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Abstract – AIMCAL Fall Conference 2006

Metallizer Performance Evaluations – Capacity Improvements

This paper will focus on a method which can be used to determine the existence of productivity constraints on a vacuum metallizers performance. In general there are several potential sources of poor metallizer performance, defined as output of acceptable quality product. Process constraints can be identified which range from poor manufacturing material flow, roll handling system, incoming film roll quality, number and type of product changeovers and ambient environmental conditions as well as process constraints due to vacuum level, pump down time and pumping sequence control, evaporation boats, wire feed rates, chill roll temperatures, free span metallization, tension control, film product design etc.

This paper will walk thru procedures which can be used to evaluate the fitness of a manufacturing operation for the production of vacuum metallized products and a method to determine the constraints inherent to the manufacturing operation and or metallizing chamber. A procedure of this sort then allows the development of corrective actions, both operational and equipment based to increase the overall productivity of the operation and to define the suitability of capital programs.

Metallizer Performance Evaluations – Capacity Improvements

Extended Abstract:

The fitness of a manufacturing process in any industry hinges on the ability of the process to produce the maximum amount of fully acceptable product at the minimum production cost. Productivity of the process should be measure as the output of the manufacturing system starting from the receipt of the raw materials to the shipping of the final product. The ultimate measure of this process is the yield of fully acceptable product and the time it takes to convert the raw materials into the final product.

If we want to optimize a roll to roll metallization process our starting and end point should be at receiving where the rolls are received and shipped. Starting with the incoming rolls of film, material flow through the plant should be reviewed to insure sufficient space and storage racks and cradles are available to minimize the shuffling of product from point to point as product is received, unpacked, inspected for incoming quality conformance, stored if necessary and then metallized, tested, slit, labeled, packaged and shipped. The importance of material flow and handling can not be underestimated as it impacts the amount of labor required to simple move material from place to place and the level of waste due to damage. Regardless of the plant layout the analysis should be performed to look for means of improving material flow and then developing capital programs to improve. One area of principle concern should be the methods and equipment available for loading and unloading rolls of film into the metallizer. Efficient control of the loading and unloading process and significantly reduce the number of people required to load and clean the chamber which will minimize the time the metallizing chamber is open. Minimizing open time improves productivity as cycle time is reduced simply by improved procedures. Also reduced open time for the chamber can improve the pumping cycle time by reducing the moisture load absorbed by the interior surface of the chamber.

Having control of the material handling the optimization of the metallization process can be conducted. The first step in optimization is to determine the incoming roll and film condition and conformance to raw material specifications. This may take several forms, A low level evaluation would be a simple comparison of several suppliers overall product yields. In this instance comparable materials, capable of producing salable goods, are obtained from several film suppliers and the film run through the metallization manufacturing process and the overall yield of acceptable product shipped is measured and compared to select the film supplier. Tests of this nature should be sized to allow a meaningful evaluation and should extend over several complete manufacturing cycles. This could be defined as a week or month of production or as several shift rotations. The length of the evaluation will depend in part on the yield variance observed between film suppliers.

Once a supplier is selected productivity optimization should begin (or continue if a supplier selection process was conducted). The analysis should be divided into the following segments:

1. Incoming film and roll characteristics
2. Machine settings and operating variables
3. Film properties and yield.

The first step in optimizing the productivity of a metallizing process would be to optimize the film and roll properties to minimize waste and process upsets. Principle film characteristics should be measured and correlated to overall yield of the product. Primary film variables to control would be:

1. Film gauge and overall flatness
2. Surface treatment level and location (back side treatment or orientation)
3. Optical properties (Gloss in particular)
4. Other critical film properties defined by final customer
5. Roll conformation and edge quality
6. Roll density (weight/volume)

Having established incoming film control the process should be monitored to permit statistical process control of the metallizer. Primary process variable to control would be:

1. Chamber open time
2. Time to starting vacuum level (pump down time)
3. Starting vacuum level
4. Unwinding or breaking tension level
5. Line speed
6. Cooling roll temperature
7. Average optical density
8. Final vacuum level
9. Winding tension

Film properties to measure would be:

1. General roll appearance and winding quality
2. roll density (weight/volume)
3. Average wound roll temperature
4. Film appearance
    - scratches & surface defects
    - narrow width lanes (railroad tracks or tram lines)
    - optical density uniformity (OD range and visible banding)
    - gage uniformity
5. Metal pickoff and blocking at rewinding
6. Barrier values
7. Specific properties required by the film customer
8. Slitting yield

Optimization experiments should proceed as follows, select the principle incoming film and principle metallizing chamber process variables and conduct a screening experiment to determine the most significant variables affecting the critical film properties. Having determined the significant variables, perform a designed experiment aimed at elucidating the existence of interactions between the variables and finally conduct a surface response and/or optimization experiment to determine to optimum operating point for the process

As an example for a barrier film product the following experimental sequence would be chosen:

1. Dependent variables will be:
    - Moisture barrier
    - Oxygen barrier
    - (other gasses or aromas as required)
    - Metal adhesion or lamination bond strength
    - Metal pickoff / blocking on unwinding
    - Film conversion yield

2. Screening experiment on;
    - Film treatment level
    - film gloss
    - Mill Roll Density
    - Chamber starting pressure
    - Optical Density
    - Cooling roll temperatures
    - (line speed optional variable)

3. Perform a two level Fractional factorial experiment on three most significant variables screened to look for interactions and curvature or non-linearity in the dependent response variables. Repeat as necessary if more than three significant variables found on screening. Report results in terms of statistically significance of the findings and in terms of the design variables;
   i.e. Response1 = C1*variable 1 + C2*variable 2+C3*variable1*variable3
4. If non linearity and interactions present from step 3 then perform a surface response experiment (3 or 5 level experiment) to determine presence of maxima or minima in the response variables. Report results in terms of statistically significance of the findings and in terms of the design variables
5. Set process and film variables to optimize product properties and then begin evolutionally process optimization (EVOP) to improve overall productivity.

During the course of the podium presentation an example will be presented