Food Science and Technology Notes

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MATERIALS FOR USE IN FOOD PROCESSING EQUIPMENT

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1.0 INTRODUCTION

Food processors are constantly faced with a materials problem in the selection of food processing equipment, in modifying existing equipment to meet food handling requirements, and in construction of equipment of their own design. The purpose of this paper is to provide basic information to guide in the selection of materials to be used in food processing equipment. Section 2.0 discusses available metals that will meet the requirements. Section 3.0 deals with various suitable finishes for the metals and Section 4.0 describes coatings that are available and are used primarily for materials that would normally be corrosive under the environmental conditions encountered in a food processing plant.

2.0 METALS

Because of their anti-corrosive and non-toxic properties, stainless steels and various aluminum alloys are most commonly used for food processing equipment. Less expensive metals such as low carbon steels can be used if coatings are applied to give them the anti-corrosive and non-toxic properties.

The alloys of stainless steel and aluminum best suited for such equipment are discussed below. The characteristics listed should help in the selection of the proper material for specific use.

2.1 Stainless Steel

Types 302, 303, and 304 are the general purpose steels. By selecting from these three, the food processor can meet all requirements in his plant except perhaps highly specialized applications where he would require expert assistance anyway. Chart I gives comparative characteristics of the three types.

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CHART I

TYPE	302	303	304
Use	General Purpose	General Purpose Free-machining grade	General Purpose, also welded construction
Available Forms	Sheet, strip, plate, bar, wire tubing	Bar, wire forgings	Sheet, strip plate, bar, wire, forgings, tubing
Corrosion Resistance	Excellent atmospheric resistance also resists food products, acids, and other chemicals	Very good atmospheric resistance some resistance sacrificed for better machinability	Excellent atmospheric resistance slightly better than 302
Weldability	Excellent	Not recommended	Excellent
Machinability	Fair	Good	Poor

2.2 Aluminum

Aluminum has several advantages that make it desirable for use in the food processing industry. It is non-toxic and odor free, easy to fabricate, corrosion resistant, and takes anodic coatings that give hard, wear-resisting surfaces. Listed below are three of the most commonly used alloys. The temper designation - the numbers following the dash - are those best suited for that particular alloy for this application.

Chart II gives comparative characteristics of the three alloys.

Chart III lists physical characteristics of the aluminum alloys and the stainless steels discussed herein.

CHART II

Type	5052-H38	6061-T6	2024-T3
Use	Marine application, kitchen cabinets, aircraft, tubing	Heavy duty structure, marine use, pipe, furniture	Structural parts, aircraft application
Available Forms	Sheet, plate, wire, rod, bar, drawn tube, rivets	Sheet, plate, wire, rod, bar, pipe, tubing, rivets	Sheet, plate, extrusions, tube, structural shapes, rod, bar
Corrosion Resistance	High resistance to industrial and marine atmosphere. Good resistance to fresh water, sea water, many foodstuffs, organic acids and anhydrites	Good resistance to industrial and marine atmosphere. High resistance to rural atmosphere	High resistance to rural atmosphere, fair resistance to industrial atmosphere, poor resistance to marine atmosphere
Weldability	Excellent	Excellent	Poor
Machinability	Fair - easily bent	Good - easily bent	Excellent

CHART III

Type	Aluminum			Stainless Steel		
	6061-T6	5052-H38	2024-T3	302	303	304
Density-Lbs./cu. in	.098	.097	.100	.29	.29	.29
Coeff. of Therm. Exp. ^oF.	$13x10^{-6}$	$13.2x10^{-6}$	$12.9x10^{-6}$	$9.6x10^{-6}$	$9.6x10^{-6}$	$9.6x10^{-6}$
Tensile Strength PSI	45,000	42,000	70,000	110,000	110,000	110,000
Yield Strength PSI	40,000	37,000	50,000	75,000	75,000	75,000
Machinability	B	C	A	B	A	C
Weldability						
Torch	A	A	D	A	Not Rec	A
Inert Arc	A	A	B	A	Not Rec	A
Elec. Res.	A	A	B	A	Not Rec	A

Letter A indicates most favorable, B. less favorable, etc. relative to aluminum alloys or to stainless steel alloys, but does not indicate relativity between aluminum and stainless steel.

3.0 FINISHES

Even though the stainless steels and aluminum alloys listed herein are corrosion resistant, adding a finish can increase this resistance, and for aluminum can substantially increase wear resistance.

3.1 Stainless Steel Finish

After all fabrication is complete, stainless steel parts should be passivated. This finish serves the purpose of cleaning the part and decreasing the anodic corrosion. Generally, the steps involved are as follows:

. . . solvent clean by immersion, spray or vapor degreasing

. . . immerse for 30 minutes, in a hot (120 to 130^{o}F) aqueous solution containing 20% by volume of nitric acid and 2% by weight of sodium dichromate. Rinse in clean hot water.

3.2 Aluminum Finishes

The following describe finishes that will substantially increase corrosion and wear resistance of aluminum. Aluminum will build up an oxide film over a period of time that prevents further corrosion. These finishes basically expedite the forming of this film.

Chromate Finishes (Irridite)

Chromate finishes are used to protect the surface against corrosion and to enhance surface appearance. They provide a very flexible coating, good paint bond, low electrical resistance and cost is lower than anodizing.

Chromate finishes are much thinner (about 0.01 mil) than anodic finishes and color varies from clear to dark as thickness increases. The amount of aluminum that enters into the reaction is so slight that diminsional stability of closely machined surfaces is not affected. For a given thickness, chromate finishes provide better corrosion protection than anodic finishes. They are, however, less abrasive resistant.

Anodized Finishes

Anodized finishes are used to improve the resistance of metals to corrosion and abrasion and to enhance surface appearance. Organic coloring dyes and pigments can be absorbed in the pores of anodized finishes to produce a wide variety of decorative effects. Adding color allows parts to be readily identified as anodized. Coating thickness vary from 0.1 to 2.0 mils. Following are three types of available anodized finishes.

Sulfuric Acid Anodizing

Sulfuric acid anodizing is the most popular anodizing process. These finishes vary in appearance from transpartent to translucent and have high abrasion resistance.

Chromic Acid Anodizing

Chromic acid anodizing is more expensive, produces thinner less abrasion resistant coatings, but because of the chrome has higher resistance to corrosion. The finishes have an opaque, slightly irridescent appearance.

Hard Coating

Hard coating is produced by various proprietary techniques and is particularly valuable where high resistance to abrasion, corrosion, and errosion are required. Thicknesses vary from 1 to 5 mils. This build up must be considered where close tolerances are required. In general, an allowance of 50% of coating thickness should be made for surface growth. Hard coating can be applied to all aluminum alloys, but on 2024 the coatings are not as resistant to abrasion as coatings on 5052 and 6061.

4.0 COATINGS

Coatings are applied to metals to impart to them a physical characteristic the base metal does not have, the chief one being corrosion resistance. They are also used to increase wear resistance, decrease friction, reduce cost, improve the aesthetic value, and to build up worn surfaces.

The food processor may wish to consider some type of coating in application such as the following:

. . . to repair a worn machine by building up worn surfaces

. . . to convert a piece of equipment to meet food handling requirements

. . . to reduce costs of a new design

A brief description of the most common coating processes along with acceptable coating materials for each process are described below.

4.1 Electroplating

When a direct current is applied to a water solution of a metallic salt, there is a passage of current through the solution and a chemical change occurs at each electrode. If the part to be plated is made, the negative electrode, an excess of electrons supplied by the battery neutralizes the positively charged metallic ions that migrate to it and convert the dissolved metal to the metallic solid condition. The positive electrode is of the material to be plated and an equivalent amount of the metal goes into the solution to replace that plated out.

Practically all metals that are deposited for protective purposes, except cadmium and zinc, prevent corrosion on the basic metal by mechanical envelopment. Copper, nickel and lead are the three most important metals used for protection by mechanical coverage, and form the base metal for further electrodeposition of other porous metals such as chromium. Zinc and cadmium protect steel by galvanic action whereby it becomes consumed in the process. For this reason, combined with the toxic nature of these two materials, zinc coated, or galvanized, and cadmium plated materials should never be allowed to come in contact with foods.

Acceptable platings for contact with food are nickel, tin and chromium.

Nickel

Nickel is the material most often used in plating and is relied upon to bear the brunt of the load of protecting materials from corrosion. It can be plated on steel and aluminum.

Resistance to abrasion is good. Flexibility is fair. Thickness may vary from .0002 to .0008 inches.

Tin

Tin is most commonly applied as a hot tin dip. Electroplating of tin is done primarily by manufacturers of food and beverage containers, the main reason being to conserve tin.

Since electroplated tin is porous, the electrotinned parts are boiled in palm oil which seals the surface. It is a peculiar property of tin that on the inside of a sealed food container, the coating is electropositive and, thereby, prevents rust of the steel by the same galvanic mechanism that enables zinc to prevent the rusting of steel in atmospheric exposure. The tin on the outside does not afford such corrosion resistance, therefore, it is a common practice to store filled containers in a cool dry location to prevent exterior rusting.

Tin has very poor abrasion resistance, but excellent flexibility. Thickness varies from .0001 to .0003 inches.

Chromium

Chromium plate is porous and, therefore, should always be plated over nickel if corrosion resistance is required. Chromium is used because of its hardness and wear qualities as well as its decorative characteristics.

The decorative coat is much thinner than when the requirement is for hardness and wear and is referred to as a "flash" chrome. Thicker platings for hardness and wear are commonly referred to a "hard" chrome plate, the only difference in the two being thickness - not hardness of chrome.

The thickness of flash chrome is from .000015 to .000030 inches. Hard chrome is from .0005 to .01 inches. The plating is very hard with excellent wear resistance, but poor flexibility.

4.2 Metal Spraying (Metallizing)

This method is similar to spray painting. The spray gun is so constructed that metal powder or wire is fed into the nozzle where it is heated, melted to liquid droplets and sprayed onto the work. As the droplets strike the work, they are cooled and flattened forming a coating of interlocking plates that adhere to each other. One of the most useful applications of this technique is in salvage and maintenance work around large and small machinery.

Almost any metal can be used in the spraying operation including stainless steel, nickel, and aluminum. For protective coatings, aluminum should be approximately .010 thick. Other materials that protect by enveloping such as stainless steel and nickel should be .020 thick.

4.3 Hot Dip

Metals most commonly applied by hot dipping are tin, lead, and zinc. The latter two are not suitable for use in food handling equipment. Tin is widely used as a coating for steel food containers.

Sheet steel for tinning is required to be held to close chemical composition limits and must receive careful surface preparation before being introduced into the tin pot or furnace.

Tin plated by this method varies in thickness from .0003 to .002 inches

4.4 Fluidized Bed

The fluidized bed process is used to coat metal parts with plastic. It consists basically of heating the metal part above the melting point of the plastic, then dipping it into a whirling suspension of finely divided plastic powder. Today nylon and vinyl powders account for approximately 70% of the total powder coating market. Other available materials are cellulose, epoxy, chlorinated polyether, polyethylene, and FEP-fluorocarbon.

Vinyl coatings are particularly useful in protecting against weathering and corrosion.

Nylon coatings are used because of their low friction and because of the solvent resistance.

However, before any coating is applied to food handling equipment, the supplier should confirm that the powder used meets FDA approval. Each powder mix contains not only the basic plastic but also may contain a catalyst, pigments and stabilizers. Therefore, one powder mix may be approved, but another may not be.