upper belt tension (90%) thresholds are deduced and the values (75-85%) between these limits are optimal/nominal belt tensions.

From dynamic case effect of different belt tensions on material transportation time are analyzed, for results see the attached **“dynamic case file”.** For dynamic case the most interesting results were recorded for 70% belt tension (lower threshold). For this belt tension conveyor belt moves with jerks (see the attached short clip) and there is product mis-tracking and significant belt slip at head pully as well as more friction on conveyance path, which is harmful for belt health and leads to belt tear and wear.

In total, approximately 5000 data samples at 1sec sampling rate were collected to analyze the pattern of energy signature of conveyor motor driver under different belt tensions and load and the effect of conveyor zones is also consider because the presence of load on different zones for same belt tension affects motor driver power consumption, differently.

Our predictor model is an Artificial Neural Network and trained on approx. 4500 data samples from static case and tested on 500 unseen data samples during offline model processing and it was able to classify the belt tension classes with an accuracy of 98% and error/loss 2%. This model had been tested on 1500 real-time data samples from FASTory line and it works as expected. During real-time testing belt tension had been changed gradually by line operator.

The assembly line starts having the set the nominal belt tension for each workstation’s conveyor belt and predictor utilizes the real-time power consumption data and load on conveyor to predict belt tension class but as soon as belt tension of any workstation starts deviating from nominal belt tension, the energy signature i.e. power consumption also deviates and with aid of our predictor model we address this anomalous situation in time to avoid any serious harm to component health.

**Previous work done at FAST:**

Related to previous work done at FAST on S1000 energy modules, I read the papers that Professor proposed. Both papers try to predict an anomalous behavior related to the misalignment of conveyors of successive workstations (The misalignment that we saw during the inspection of FASTory line). This situation only occurs when the workstation leveling screws are misaligned and this situation is rear to occur. There some short comings in theses paper related to predictor model and co-relation of the predicted result to behavior of equipment, such short comings reader can easily find by reader.

For belt misalignment please visit:

<https://www.autoblog.com/2015/11/30/common-signs-your-drive-belt-is-misaligned/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAAB9WSNA2nufCLUvwKWnmU_LfKEwRsCsr0wzpEL3MM0wM1Z4iYVx-AV1yVQoydFOMZ-WSBYGJecJ1hsY3bH82A8rHeRuGsfVgca9v5hDKOtwxDkmuOYHr40kfhfxozmTzXLGC5LvgOOeY2DMsyI_jC7UFmmDDR5QpEyP6hCXnYJu>

For belt tracking please visit:

<https://www.engineerdo.com/2019/10/04/belt-mistracking/>