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Material Handling Equipment Selection: New Classifications of Equipments and Attributes

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Abstract. This paper analyses the existing literature (27 articles) on material handling equipment selection through equipments and attributes aspects. It is found that the maximum material handling equipment types used by developed systems for resolving the selection problem is 50 equipment types. The greatest number of attributes used in one article is 42 attributes. However, systems should be more robust and practical by being close to the reality of the selection problem. According to the continuously growing market, much more material handling equipments exist. Therefore, more complete new classifications of individual unit load material handling equipment types and attributes are provided. Equipment categories, classes and types are clarified. Reasons of the necessity for new lists are discussed.

Keywords. Material handling equipments, attributes, new classifications, material handling equipment selection.

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I. INTRODUCTION

A material handling system is constituted of methods using material handling equipments (Apple, 1972). It could be a source of cost savings or excessive expenditure if it is not efficiently designed. Its design goes through material handling equipment selection. It is an obligatory passage and a phase among others in warehouse design (Gu, Goetschalckx, & McGinnis, 2010). Moreover, selecting material handling equipments requires facilitating more efficient tools rather than consulting equipment vendors or doing thinks as usual.
A literature review of the last 30 years researches on material handling equipment selection has identified 27 articles on this subject: Bookbinder et Gervais (1992), Chakraborty et Banik (2006), Chan, Ip et Lau (2001), Cho et Egbelu (2005), Chu, Egbelu et Wu (1995), Fisher, Farber et Kay (1988), Fonseca, Uppal et Greene (2004), Gabbert et Brown (1989), Hassan (2010), Hassan (2014), Hassan, Hogg et Smith (1985), Kim et Eom (1997), Kulak (2005), Malmborg, Krishnakumar, Simons et Agee (1989), Maniya et Bhatt (2011), Matson, Mellichamph et Swaminathan (1992), Mirhosseyni et Webb (2009), Onut, Kara et Mert (2009), Park (1996), Raman, Nagalingam, Gurd et Lin (2009), Sharp et al. (2001), Telek (2013), Trevino, Hurley, Clincy et Jang (1991), Tuzkaya, Gülsün, Kahraman et Özgen (2010), Velury et Kennedy (1992), Welgama et Gibson (1995), and Yaman (2001).
Those papers have developed solutions organized in 5 groups: optimization models (4), expert systems (10), hybrid systems (2), multicriteria decision methods (4), and systemic framework approaches (2) (Ahmed Bouh & Riopel, 2015). They became new alternatives for handling systems designers. Otherwise, they dispose few decision making tools to select optimal material handling equipments for specific material handling operations in a factory or in a logistic warehouse. They are currently facing three choices: (1) using their own experiences while seeking in material handling books and handbooks, (2) trusting an equipment seller and its catalogs, (3) requesting recommendations from an external consultant (Chan et al., 2001). The selection process is discussed in detail in the literature review of Ahmed Bouh et Riopel (2015).
This work comes to begin exploring one axe of the research opportunities identified by the late literature. Classifying material handling equipments and attributes is a preliminary task between other in the process of developing a solution for warehouse material handling equipment system.
However, various schools of thought exist concerning “material handling equipment" definition. This expression returns to the definition of “material handling”. In certain papers which treat material handling equipment selection problem, it is regarded as being the fact of moving product from a point to another, while storing it on racks or manipulating it (Matson & White, 1982). But, there is a difference between product manipulation, handling it, transporting it, and warehousing it. Material handling is "the process and systems that transfer and manage the transfer of goods from one place to another" (Institute of Industrial Engineers, 2000). On the other hand, "manipulating is the action to move automatically, mechanically or manually products in a work station. Transportation is the external long distance travel of goods towards other places. Storage is the action to gather and have goods constituting stocks under material conditions favorable to their conservation and their taking away” (Riopel & Croteau, 2013)."Material handling equipment cannot be used to store products. Similarly a pallet rack is not designed for moving a pallet in a distance"(Ahmed Bouh & Riopel, 2015). This is one of constraints in developing effective and practical systems for material handling equipment selection problem resolution. System requirements in knowledge base and rules approaches are different from material handling to warehousing or transporting.

With equipments analysis, it is found that the maximum material handling equipment types used by developed systems which are resolving the selection problem is 50 types, while the minimum is zero type. This is far from the reality since much more material handling equipment types exist in the market. So, it is made possible to propose a more complete new list of the material handling equipment types for particularly individual unit load manufacturing plants and warehouses. This work was completed by using existing technical literature in this field (encyclopedia, specialized dictionaries, handbooks, books, magazines, reports, courses notes). In addition, as requested by Ahmed Bouh and Riopel (Ahmed Bouh & Riopel, 2015), another more complete new list of attributes for identifying suitable equipment for material handling tasks is provided.

This new classification is relevant because it takes in account all material handling equipment selection aspects without limitation to any situation while previously researchers limited their systems in some context and so unusable elsewhere. Hence it will be possible to propose a generic system of material handling equipment selection using a harmonized synthesis of published attributes.

After a recall on schools of thought on material handling concept, material handling equipments and related equipments used in material handling equipment selection research papers are analyzed. Then, a new classification of material handling equipments is described. Published attributes in aforementioned articles are analyzed, followed by their more complete new list in order to deal with selection problem effectively. Finally, we answer why new classifications are necessary for material handling equipments and attributes respectively before concluding.

II. MATERIAL HANDLING AND RELATED EQUIPMENTS

A. Material handling equipments analysis

The number of material handling equipments available on the market increases continuously. It is possible to determine categories, classes, types and models of those which currently exist. Material handling equipments categories treated in scientific research articles are as following.

- Manual: "operated by people rather than automatically." (Institute of Industrial Engineers, 2000)
- Hoist: “mechanism for lifting and lowering loads.” (Institute of Industrial Engineers, 2000)
- Industrial truck: “a wheeled vehicle, primarily for the movement of objects or materials, and usually associated with manufacturing, processing, or warehousing, but not including vehicles intended primarily for earth-moving or over-the-road hauling.” (Institute of Industrial Engineers, 2000),
- Pipe : "pipings in which a fluid circulates." ("Canalisation," 2012),
- Robot: “a robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.” (Institute of Industrial Engineers, 2000),
- Automated guided vehicles system: "a self-controlled vehicle that follows specified paths in a plant floor to move material, tools, and other items. Although most systems are directed (guided) through a set of predefined (fixed) paths, new guidance systems can plan paths and control the vehicle dynamically" (Institute of Industrial Engineers, 2000),
- Unit load conveyor: "a horizontal, inclined or vertical device for moving or transporting bulk materials, packages or objects in a path predetermined by the design of the device and having

points of loading and discharge fixed, or selective; included are skip hoists and vertical reciprocating and inclined reciprocating conveyors; typical exceptions are those devices known as industrial trucks, tractors and trailers, tiering machines (truck type), cranes, hoists, monorail cranes, power and hand shovels, power scoops, bucket drag lines, platform elevators designed to carry passengers or the elevator operator, and highway or rail vehicles." (Institute of Industrial Engineers, 2000) ,

- Bulk load conveyor: this equipment has the same definition as unit load conveyors except that the products are handled in bulk.

Table 1 presents material handling equipment categories used in the 27 papers. Eleven papers in material handling equipment selection problem have added in their studies related equipment categories which are not intended for handling. Some authors have specified the whole material handling system. Moreover, five other papers did not precise used equipment types (Chakraborty et Banik (2006), Hassan et al. (1985), Hassan (2014), Raman et al. (2009), and Telek (2013)).

B. Related equipments analysis

By mentioning related equipments, authors are interested in all devices in a material handling system. Certainly, there are connexions and ongoing contacts between static and dynamic technologies in warehouse environment. For example, Hassan (2010) states that the hierarchy of equipments presented in his article reflects all equipments found in the material handling system of pharmaceutical sector. Related equipments found in papers but not concerned are as following.

- Grippers: "a device by which a robot may grasp and hold external objects" (Institute of Industrial Engineers, 2000) ,
- Identification and communication devices (scanner, printer et terminal),
- Manipulators: "a mechanism typically consisting of a series of segments, jointed or sliding relative to one another, for the purpose of grasping and moving objects, usually in several degrees of freedom. It may be remotely controlled by a computer or by a human." (Institute of Industrial Engineers, 2000),
- Sortation systems: "an automated conveyor system with diverters used for sorting items in a warehouse." (Institute of Industrial Engineers, 2000),
- Warehousing systems (racks),
- Unit loads: "Any load configuration handled as a single item" (Institute of Industrial Engineers, 2000).

C. New classification of material handling equipments

Gu et al. (2010) address the need for more widespread classification of equipments used in warehouse. One track would be to use technical literature and research in this field to extract a new list adapted to the warehouse. Indeed, the Dictionnaire illustré des activités de l'entreprise : industrie, techniques et gestion : français-anglais (Édition mise à jour) of Riopel et Croteau (2013), the Dictionary of industrial engineering terminology (Institute of Industrial Engineers, 2000), the Encyclopedia of material handling (Syndicat des industries de matériels de manutention, 1983a, 1983b, 1983c), different handbooks of material handling (Mulcahy, 1999) and (Cahill et al., 2008; Feit, Mazzola, Reisinger, & Mitchell, 2008; Fitzpatrick, 2008; Footlik, 2008; Hinterlong, Conveyor Equipment Manufacturers Association, & Sinden, 2008; Hubbell & Pomerantsev, 2008; Koff & Boldrin, 2008; Lewis, 2008; O'Connell et al., 2008; Quinn et al., 2008; Schultz, 2008a, 2008b; Sims, 2008; Smyre, 2008; Zenz, Stankovich, Gerchow, &

Carstens, 2008), the books (College-Industry Council on Material Handling Education (CICMHE), Malmborg, Petrina, Pratt, & Taylor, 1998; Roux, 2011; Tompkins, White, Bozer, & Tanchoco, 2010), and the courses notes (Riopel, 2012, 2014) provide sufficiently the material needed for this work. With these collections, it is possible to try to be comprehensive and address the selection problem with a more complete list of main equipments types, which was not the case until now.

The list is organized in Table 2 into three levels: category, class and type. Some categories are not divided into two subgroups (class and type), but rather in one, then they go straight from category to type. In total, we consider 122 types of material handling equipments for this selection problem under nine different categories.

However, each type has many varieties depending on its mechanical characteristics and accompanied accessories. Each variety is sold in several models depending on brand, mechanical performance and embedded options.

D. Why a new material handling equipment types classification?

Beside the fact that largest material handling equipment types number used in resolution material handling equipment selection is 50 types by Chan et al. (2001), existing classification is confused. It is current to see one equipment name for several equipment types or even for classes. For example, *pallet jack* is a device "used to lift, maneuver, and transport a pallet load of material in short distances. The pallet jack can be either manual or battery powered for both lifting and transporting. The lifting capability is typically from 6" to 10"." (Tompkins et al., 2010). This definition returns to equipment class aggregating several equipment types. Some papers (Cho & Egbelu, 2005; Chu et al., 1995; Fisher et al., 1988; Park, 1996) have used it, so their systems are proposing equipment classes and not equipment types. Material handling selection problem is a decision between equipment models knowing the equipment type. Systems should be able to select firstly equipment category, secondly equipment class, thirdly equipment type and finally equipment model. The selection process is more analysed in (Ahmed Bouh & Riopel, 2015).

The new classification is a comprehensive list of material handling equipment types and it is able to facilitate more practical solutions. Proposed material handling equipments types are the most used. Industrial truck category is exploded and privileged categories are provided. They are : 35 lifting equipment types, eleven elevators types, 31 industrial hand truck types, eleven self-propelling truck types, six stackers types, fourteen unit load conveyor types, three automatic guided vehicle system types, five tractor types, and six pallet truck types. A total of 122 unit load material handling equipment types is listed. Bulk load equipments such as pipes and bulk load conveyors are discarded since individual unit load manufacturing plants and warehouses are considered in this paper.

Each device has specific attributes. Questions addressed to user are designed in order to know values of these attributes. In fact, they are simply requirements of the material handling operation to perform.

III. ATTRIBUTES

A. Attributes analysis

Attributes used in material handling equipment selection are grouped into several families. Titles of these families are: product, movement, equipment, environment, infrastructure, method, process, general, data processing, direct, inferred, and direct / inferred. It appears that some names of these groups almost mean the same things as their content, but authors change only in name. In addition, some attributes are found in different categories of an article to another, for example they pass from "movement" family to "operation" or to "environment" and vice versa. This shows that material handling equipments and their attributes are not very well mastered. Some papers distinguish an attribute group called "operation" (Chan et al., 2001; Cho & Egbelu, 2005; Kulak, 2005; Mirhosseyni & Webb, 2009; Park, 1996). It includes variables that indicate if the desired equipment is intended for handling or storage or manipulating. But this question does not arise in this case because we cannot put together all these different devices belonging to different operation categories. Thus we particularly specify material handling equipments.

We propose a list of attributes that would be comprehensive and may be used in future researches. Collecting a comprehensive data concerning material handling equipment and attributes is the first step for designing a system of material handling equipment selection. We describe here the data and its organization. We also explain what conducted to propose this new classification and makes it relevant.

B. New classification of attributes

We classify the attributes of material handling equipments in four main groups. Research has not used them yet in this complete way. They are unit load attributes, movement attributes, equipment attributes and environment attributes.

- Unit load: characteristics of single item handled,
- Movement: characteristics of desired transfer the material handling equipment is supposed to do,
- Equipment: built-in characteristics of required material handling equipment,
- Environment: characteristics of workplace.

Table 3 provides most significant attributes illustrating requirements of material handling tasks.

C. Why a new attributes classification?

This makes possible to develop a generic system for selecting material handling equipments which is independent largely applicable.

Researchers have not specifically addressed the same material handling selection case. Some have worked for specific companies or a specific industry sector or a particular category of equipment such as conveyors and then they have restricted their study with the necessary attributes. Others preferred to simply give illustrative examples of their solutions, which do not imply their applicability to all material handling system design problems.

The greatest number of attributes used till today by an article is 42 attributes under four groups (general, product movement, operation and data treatment) by Cho et Egbelu (2005).

Proposed attributes in this paper concern unit load equipments. They are 81 attributes: fifteen of unit load, 36 of movement, 23 of equipment, and 7 of environment.

TABLE 1: EQUIPMENTS CATEGORIES AND ATTRIBUTES IN PAPERS

Article	**Material handling equipment categories**								**Related equipments categories**						**Attributes families**			
	M1	IT	ULC	BLC	R	H	P	AGVS	WS	SS	G	UL	M2	ICD	UL	M3	E1	E2
Bookbinder et Gervais (1992)		*	*			*									*	*	*	*
Chakraborty et Banik (2006)															*	*	*	
Chan et al. (2001)		*	*		*	*		*	*						*	*	*	*
Cho et Egbelu (2005)		*	*			*		*	*				*		*	*	*	*
Chu et al. (1995)		*	*		*	*		*	*			*	*		*	*		*
Fisher et al. (1988)	*	*	*		*	*		*							*	*		
Fonseca et al. (2004)		*	*	*		*				*					*	*	*	
Gabbert et Brown (1989)			*						*								*	
Hassan et al. (1985)																	*	
Hassan (2010)	*	*	*	*		*		*	*	*		*	*	*	*	*	*	
Hassan (2014)																		
Kim et Eom (1997)	*		*					*	*						*	*		
Kulak (2005)		*	*		*	*		*	*						*	*	*	*
Malmborg et al. (1989)		*						*							*	*	*	*
Maniya et Bhatt (2011)								*									*	
Matson et al. (1992)	*		*		*	*		*					*		*	*	*	*
Mirhosseyni et Webb (2009)	*	*	*			*		*							*	*	*	
Onut et al. (2009)		*	*			*		*									*	
Park (1996)		*	*				*								*	*	*	*
Raman et al. (2009)																	*	
Sharp et al. (2001)		*	*	*		*		*	*	*	*	*			*	*	*	*
Telek (2013)																*	*	*
Trevino et al. (1991)		*							*									
Tuzkaya et al. (2010)		*														*	*	*
Velury et Kennedy (1992)		*		*											*		*	
Welgama et Gibson (1995)		*	*			*		*							*	*	*	*
Yaman (2001)	*	*	*		*	*		*							*	*	*	

Legend:

M1: Manual
IT: Industrial truck
ULC: Unit load conveyor
BLC: Bulk load conveyor
R: Robot
H: Hoist
P: Pipe
AGVS: Automated guided vehicle system
WS: Warehousing system
SS: Sortation system
G: Gripper
UL: Unit load
M2: Manipulator
ICD: Identification and communication device
M3: Movement
E1: Equipment
E2: Environment

Table 2: NEW CLASSIFCATION OF MATERIAL HANDLING EQUIPMENT TYPES

Material handling equipments (**category**, *class*, type)		
Pallet truck	**Lifting devices**	**Elevators**
Pallet jack	*Hoist*	Freight elevator
Hand pallet truck	Hand hoist	Material hoist
Power operated pallet truck	Powered hoist	Scissor lift
High lift pallet truck	*Winch*	Work assist vehicle
Electric scissor lift pallet truck	Hand winch	*Step ladder*
Hand high lift pallet truck	Motor-winch	Rolling service extension ladder
Platform truck	*Jack*	*Lift table*
Hand operated stillage truck	Manual jack	Constant-level table
Power-driven platform truck	*Lifting cylinder*	Manual mobile scissor lift table
Industrial hand truck	Manual cylinder	*Boom lift*
Basket-truck	Motorized jack	Articulating boom lift
Beam type truck	*Monorail*	Self-propelled boom lift
Cage cart	Automated electrified monorail	Telescopic boom lift
Dolly	Manual monorail	Towable boom lift
Fit-in truck	*Jib crane*	**Continuous material handling**
Metal wheelbarrow	Articulated beam jib crane	Ball table
Platform truck with upright sides	Floor-mounted jib crane	*Conveyor*
Rack truck	Hand rotated jib crane	Automatic baggage conveyor
Roll-container	Jib crane with powered slewing	Belt conveyor
Service cart	Pillar jib crane	Chain conveyor
Specialised truck	Wall jib crane	Chute conveyor
Stock picking truck	*Gantry crane*	Mesh band conveyor
Tilt truck	Cantilever gantry crane	Overhead conveyor towing floor truck
Tipper truck	Cross aisle tie	Overhead monorail chain conveyor
Towable truck	Fixed gantry crane	Overhead power and free chain conveyor
Trolley for carrying boards	Hand-operated gantry crane	Roller conveyor
Platform truck	Radial gantry crane	Single strand floor truck conveyor
Folding platform truck	Self-propelling gantry crane	Skatewheel conveyor
Low lift platform truck	Single-girder gantry crane	Sort conveyor
Narrow aisle cart	Travelling gantry crane	Steel band conveyor
Tilt platform truck	Twin-girder gantry crane	**Stackers**
Two wheel hand truck	*Bridge crane*	*Manual stacker*
Appliance truck	Automatic overhead crane	Manual hand stacker
Barrel truck	Cab operated bridge crane	Manual hydraulic stacker
Convertible two-wheel hand truck	Double-girder crane	Semi-electric stacker
Dual cylinder truck	Flameproof overhead travelling crane	*Power operated stacker truck*
Dual directional hand truck	Manually operated crane	Electric stacker
Folding two-wheel hand truck	Overhead travelling stacking crane	Reach stacker
Lift two-wheel hand truck	Single-girder crane	Weighing stacker
Luggage cart	Top-running bridge crane	**Self-propelling trucks**
Multiple-cylinder truck	Underhung bridge crane	Burden carrier
Single-cylinder truck	*Semi-gantry crane*	Straddle carrier
Stair climbing hand truck	Motorized semi-gantry crane	*Power lift truck*
Automated guided vehicle systems (AGVS)	*Portable crane*	All-wheel drive multidirectional forklift
Automated guided vehicle (AGV)	Hydraulic floor crane	Articulated frame lift truck
Heavy load Automated guided vehicle	**Tractors**	Counterbalanced lift truck
Light load automated guided vehicle	Industrial trailer	Forklift truck
Medium load Automated guided vehicle	*Industrial tow tractor*	Order-picking truck
	Electric tow tractor	Reach forklift truck
	Internal combustion powered tow tractor	Rotating cabin lift truck
	Powered rider tow tractor	Rough terrain lift truck
	Walkie tow tractor	Telescopic handler

When it comes to choose a model among several of the same equipment type, evaluation criteria are used. They are inspired by the research of Kulak (2005) who used them to select between several equipment types and not between equipment models of the same equipment type. These evaluation criteria are: adaptability, steering angle, load capacity, fixed cost, variable cost, degree of freedom, usability, flexibility, lifting height, width, length, maximum length of conveyor, load weight, precision, safety, driving speed, and also pick-up and set-down speed.

Table 3: NEW CLASSIFICATION OF ATTRIBUTES

Attributes

Unit load

Bottom surface : rigid or not, flat or not
Easy to clean : plastic container, metal container
Height : short, medium, high
Length : short, medium, high
Nature : fragile, robust, compact, granular, block (bulk)
Production trend : increase, increase sharply, regression, strong regression, stable,
Quantity to handle : low, medium, high
Shape : regular, irregular
Size : regular, irregular, small, medium, large
Temperature : °C
Type : container, pallet, individual, tray handling, bar, bulk, reusable or not
Volume : m3
Warehousing properties : nestable and stackable
Weight : light, medium, heavy
Width : short, medium, high

Equipment

Accumulation : permitted or no
Acquisition cost : low, medium, high
Bearing strength : newton
Design of the loading platform : roller, skatewheel, stationary, lifting
Engine type : diesel, gasoline, other
Equipment battery : low, medium, high
Equipment Compatibility with others : yes or no
Equipment profile complexity : straight line, composed, simple (continuous handling)
External energy required : yes or no
Gripping equipment : platform, skate, pallet fork, tractor, trailer etc ...
Lifting/ loading/unloading speed : low, medium, high
Loading capacity : Kg
Mode : manual, semi-programmable, programmable
Operation control : alone, manual, automatic, yes or no
Operation cost : uniform, variable, irregular
Operator : accompanying, standing, sitting
Power source : gravity, electrical
Primary function : movement, warehousing, manipulating, transportation
Product protection : yes or no
Transportation method : carry, tow
Wheel type : demountable tire, bonded tire, etc.

Environment

Depth of the rack : simple, double
Floor space : available or no
Floor space nature : smooth, rough
Slope : degree
Space between column : m2 or f2
Warehousing : floor, pallet rack, automatic warehouse system
Working condition : noise, exhaust, dirt, debris, etc.

Movement

Aisle length : meter or foot
Aisle width : meter or foot
Automation level : manual, semi-automatic, automatic, required or not
Available height : meter or foot
Coverage area : point to point, confined to variable, fixed, variable, linear, 2D, 3D
Cross traffic : present or absent
Direction/plan : descent, horizontal / angled, vertical (up / decreasing)
Distance : short, medium, long
Flow : controlled or not
Frequency : fixed, continuous, intermittent
Handled load/time unit : uniform, variable, combination
Interface handling equipment type : manual, semi-programmable, programmable
Lifting height : meter or feet
Loading nature : simple, double or other
Loading/unloading : alone, controlled or not
Location : indoor, outdoor, Mixed
Loop : open, closed
Management mode : FIFO, LIFO
Movement configuration : continuous, intermittent
Nature : transfer, rotate, capture, distribution, stacking, loading, unloading, conveying, transportation, lifting, wrenching, fixing, inserage, orientation, dock, order preparation, handling assets, outdoor handling
Obstacle : yes or no
Operation accuracy : low, medium, high
Operator lift height : low, high
Origin/destination : fixed, variable, racks
Output : low, medium, high
Path : straight, curve, right angle
Path variability : fix, variable
Route : fixed point to fixed point, fixed point to variable point, variable point to variable point
Sequence : fix, variable
Speed : low, medium, fast, uniform, irregular, variable
Tilt : degree
Transaction data processing : manual, semi-automatic, automatic (barcode)
Type : horizontal (above ground, overhead), inclined, rotational
Unloading places : one place, several places at equal intervals, different places at unequal intervals
Working level : ground, breast height, raised (horizontally, vertically, inclined)
Workstation types : one lane or two-way

IV. Conclusion

This work comes to begin exploring one axe of the research opportunities identified by the literature of Ahmed Bouh et Riopel (2015). Research in generic warehouse material handling systems is required.

Classifying material handling equipments and attributes is a preliminary task in the process of developing a solution for warehouse material handling equipment systems. Because material handling equipments and attributes are important elements of the knowledge base of every expert system resolving material handling selection problem. Defects found on that level will be collected on the proposed choice. The more the base would be qualified as complete and up to date the more the solution would be more precise in its results.

These new classifications allow getting this precision through the appropriate selection rules. It is made possible to treat the problem with more data while not complicating the process. It is also necessary to be in technological watch in order to improve continuously the knowledge base

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