A dynamic Milk Run in WEEE Reverse Logistics

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Abstract: - The management of waste electrical and electronic equipment (WEEE) is an important and critical aspect in the field of Reverse Logistics. The strategic importance of good treatment of waste is fundamental for reaching the objectives of environmental protection (as energy, natural resources, waste reduction) and economics goals (the lower cost of secondary raw materials for example). The following study is focused on the problem of management of waste electrical and electronic equipment. The objective is to build a new different system of waste based on a pull – logic. It starts with the analysis of present system and identifying its key features so it builds a new different management system of WEEE based on a pull – logic. Then it assumes a new system and following the basic concepts of Lean Production it separates the waste stream into two flows resulting one from the classic warehouse and the other from the new points of storage called collection center based on a pull logic. The Treatment Center is the system pacemaker process; it requires the amount of waste to Supermarket and it obtains its needs by a Milk Run system. We introduce the main features of new system with the use of a causal loop diagram (CLD) that shows the links (feedback or loops) between the variables of the system, then following the system dynamics approach it builds the stock and flow diagram (S&FD's) of the system. S&FD's it is necessary in order to use the simulation software (*Powersim*). In fact it analyzes the behavior of the model in simulation; by simulation it shows a positive trends in the level of WIP and a particular behavior of the treatment center. Then at the beginning are shown the concepts and tools that we use, that is Reverse Logistics and Lean Production System, Milk Run, vehicle routing problems, System Dynamics approach, and finally the design of new system and this new model simulation with the results analysis.

Key-Words: -Reverse Logistics, Closed Loop Supply Chain, Waste Electric and Electronic Equipment, Vehicle Routing Problem, Milk Run, Scheduling, Simulation, System Dynamics.

1 Introduction

When we define logistics we want to indicate both forward and reverse logistics. Reverse Logistics is the process planning, implementing and controlling the efficient, cost effective flow of raw materials, in process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, Reverse Logistics is the process of moving goods from their typical final destination for the purpose of capturing value or proper disposal. Remanufacturing and/or refurbishing activities also may be included in the definition of Reverse Logistics. In an optical efficiency of both environmental and economical - financial system there is a need to integrate the two networks: forward and reverse logistics network. In fact, making sure that products are not simply discarded to landfills, but arrive in the treatment centers/remanufacturing/recyclingcenters, you can implement a policy of reuse/remanufacturing/recycling that supplies forward logistics network directly with key products [10].

To ensure rapid and efficient materials replenishment from the reverse flow, to use those in the forward logistics, it is necessary to, among other things; to try to optimize the transport time and the information flows from different network locations. For these reasons, in the present work, has been considered the problem optimization of freight transport from collection centers to treatment

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centers.Many studies stated that there is a high degree of correlation between lean production and a good logistic strategy. The implementation of a good logistic strategy on production planning plays an important role on the success of the whole management [1].

In this study it is examined a new Milk Run method, defined Reverse Milk Run because it reverses the traditional concept. In fact in the traditional Milk Run the names comes from the traditional system for selling milk in the West, in which the milkman used to walk to the doors of the costumers' houses with his dray in a specified route and deliver the milk containing bottles to his costumers and finally take back the empty bottles [2, 3].

In our case suppliers arethose who generate wastes that are treated in the Treatment Center. The vehicles move discharges from producers or from the Treatment Centers and will load visiting different Collection Centers. From those Collection Centers will unload the empty pallets and after will load WEEE (*Waste Electric and Electronic Equipment*), exactly in the opposite order as provided in the classical Milk Run.

However, each vehicle route is variable because of signs of withdrawal sent by means of logical pull from each collection center. These signals are managed by the priority logic. It is thought to set a priority rule in order to visit those centers, which are characterized by the highest increase in accumulation of waste. In this way should ensure a continuous production flow in the forward logistics with a consequent reduction of the request of the raw materials and an increase of quotas of materials coming from the processing treatment of electrical and electronic waste. The following pull management, however, allow decreasing the stock levels in the collection centers and stimulating policies to increase proper disposal of electrical and electronic equipment, allowing, at the same time a net reduction of environmental impact.

2 Problem Formulation

Milk Run gets its name from the dairy industry practice where one tanker collects milk every day from several dairy farmers for delivery to a milk-processing firm. So Milk Run is a tested and proven method of optimizing a provider's trucking (collection or dispatch activities). Transportation requires optimization in terms of cost and time. Milk-run method can solve the problem of scheduling and dispatching inventory with internal transport systems within warehouses and production facilities. Depending on the variables that matter to a particular vendor, milk run routing of optimizing trucking can be used. Milk-Run especially becomes very important in cases where there is demand at multiple pick-up /delivery points for urgent services, hence the need to optimally prioritize, when a provider runs a number of vehicles (ex – trucks) to provide delivery / pick-up of items and hence needs to optimize the routes, when precision stuff from certain manufacturing clients need to be urgently shipped to the next stage in the supply chain.

The benefits are:

- Cost minimization – When there are a number of collection / delivery due to high demand for the same, the cost of overheads becomes very high. Optimal routes becomes a necessary evil to reduce cost;
- Reduced pick-up / delivery time;
- More customized services to the clients asdelivery / pick-up priorities are gauged andexecuted;
- It is easiest to adapt and executeeverything all routing heuristics.

Solving the vehicle – dispatching problem in a milk run network is similar to solving vehicle routing problem (VRP) [3]. A Vehicle Routing Problem (VRP) can be described as the problem of designing optimal delivery or collection routes from one or several depots to a number of geographically scattered cities or customers, subject to side constraints. The VRP plays a central role in the fields of physical distribution and logistics. There exist a wide variety of VRPs and a broad literature on this class of problems. The vehicle routing problem (VRP) involves finding a set of routes, starting and ending at a depot, that together cover a set of customers. Each customer has a given demand, and not vehicle can service more customers than its capacity permits. The objective is to minimize the total distance travelled or the number of vehicles used, or a combination of these. Several variations and specializations of the vehicle routing problem exist:

1. Vehicle Routing Problem with Pickup and Delivery (VRPPD): A number of goods need to be moved from certain pickup locations to other delivery locations. The goal is to find optimal routes for a fleet of vehicles to visit the pickup and drop-off locations.
2. Vehicle Routing Problem with LIFO: Similar to the VRPPD, except an additional restriction is placed on the loading of the vehicles: at any delivery location, the item being delivered must be the item most recently picked up. This scheme reduces the loading and unloading times.

3. Vehicle Routing Problem with Time Windows (VRPTW) [4]: The delivery locations have time windows within which the deliveries (or visits) must be made.
4. Capacitated Vehicle Routing Problem (with or without Time Windows) [5]: CVRP or CVRPTW. The vehicles have limited carrying capacity of the goods that must be delivered. Please, leave two blank lines between successive sections as here.

3 Problem Study

The WEEE is managed, currently, according to pushlogic, so the request and consequently the withdrawal to the CDT (Treatment Center) occur only after complete saturation of storage capacity in every Collection Center [15, 16].

The study of the process and analysis of data show a great disparity between the incidence of value – added activities and those with no value, confirmed by the presence of more types of inefficiency (for example the time of waste in storage).

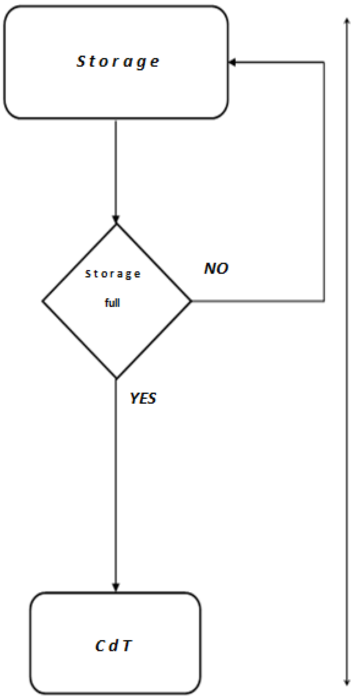

Fig. 1: Current WEEE management system

In new system we distinct two "sources" ofwaste, one from simple waste citizen generation without a corresponding purchase ofnew equipment and that we calledwaste from the "*Ecological Citizen Space*" (IE); theanother source "produces" waste that originate both from simple waste elimination in relation to a failure that it isn't repaired and from the replacement of an old product with a new. These wastes are collected in a space that named collectioncenter (CdR). So from now we refer to twodifferent methods of collecting: the wastethat arrives both from citizens (IE) and fromCdR and that were generated by the change of the old equipment with a new product. With thischange the waste are pulled from the wastetreatment center and not pushed (sent) fromthe collection center; the idea behind thedistinction between the origin wastes is tocreate a hybrid system (*Push + PullSystem*). For the feasibility of the new process we introduce a supermarket (that cover the entiregeographic area) [19]. A Supermarket represents a typical stock that uses pull logic.In other terms if we pick-up any material, in the same time we put down Kanban card [18] that prioritizes production or integration codes. In this case the codes are equipment that we need in the forward line to produce new products [17].We define a Milk-Run logic tothe dynamic collection of waste from the treatmentcenter to the supermarket and the withdrawalof the same at its distribution centers by thesupermarket. When we collect codes from supermarket starts a withdrawal politics based on new Milk Run from Supermarket to the Collection Center. The new system is show in thefollowing figure (fig. 2):

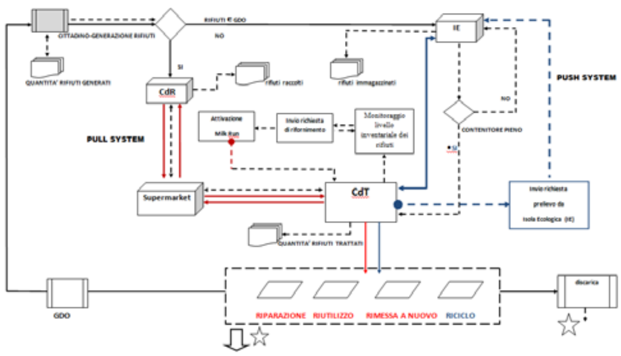

Fig. 2: Flow Chart representing future WEEE management system

To define which variables and relative links we build the Causal Loop Diagram.Naturally we define as initial event thegeneration of waste, then we define a "virtualbuffer" (WIP) because we have, ashypothesized, two different flow of waste;these define the events flow in CdR and flowin IE. The first event terminates in WIP_CdR,the other in WIP_IE. The last variable, at theend of the diagram is "bAmb", defined as thedifference between the outflows fromprod.CdT (production in CdT) and flows outof discharge center ("fdisc" veriable). In CLD (figure 3) there are a lot ofinterconnections between different variables,which determines the

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loops themselves. Theincrease of production capacity, for example,increases the production of electricaland electronic production; the productioncapacity is influenced by demand and demandaffects production capacityconnections determinate cycles. Obviouslythere are other links and therefore differentcycles (loops), easily identifiable by diagram.The Casual Loop Diagram shows all thedependencies between the variables involvedin the system. The Causal Loop Diagram(CLD) is in fact a representation (map)consists of a set of variables, interconnectedby arrows which show the influenceof variables themselves; the aim is toprovide a first graphic interpretation of theproblem through a simple and schematicrepresentation. If it's increase pull treatment we identify an increase of remanufacturing and/or recycling products. This last situation is the more effectivethe recovery system is fast.

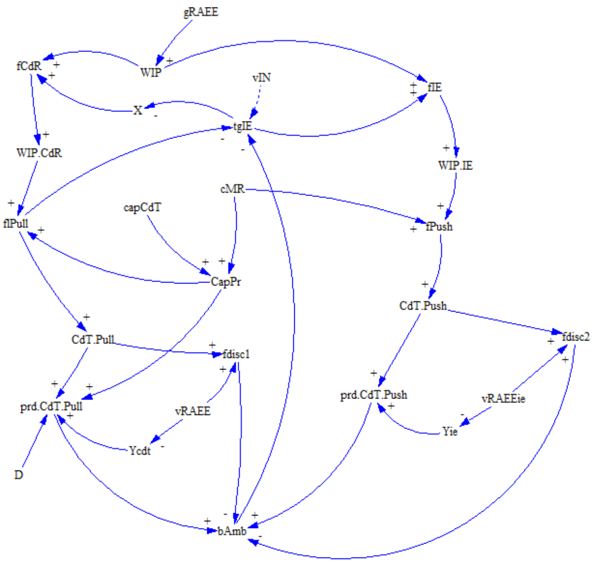

Fig. 3: Causal Loop Diagram of the new Waste Management paradigm

3.1 Reverse Milk Run Logic

The dynamic Milk Run follows these logics:

1. Treatment center produces with a continuous flow pulled from the downstream processes: forward logistics;
2. There is a stock of old and/or waste in incoming of Treatment Center;
3. The Treatment Center place orders when the stock level becomes below to the predetermined level;
4. Continuously Treatment Center receives situation of stock level of the different collection center in the predefined zones;
5. The Treatment Center sends a vehicle that goes around to the different supplier (collection center) indicated in the schedule priority where running the pick and stores the signals (kanban or deposit material boxes) of various materials that those suppliers deliver it. By doing so frequent deposits and withdrawals from various supplier, it can keep low inventories and response times along value chain.Then as a function of the frequency of withdrawal also depends on the quantity of the batch of product delivered. Lean Companies generally have at least one sample per day of various suppliers neighbors, but often more than one. For farther suppliers instead tends to have around every 2-3 days or at last once a week.
6. Many may think that is economically advantageous to have samples of materials in a very short time, but if you have many vendors who supply the little material at the end of the truck is completely filled and neither the vendor nor the customer bear the weight of large stores of the productwin-win for both.

3 Problem Solution

The model implemented needs a clear "dynamic Hypothesis", a description of a feedback structure, combined with a "reference model", or description of the system behavior that the structure is thought to generate. A simulation model can test this dynamic hypothesis. The dynamic hypothesis described below served as a guide for model construction and for subsequent policy experiment. From analysis of CLD it build FlowDiagramandsothemodelused in simulation (figure 4 and 5) [21]:

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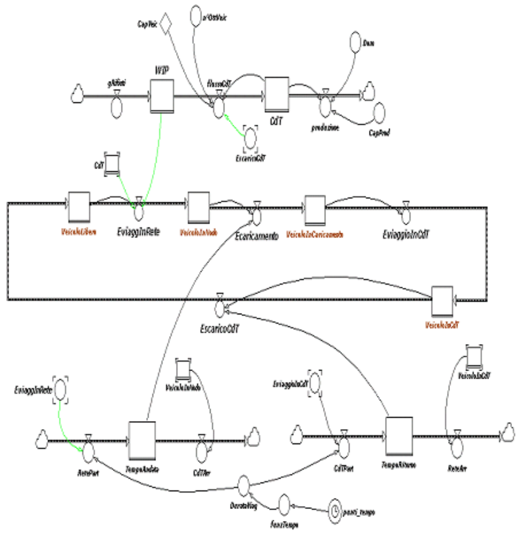

Fig. 4: Milk Run model designed trough SD logic

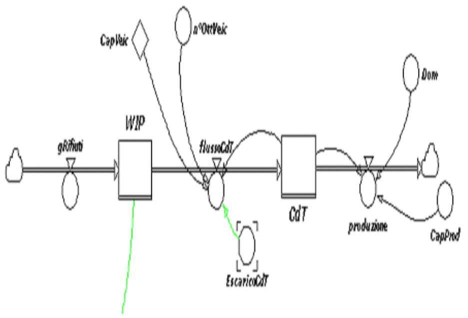

Fig. 5: Stock and Flow Diagram representing physical flow (waste flow)

The figure 4 shows the entire system functionality: the model consists of stock and flow variables. The WIP variable represent the accumulation of waste in the Collection Center; the Treatment Center represent instead the waste that arrive in the Treatment Centerand then wait a time necessary to do a treatment operation (ie: recycling or remanufacturing) before going on the production line. WIP variable is loaded from waste generation flow named "*gRifiuti*", the amount of waste produced in one day. The waste arrives in every Collection Center from different geographical zone and here the amount of Electric and Electronical Waste increase. When the stock amount reaches a threshold level sends signal to the Treatment Center. The latter Centerplansthe minimum time route going to each center, which meets the excess over the threshold level. The Collection Center begins to empty when the vehicle collect the waste. Only at this time it is possible to activate the flow of discharge (such discharge valve) that transfers the waste to the forward logistics. When the routing starts it is activate the sub-model (rectangle stock and flow in the lower part of figure 4) in which starts an event sequencesthat simulate sequences of different states featuring transports, loading and unloading vehicles.The events chain is activated by the WIP and the Treatment Center (CDT) signals determined by levels. This logic defines a pull system, in fact, only when the production process (downstream process) needs material requests to the upstream processes. The same logic starts when it's need to withdrawal the supermarket trough materials that came to the Collection Center that at the same manner send signals about your capacity to the supermarket. So starts a new milk run routing showed with similar Event Chains of the figure 4.

4 Simulation and Results analysis

At the beginningitmakessimulation to provide the necessarydata for the start simulation (for example to determine the values of parametersasquantification of the safety stock of the treatment center or the initialnumber of vehicles).

- • WIP
- • CdT

WIP is a storagepointcontaining the waste of Supermarket and of IE. The WIP has a strongly growing trend at the beginning, thenoscillates. Thisisjustifiedbecauseinitially the CdTdoesnotrequirematerialbecause it is assumed an initial level of products (waste) in the CdT. After the startup the CdTneedsmaterial and then the WIP begins to be emptied.

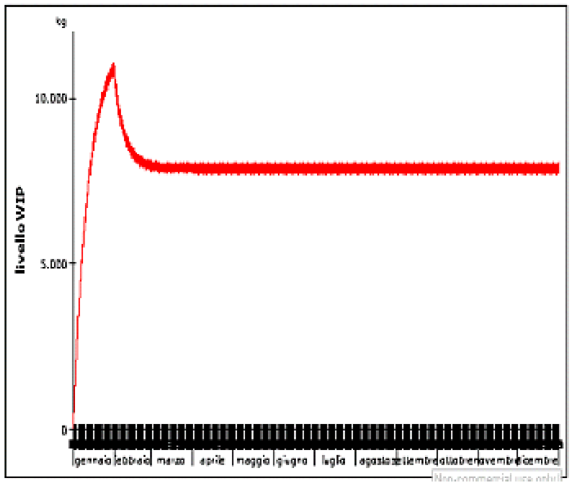

Fig. 6: WIP Level

The level of the treatment center in pull systemiscompared with the level of the treatment center in pushsystem; in the second situation (pushsystem) the CdT performance is lessstablethan the case of the pull system, asshown in figure 6 and 7:

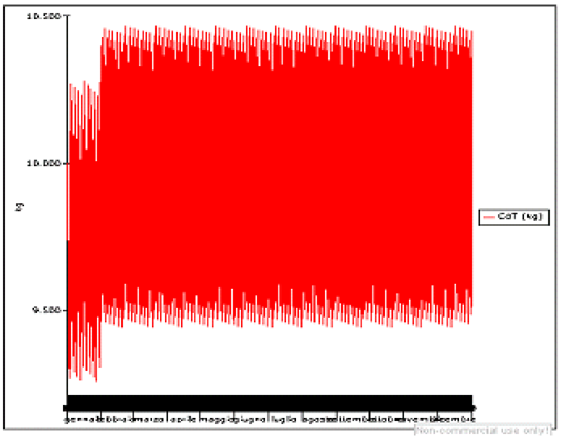

Fig. 7: CDT (Treatment Center) Level in a push system

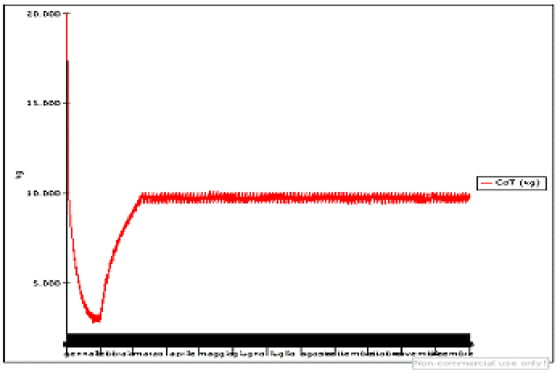

Fig. 8: CDT (Treatment Center) Level in a Lean environment

5 Conclusions

The analysis of currentsystem of waste management hasshown somecriticalissues. So it'ssuggested a newsystemapplying the basicsconcepts of Lean Production; the currentsystem of wastemanagement isbased on a pushlogic, the new systeminsteadisbasedon pull logic. There are twodistincttypes of waste flow and it'sidentifiedapacemaker process of new system, thatis the Treatment Center (CdT); thisprocessintroduces a bettercentralized management of the system. The CdTrequires the amount of waste to Supermarket and obtainsitsneeds by a Milk Runsystem. Itintroduces the mainfeatures of new systemwith the use of a causalloopdiagram (CLD) that shows the linksbetweensystemvariables; thenfollowing the systemdynamicsapproach, itbuilds the stock and flow diagram (S&FD's) of the system. S&FD'sitisnecessary in order to use the simulation software (Powersim). In factweanalyze the behavior of the model in simulation; by simulationit shows a positive trends in the level of WIP and the behavior of the treatment center.

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