Belt-type Conveyorised Coating Lines for Sheet Metal Cuttings

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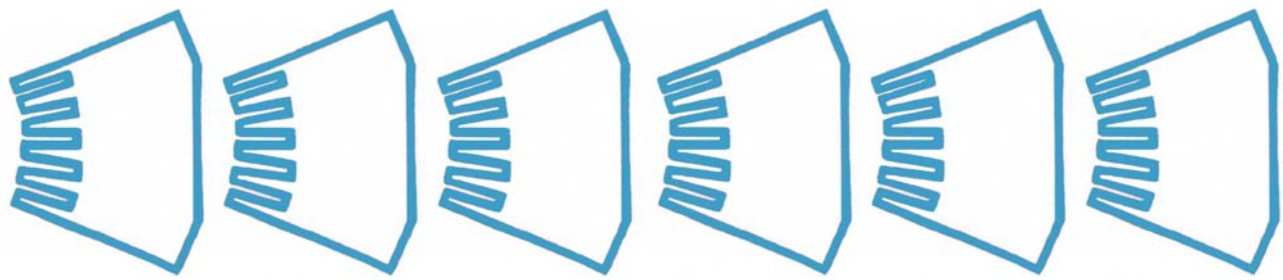

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Where considerable through puts of sheet metal cuttings have to be coated production lines with belt type and cross-rod conveyors are used since long time. The geometry of the cutting decides the design of the handling while coating process and the form of the conveyor while the treatment of the coatings. The following report contents some generally accepted considerations of coating lines for sheet metal and especially short descriptions of typical coating processes for sheet metal cuttings and segments.

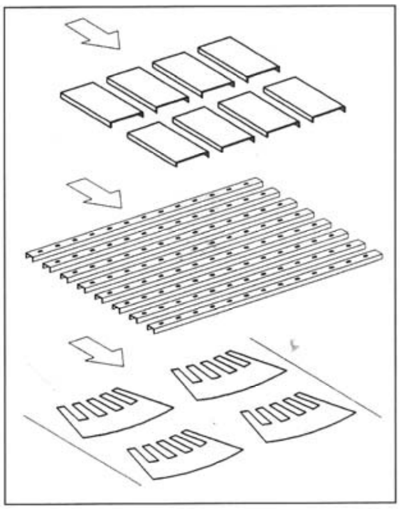

Fig. 1: Typical sheet metal cuttings

Typical Cuttings and their Coating

An important part of the world steel production comes in the form of thin sheet metal from the steel mill. In simple cut, punch an remodelling processes, the thin sheet metal is converted into mass products such as walls and roofs of buildings, partition walls, metal furniture and shelves, ceilings of offices, common trays for each purpose, but also into stator and core sheets for electrical machines. They all have to be coated before they find their final place of use, Fig. 1.

The hollow bodies formed from thin sheet metal which require considerable remodelling energy, such as for example for car bodies, are not subject of this consideration.

The above mentioned necessary coating processes are realized in processing lines with belt-type or cross-rod conveyors. The throughputs of sheet metal cuttings in these processing lines with 400 and up to 800 m²/h are no rarity. In most cases front as well backside of these cuttings are coated in one run-through.

Heat and Mass Transfer for The Treatment of Coatings

For the treatment of wet or powder coated metal surfaces there is no big choice of possibilities for heat and mass transfer: Hot air convection and IR-radiation are dominating. The heat-up in an electric alternating field got never any importance in big technical processes.

In the beginning was the radiation, it is participating in all heat-up processes, more or less and according to the temperature level. The technical heat radiation is energy transfer by emission and absorption of electromagnetic waves in the range of ultra- or infrared, that means in wave length approximately between 0,75 and 400 µm.

The temperature of the sheet metal while one side radiation can be calculated according to the following relation:

$$z = \frac{D}{2} \cdot \left(\operatorname{arctan} \frac{T}{T_s} + \operatorname{artanh} \frac{T}{T_s} - \operatorname{arctan} \frac{T_o}{T_s} - \operatorname{artanh} \frac{T_o}{T_s} \right) \quad (1)$$

z [min] is the processing time,
D [min] has to be calculated with help of the following relation:

$$D = \frac{6 \cdot 10^3 \cdot c_A}{C \cdot \left(\frac{T_s}{100} \right)^3} \quad (2)$$

Here is c_A [kWh/m²K] the specific heat of the radiated specific surface, C [kW/m² * K^4], the radiation exchange coefficient which is depending on the properties of the surfaces, T_S [K] the surface temperature of the radiator, T_o/T [K] is the start/final temperature of the sheet metal.

In order to achieve short processing times and short equipment the radiator temperatures are in a range between 900 and 1300 K. The specific radiator capacities are in a range between 15 and 50 [kW/m²].

The heat transfer by means of convection is unavoidable in all cases, where there not only has to be heated up, but also dried. For the drying process air is required as transport medium. The intensity of heat and mass transfer depends on the intensity of air movement directly over the surfaces to be treated. Maximum heat and mass transfer coefficients are achieved by vertical impinging air flow.

The convective heat-up and cooling of thin sheet metal cuttings with one sided ventilation can be calculated according to the following relation:

$$z = \frac{60 \cdot c_A}{\alpha} \cdot \ln \frac{T_{ZL} - T_o}{T_{ZL} - T} \quad (3)$$

Here is a [kW/m² * K] the real heat transfer coefficient, T_{ZL} [K] the supply air temperature, T_o and T [K] are the start and final temperatures of the sheet metal.

In technical processes heat transfer is nearly exclusively realized by a combination of heat radiation and hot air convection. Also where no radiators are integrated, the radiation of the ventilation jet boxes for hot air convection participate with a considerable share in the heat exchange.

Processing Lines for the Powder Coating of Panels and Coffers

This specification of thin sheet metal cuttings are for example elements of coffered ceilings, partition walls, walls and boards for shelves, metal furniture. For optical reasons and to maintain product value they are all double sided powder coated. For these big throughputs of surfaces powder coating is the most environmental compatible coating method. Simultaneously a great advantage for the application is achieved: All cutting edges are perfectly rounded. The coating process is realized for both sides in one run-through. Conveyor speeds between 3 and 12 m/min are usual as well as a conveyor width between 1600 and 2800 mm. The heat treatment of the coated surfaces is realized with a combination of medium-wave IR-radiation together with hot air convection. As radiators direct-fired gas-IR-elements or electrical medium-wave IR-radiators are used. The supply air units for the hot air convection are directly gasfired.

The conveyor is equipped with cross-rods with thin blades to support the double sided coated coffers. Thus to avoid unacceptable markings at the surfaces to be coated, Fig. 2.

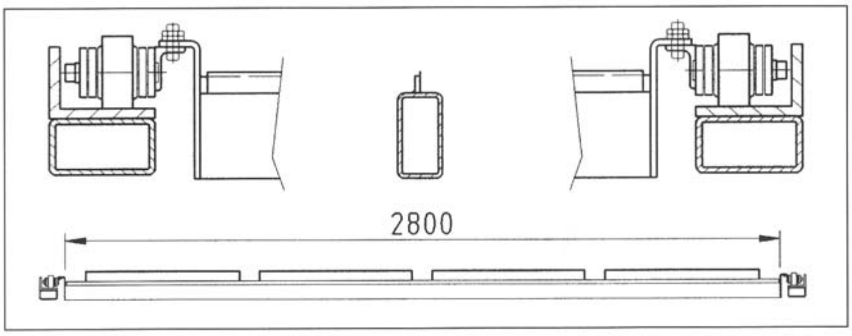

Fig. 2: Cross-rod for the support of panels and coffers.

Coating Lines for Sheet Metal Profiles

A lot of articles made of sheet metal, such as for example sheet metal profiles, are generated by simple coldroll forming. Among these products are the huge number of standardized and tailor-made profiles for all purposes.

If they are used coated, powder coating is the mostly used application. The conveyance through the processing line is realized on thin blades, which leave only small and acceptable traces on the surface to be coated. The particular feature of these lines is that the profiles run across to the direction of conveyance, Fig. 3.

Production speeds up to 5 m/min, thickness of sheet metal up to 3 mm and width of conveyor up to 1800 mm are usually nowadays.

Heat transfer is realized by means of hot air convection combined with IR-radiation. Heat-up of supply air is effected by electric energy or direct-gas-firing with natural gas.

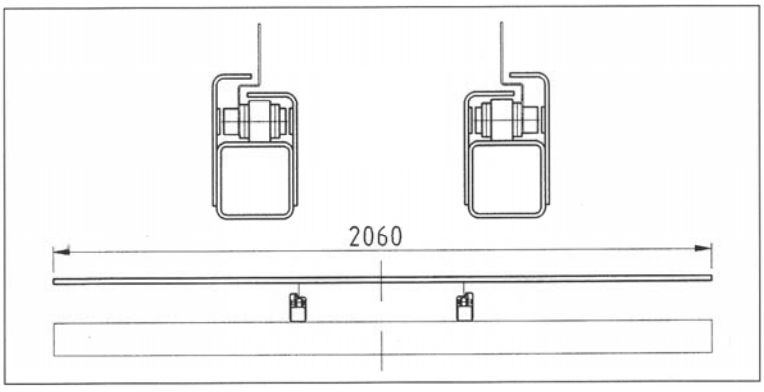

Fig. 3: Cross-rod for the support of profiles.

The Coating of Stator and Core Sheets for Electrical Machines

Sheet metal used in rotors and stators in layered packages are double sided coated in order to achieve highest efficiency, Fig. 4. The coating process on both sides with liquid coatings is realized in one run-through. The electro-insulating coatings are today mostly waterbased with only a small percentage of flammable solvents. Sheet metal thicknesses are 0,35 up to 0,5 mm, sometimes 0,65 mm, in very seldom cases still 1,0 mm, what was standing more than 20 years ago. The insulating coatings have a good adhesion and highest insulating values, they have not to protect against wheather and corrosion. As soon as they are included in the package of a rotor or stator, only good insulation and good temperature resistance are requested, Fig. 5.

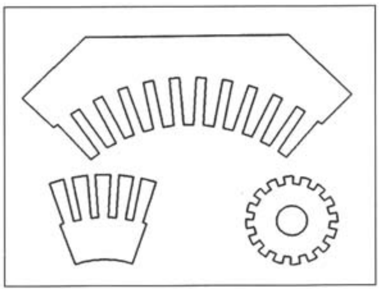

Fig. 4: Typical core and stator sheets.

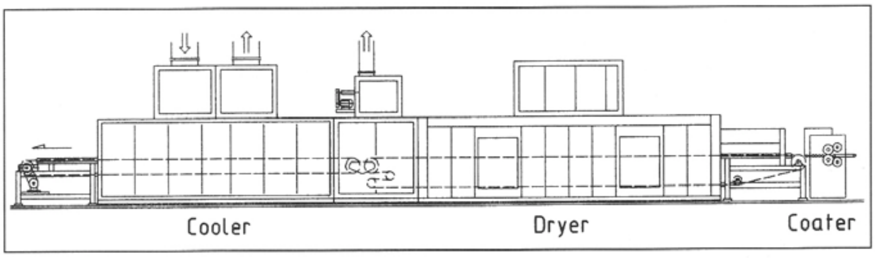

Fig. 5: Typical coating line for core and stator sheets.

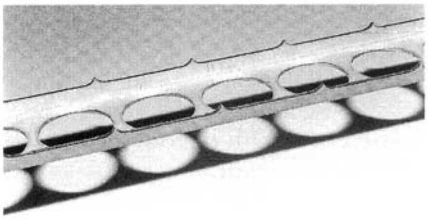

Fig. 6: Cross-rod for the support of double sided wet coated sheet metal segments

The handling of the double sided coated segments in wet state is executed by a special cross-rod conveyor. The cross-rods are fit out with spikes in order to produce a minimum of traces in the drying bottom side surface, Fig. 6. The drying of top and bottom varnish layer is realized by hot air convection with support of IR-radiation, in order to have short drying times as well as short dryers. High supply air temperatures between 250 and 350 ^{0}C and resulting high peak metal temperatures are therefore usual.

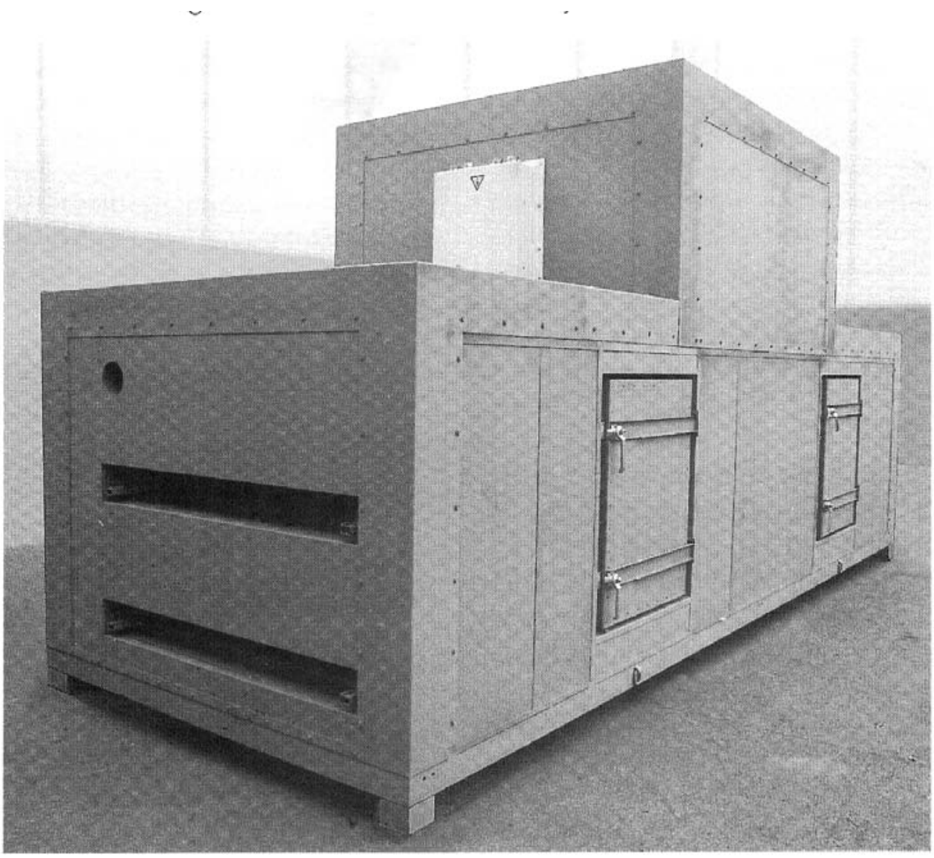

Fig. 7: Dryer section, electrically heated.

The use of convection is for a physical drying process unavoidable: Drying is a transport phenomen, air is the transport medium which takes away the evaporated thinners.

A standard width of the conveyor is 1300 or 1500 mm, sufficient in nearly 100% of all economically layouted applications is 1300 mm. Usual conveyor speeds are between 5 and 15 m/min.

Final Conclusion

For the coating of sheet metal cuttings and segments today advanced design and equipment are available. Advanced are the conveyors, the automatic lubrication devices, gas-burners and electrical air heaters for the heat-up of supply air, electrical and direct-gas-fired medium-wave radiators for the heat transfer by IR-radiation and of course the several coating machine types. Latters have not been subject of consideration of this report. Economical operation and reasonable coating costs are achieved by optimal adjustment of the layout to the real requirements. Oversized layouts are for the cost accounting detrimental as well as the operation in only one shift. Environment compatibility is mainly achieved by the use of environment compatible coatings but also by an economical use of heat energy for the dryer and electrical energy for all the numerous motor drives. One man operating of a processing line is standard today.

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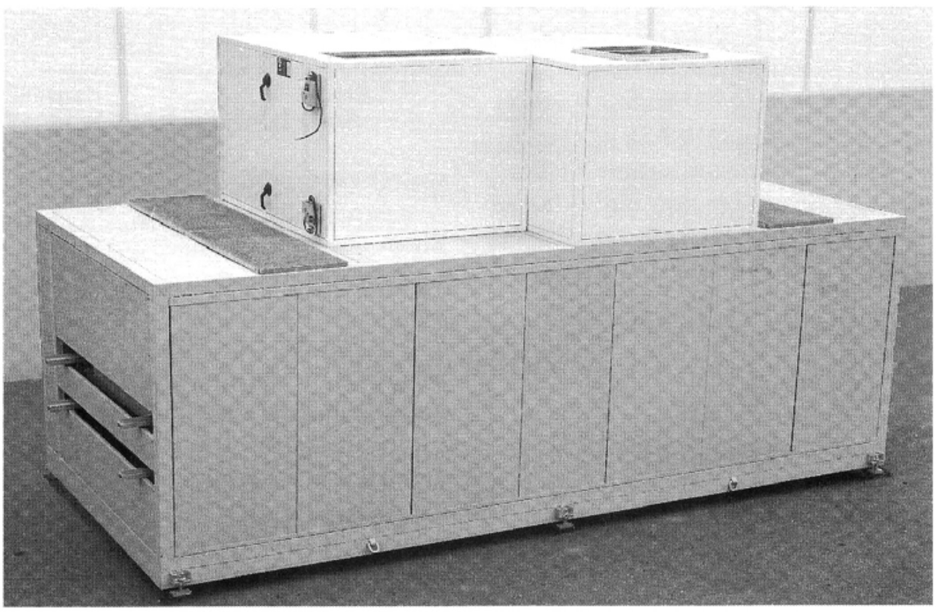

Fig. 8: Coating section, heavy duty jet cooler.