Neutrosophy, Method of Uncertainties Process Analysis

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Abstract. This paper presents the importance of Neutrosophy theory in order to find a method that could solve the uncertainties arising on process analysis. The aim of this pilot study is to find a procedure to diminish the uncertainties induced by manufacturing, maintenance, logistics, design, human resources. The study is intended to identify a method to answer uncertainties solving in order to support manufacturing managers, NLP specialists, artificial intelligence researchers and businessman in general.

Keywords: communication, neutrality, solving of uncertainties, process analysis.

1. Introduction

This study is the first step of a research that points out the solving of uncertainties in process analysis. The research is based on Neutrosophy Theory [11], a new concept of states treatment with a generous applicability to sciences, like artificial intelligence [12],[16].

We believe that such as method would be useful for manufacturing managers, NLP specialists, artificial intelligence researchers, other scientists interested to find a method of uncertainties solving.

The paper is structured as follows: after a brief introduction, section 2 describes the background related to neutrosophy applicability; section 3 discusses the annotations regarding neutrosophy theory described in transposed in algebric structures, section 4 presents some indicators of process stability, section 5 introduces a sample of neutrosophic interpretation on manufacturing process, and finally section 6 depicts some conclusions and directions for the future.

2. Previous work

According to the neutrosophy theory, the neutral (uncertainty) instances can be analysed and accordingly, reduced.

There are some spectacular results of applying netrosophy in practical application such as artificial intelligence [6]. Extending these results, neutrosophy theory can be applied for solving uncertainty on other domains; In Robotics there are confirmed results of neutrosophics logics applying to make decisions when appear situations of uncertainty [8],[13].

The real-time adaptive networked control of rescue robots is another project that used neutrosophic logic to control the robot movement in a surface with uncertainties for it [13].

Starting from this point, we are confidence that neutrosophy theory can help to analysis, evaluate and make the right decision in the process analysis taking into account all sources that can generate uncertainty, from human being (not appropriate skill), logistics concept, lack of information, programming automation process according requirements, etc.

3. The Fundamentals of Neutrosophy

The specialty literature reveals that Zadeh introduced in 1965 the degree of membership/truth (t), the rest would be (1-t) equal to f/ false, their sum being 1, so it was defined the fuzzy set.

Why was it necessary to extend the *fuzzy logic*? Because a paradox, as proposition, cannot be described in fuzzy logic; and because the neutrosophic logic helps make a distinction between a ‘relative truth’ and an ‘absolute truth’, while fuzzy logic does not.

As novelty to previous theory, Smarandache introduced the degree of indeterminacy/neutrality (i) as independent component, defining $0 <= t+i+f <= 3$.

This theory was revealed in 1995 (published in 1998) when he defined the neutrosophic set, [11].

In manufacturing process analysis, it can appear a situation like this: an automation complex workstation, endowed with robots, which has to processes different parts with appropriate auxiliary components with deciding option for LH (left hand part) or RH (right hand part); this represents an uncertainty. Operator must take the appropriate aux component and to put it on robot tool.

If operator chooses the appropriate aux component of 2 possibilities:

Operator	*NTvalue*	
O1	T	75%
	I	50%
	F	0%

The robot can process that part and send it forward, in cycle time.

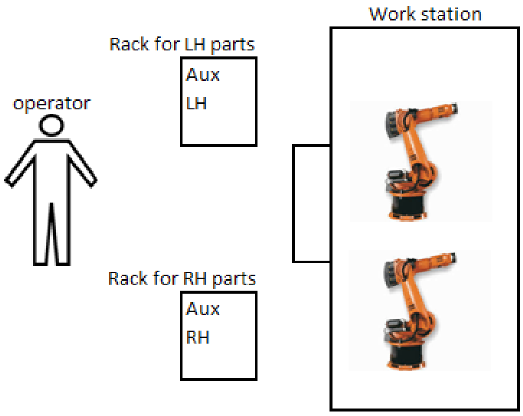

Fig. 1 Workstation

If the same operator chooses the wrong component of 2 possibilities:

Operator	*NT*	*value*
O1	T	10%
	I	50%
	F	90%

the process is stopped because the robot doesn't recognize the component, this status is uncertainty, it is waiting for attention, manual intervention; process indicators such as OEE, MTTR, MTBF are changed, efficiency decreased.

As much as the uncertainty increases, supposing that an operator has to select the right part from more than 2 possibilities:

Operator	*NT*	*value*
O1	T	10%
	I	70%
	F	90%

Percentage of wrong choice increase, so it is important to solve/decrease the uncertainty.

Logistics represents the department that supply the chain just in time (JIT) and just in place (JIP).

In case of delivering wrong parts (another code), in the wrong place, parts with defects, it is obvious that the operator induce at his turn confusion/uncertainty. In this situation it is a great concern who, what, how to intervene to diminish the confusions/uncertainties.

4. Indicators for Process Stability Measuring

In automation systems equipment operate in cycles of time defined as sum of states: cycling time (machine is in cycling/operating), starved time (machine finished cycle tine but previous station cannot deliver part), blocked time (machine finished cycle time but cannot deliver the part to the next station because it is in cycle), waiting aux part time (machine process the part in addition with an auxiliary part that is not present), waiting attention time (machine is in fault and wait for operator to make decision), repair in progress (machine is in repairing), emergency stop (general stop for whole station), bypass (station is not operating, skip), tool change (machine needs to change tool), setup (time for parameters changes), break time (break for operators lunch time), no communications (network communication error) (see Fig. 2).

These statuses are defined in PLC (programmable logic controller) for process analysis and evaluation. Related on these statuses are proceeded also the maintenance indicators.

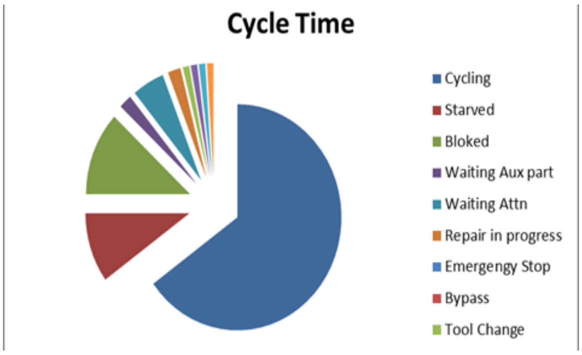

Fig. 2 The structure of a machine cycle time.

The OEE (Overall Equipment Effectiveness) is measured as:

(Availability) *(Performance)*(Quality)

where:

- **Availability** is OEE Metric that represents the percentage of scheduled time that the operation is available to operate. Often is referred as Uptime.
- **Performance** is OEE Metric that represents the speed at which the Work Center runs as a percentage of its designed speed.
- **Quality** is OEE Metric that represents the Good Units produced as a percentage of the Total Units Started.
- **Definition of a failure** - failure is declared when the equipment does not meet its desired objectives. Therefore, we can consider any equipment that cannot meet minimum performance or availability requirements to be "failed". Similarly, a return to normal operations signals the end of downtime or system failure, is considered to be "non-failed".

Mean Time to Repair (MTTR) is the mean time of the facility in the status of "Repair", and it is calculated as:

MTTR = Repair in Progress Time (min)/ Repair in Progress Occurrences.

Mean Time Between Failures (MTBF) shows the amount of time the machine spends in production time as a percentage of all the states except Break and No Communications.

MTBF = (Time in Auto / Total Time) x 100,

where:

Time in auto = Cycling Time + Blocked Time + Starved Time + Waiting Auxiliary Time + Bypass Time,

and

Total Time = Cycling Time + Blocked Time + Starved Time + Waiting Auxiliary Time + Bypass Time + Tool Change Time + Waiting Attention Time + Shutdown Time + Emergency Stop Time + Set Up Time.

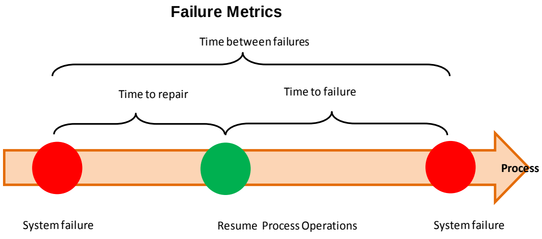

Fig. 3 Failure milestones.

A process is stable when there is no variability in the system, when the outcome is by design, as expected [14], [15].

The systems variation we are talking about in this study refers to uncertainty, confusion that can occur in various situations in the manufacturing process that, can lead to another product than expected one, or a scrap.

In a process, practically can occur such situations when we are put in a position of uncertainty that leads the process variation to instability, to errors.

Below are presented two methods of analysis, evaluation and correction of the process: the Ishikawa diagrams and Pareto chart.

Ishikawa diagrams (also called fishbone diagrams, cause-and-effect diagrams) are causal diagrams created by [2] that shows the causes of a specific event [17], [7].

Common uses of the Ishikawa diagram (see Fig.4) are product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of process variation. Causes are usually grouped into major categories to identify the sources of variation such as: people, methods, machines, materials, measurements, environment [7].

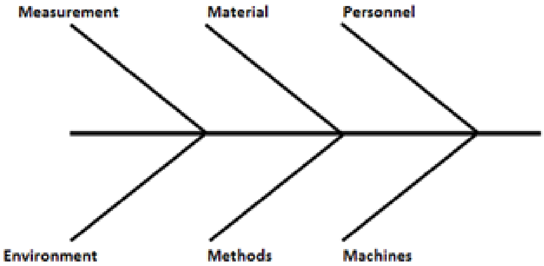

Fig. 4 Ishikawa diagram

Related to these categories can be extended to detailed items like anyone involved with the process, how the process is performed and the specific requirements for doing it, policies, procedures, rules, regulations and laws, any equipment, computers, tools, etc. required to accomplish the job, raw materials, parts, pens, paper, etc. used to produce the final product, data generated from the process that are used to evaluate its quality, the conditions, such as location, time, temperature, and culture in which the process operates [4], [5].

Pareto analysis is a statistical technique in decision-making used for the selection of a limited number of tasks that produce significant overall effect. It uses the Pareto Principle (also known as the 80/20 rule) the idea that by doing 20% of the work you can generate 80% of the benefit of doing the entire job (see Fig.5).

Step 1: Identify and list problems – that occur in manufacturing process with the highest frequency and concern the process.

Step 2: Identify the root cause of each problem – for each issue it is important to identify the fundamental cause. The used methods can be: Brainstorming, 5 Whys, Cause and effect analysis, and Root cause analysis.

Step 3: Score problems – scoring each problem depends on the sort of problem that it has to be solved, for quality, safety, efficiency, and cost.

Step 4: Group problems together by root cause – similarly problems belong to the same group.

Step 5: Add up the scores for each group – assign scores to each group of problems.

Step 6: Take action – is the moment to deal with the top priority problem, group of problems and also the purpose that you want [1].

5. Neutrosophy, Method of Uncertainty Solving

For a manufacturing process we identify some sources that influence effectiveness indicators. Using Pareto charts it was described the process (see Fig.5.)

	Frequency	Relative frequency %	Cumulated frequency %
Procedures errors	25	40.98%	40.98%
Operators errors	12	19.67%	60.66%
Bad parts	11	18.03%	78.69%
Missing parts	8	13.11%	91.80%
Equipment fault	3	4.92%	96.72%
Others	2	3.28%	100.00%
Total	61		

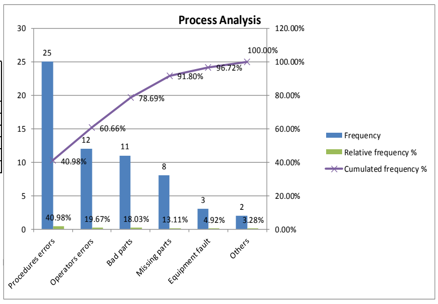

Fig. 5 Pareto chart

In this example, there are few issues that appear in process analysis such as procedures errors, operator errors, bad parts, missing parts, equipment faults, etc. According to Pareto principle, examining "operator errors" we can make the decision that reducing this cause of errors, the parameters of the system can be improved. Refining the operator errors issue by IT application, automation system, operators training, it results reducing human decision on process.

	Training lack	Automation low	IT Application poor	Logistic errors
T	20	25	35	10
I	80	75	50	70
F	50	40	28	90

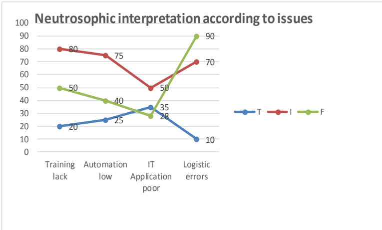

Fig.6 Neutrosophic interpretation of the process by issues

	T	I	F
Training lack	20	80	50
Automation low	25	75	40
IT Application poor	30	40	30
Logistic errors	10	70	90

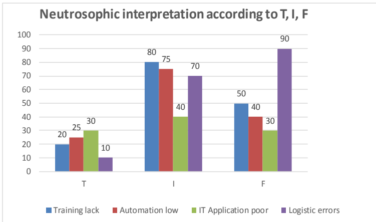

Fig.7 Neutrosophic interpretation of the process by (T, I, F)

During the refining process procedure, we observed that operator errors issue, generated also the decrease of all others errors of the manufacturing process (see Fig.8.)

	Frequency	Relative frequency %	Cumulated frequency %
Procedures errors	18	48.65%	48.65%
Missing parts	7	18.92%	67.57%
Bad parts	5	13.51%	81.08%
Equipment fault	3	8.11%	89.19%
Operators errors	2	5.41%	94.59%
Others	2	5.41%	100.00%
Total	37		

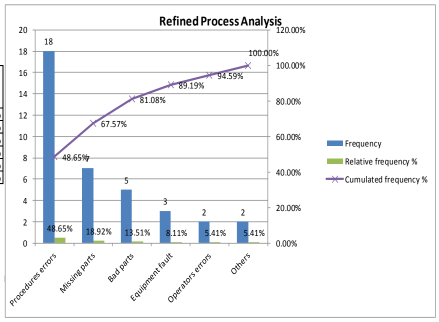

Fig. 8 Refined Pareto chart

The data of Neutrosophic interpretation show also this situation. Important is that uncertainty I and false F values decreased and true T value increased (see Fig.9 and Fig.10).

	Training	Automation	IT Application	Logistic errors
T	60	90	85	10
I	30	10	5	20
F	25	5	9	20

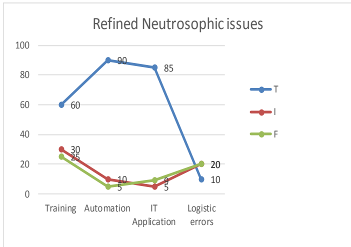

Fig.9 Refined Neutrosophic issues

	T	I	F
Training	60	30	25
Automation	90	10	5
IT Applicatior	85	5	9
Logistic error	10	20	20

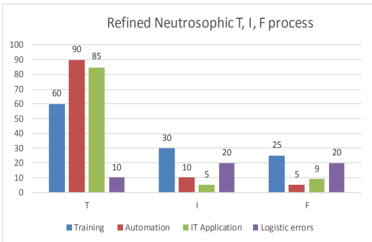

Fig.10 Refined Neutrosophic (T, I, F)

6. Conclusions and Future Work

We presented a way of correcting the uncertainties arising in process analysis applying neutrosophy theory.

This result can drive us to use the neutrosophy theory for solving the uncertainty, extended in IT applications, logistics, and human resources.

In the future work we will be oriented to find an algorithm to achieve the objectives to improve the percentage of stable statuses, to reduce the neutrality/uncertainty.

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