SYSTEMATIC INNOVATIVE DIAGNOSTICS (SID)

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Summary

Main aim of Systematic Innovative Diagnostics (SID) is to find a common functional basis for solving the engineering control and organizational problems in production systems. Its application is justified when designing reconstructions, developing new production systems, introducing additional automation or just the application of microprocessors.

In the development phase of SID—where hundreds of students took part—some methods of filmtechnics, of collective intellectual creative technics, of functional analysis and those of collective decision making have been put into one single, unified system. It has been assumed, that a visual preparation before using collective creative methods results in such an excess outcome, which shortens considerably the innovative processes in production systems compared to traditional methods and—at the same time—integrates organizational and technical design. The process of SID application is shown together with experiments for proving the input assumption. A practical example illustrates the introduced method.

Phases of technological, organizational and physical design are traditionally separated in the normal development process of production systems. Even the logical sequence is often undefined. This kind of approach frequently causes problems later, during operation. Among the consequences the underutilization of valuable equipment, as well as their unprofessional, quality-impairing use can be mentioned. To design production systems with the capability of effective future operation, all elements of planning knowledge should be integrated and making use of SID represents a proper, practically tested tool for this purpose.

The course of SID is roughly outlined in Table I. It appears from it, that the use of collective work by help of visual preparation is proposed. According to our input hypothesis, the visual preparation of collective work promotes effectively the definition of development requirements and increases the creativity needed for setting up design versions.

Table I
SID sequence

Activity		Individual work	Group work
1	Setting up the requirement system		
1.1	Inspecting the production system to be developed with the help of film or video recorder	X	
1.1.1	Flowcharting	X	
1.1.2	Composing scenario, designing adjustments, shooting, cutting, copying	X	
1.2	Work in the professionally mixed group		
1.2.1	Setting up the group	X	
1.2.2	First watching of the film; getting acquainted with the working process		X
1.2.3	Second watching: finding ideas; making notes		X
1.2.4	Exploring requirement system elements		X
1.2.5	Ranking requirement system elements		X
2	Selecting technical and organizational solutions and equipment		
2.1	Making functional schemes		X
2.2	Elaborating kinematical drafts		X
2.3	Selecting the best suitable versions		X
3	Inspection of the fulfilment of the requirement system		X

Experiments, proving the usefulness of visual preparation for collective work

To prove the correctness of our hypothesis many experiments were made. The experimental groups consisted of university students. In all phases the same number of groups were working with traditional and new rules. The outputs of the various groups, working with different rules were compared through averages. Additionally, qualitative comparisons were made as well.

For the experiment's purpose we chose two production systems, the development of which was economically reasonable. In the first system cable twisting was done; the second one was a confectionery. The machines applied in both cases were unknown for the students before, but their operational principle and function were easy to perceive. The students were however aware of designing and dimensioning of machine elements. In the various groups the students had appr. the same possibility to get acquainted with the technological details. The groups had appr. the same average study results. Six of the groups had the task to set up the requirement system of the development through on site studying the system to be developed and by using the Nominal Group Method (NGM). The NGM question was the following: "Which are the requirements considered important when developing the system?"

Other six groups were engaged with the same task, to be solved with the same method, but they were allowed to study the system's operation on film.

In total 24 groups were working (cca. 400 people). 12 of them dealt with cable twisting—the other 12 with confectionery development.

Disregarding all the details of the experiment, the results were the followings. The ideas of groups working without films was 60% of those working with help of films. The standard deviation of ideas around their own average got by groups working without films was the double of those with films. The difference of averages was independent from the group's task. These results prove not only our input hypothesis on preparation by films, but also the statement, that results are independent from the production task. Since standard deviation was much smaller in the case of film groups, the preparation by film is therefore useful independently from the group's previous results.

We analyzed also the cause of important standard deviations in groups with preparation by film. It was established, that the more a group watched the film, the more ideas they got. The groups with a number of ideas under average saw the film once; those, who had above average number of ideas, saw the film twice or more. When seeing the film first, one can only concentrate on flagrant cases (and the prompt proposals to handle them), leaving thus many important details out of consideration. Analyzing the reasons of standard deviation in such a way was an important contribution when defining accurate SID rules.

Even the elaboration of the detailed requirement system in later working phases has not proved to be purposeless. The functional schemes—illustrating the requirement system—were laid down in average 40% during shorter time by the film groups, than by the other ones. That means, that the efficiency of the intellectual creative work has grown by 250% in this phase.

The most significant differences are shown in the final results. Film groups were working according to their own functional schemes, having no respect for traditional solutions. 80% of the groups proposed totally new solution. On the other hand, 60% of the non-film groups, who gained all their information on site, proposed only minor changes of basic construction—i.e. minor developments of rationalizing character. Only 40% of the groups laid down new kinematical design for a construction.

Several control experiments were also made to clarify all the details of SID. Instead of listing them in detail, we introduce the method itself, through describing the results of one experimenting group.

The SID process

Preparing requirement system and flowchart

The flowchart is an aid, which serves as a draft for composing the film's (videofilm's) scenario. Consequently, all the operation elements, which are carried out on different places should separately be involved in the flowchart (especially handling of long machine lines).

All the operations are separated in order to have a clear man-machine functional which is one element of the innovation sharing. Two groups of operations should be set up: operations to be carried out during and apart from machine run. This is an aspect having organizational importance as well.

It's advantageous to involve a third aspect in the flowchart. The logical possibilities for organizing parallel human activities are analyzed already in this phase. Similarly the possibilities of collective working—possibly with autonomous working groups—should be brought to light as well.

One of the theoretical flowchart types—the practical application of which is proposed—is shown on Fig. 1.

Composing the scenario

A good scenario is basis prerequisite for making good (video) films. The main aim of the film itself is, to provide opportunity for analyzing all the operations deemed important within laboratory conditions (where the speed of the projection can be changed, and time measurements can be done). The scenario includes the name of activity, approximate time requirement and

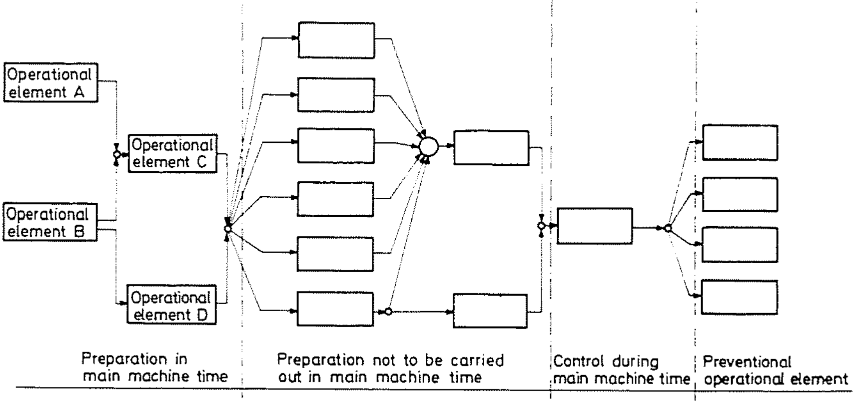

Fig. 1. Flowchart

place of all the operation elements, which are to be included (according to flowchart).

Shooting films is fully treated in the literature—we don't want to mention it any more.

Work in a professionally mixed group.
Creating the group

Since the requirement system to be set up should reflect technical (capacity and quality), ergonomical material conveying, economical, architectural aspects, therefore it is reasonable to create a professionally mixed group. A thorough knowledge of the special lines mentioned is needed; therefore working in groups is the most suitable method.

For a given day the group members are charged by their first common boss in the hierarchy, who is not necessarily the man in charge for the whole development work. The group members should not have any other tasks for that day.

The physical fitting out of the room should follow the rules of nominal group method (NGM).

Watching the film first time—learning the working process

Before starting the film we welcome the group members and ask for their contribution to the following task: the working process or machine group in question is to be developed in such a way, that not only the technical, but the

— economic
— architectural
— organizational
— ergonomical
— sociological

requirements be optimally met. The group members—respecting the SID rules—should give advices, ideas to develop this process. The time schedule for the whole day should also be outlined.

Thereafter the participants should be asked for inspecting the film without making notes. The latter is important, since writing distracts attention off the film, leaving thus certain details out of observation.

Second watching, making notes

The main aim of the whole activity is to find a new, quite different solution for the working process introduced. Therefore the requirement toward group members is not of evolutional character (e.g. accelerating the process) but a complex one. The mixed composition of the group should be utilized in integrating the knowledge of various scientific fields.

After the second watching, the group members must have possibility to work absorbed. Therefore talking to each other is not permitted neither in the course of the film, nor after it. After the projection the participants are asked to list the requirements toward a new equipment—using the knowledge, gained from the film. They should do this listening silently. It is to mention in advance, that everybody may keep his notes. When doing this work generalities should be avoided, and professional preciseness is to be striven after.

If somebody starts conversation, a polite but sound calling to order should follow.

Exploration of the requirement system

The requirement system elaborated by the working group should be of multidisciplinary character. Consequently, all the group members must have equal rights to participate and to present their best knowledge independently of their sense of phrasing.

Therefore, when setting up the requirement system, the equality and mutual respect should be demanded. For reaching equality, it is useful to collect all the parameters explored on a wall-board, using the round-robin sequence like NGM.

In this working phase participants discover, that the development of the given working process, machine line or working place should be approached from more standpoints. The mental process to learn each other's ideas starts as well.

Ranking the requirement system elements

In case of a simple equipment, the number of requirement system elements is appr. 30, at least the average number however is 200–300. It's obvious, that all the requirements could not be fully met. We are therefore forced to emphasize some of them and to treat the rest as to be met on an average level. Such a ranking of requirements is especially important from the aspect of defining the innovation's direction. In the former phase of the group work was given already the possibility to the group members to consider not only their own ideas, but all the other ones as well.

Ranking is similar to the poll in the NGM method.

Table II containts the SID parameter-list for a cable-twisting machine. The list has been compiled according to the rules mentioned before by a mechanical engineer student-group. Note, that this list strongly reminds of a modern machine's real parameter-list. In Table II there is a parameter (No 21) called "Creating parallel activities". It is responsible for organizing team-work, representing thus a precondition for setting up autonomous working groups.

After declaring the poll, the group-members may add their comments, and may give additional information, which might have influenced the poll. Knowing all the opinions and additional information, a second poll is carried out (the sequence of activities is the same). After the second poll, the group's work may be stopped temporarily.

Selecting equipment, and technical/organizational solutions

According to the explored requirement-system, functional schemes can be set up, on the basis of them completely new technical outfit and organizational methods may be drafted.

Disregarding the details of functional analysis, a functional scheme will be shown, incl. functions of second order. The functions of machine handling are new in this scheme, and these are due to SID. The groups working without SID concentrated their efforts to develop faster and more efficient methods of twisting, but not to machine handling. Consequently, the application of SID results also in qualitatively new functional schemes Fig. 2.

Since there has been a requirement to organize parallel activities, more machines can be functionally designed at the same time, with the new method. The layout of the machines is significantly different from the former practice too. Fig. 3 shows two different layout possibilities. According to draft "A", machines are arranged line-symmetrically, very close to each other. This kind of arrangement is still existing in the practice, mainly with convertible machines. A main drawback of this solution is, that machine handling and controlling are done by two persons.

When doing additional automation, or in case of labour shortage the one machine/one person organization is realized. As a consequence, service times are increasing, causing production outfall. From sociometrical point of view, this solution is disadvantageous, since it does not bear the possibility of teamwork.

The layout principle according to draft "B" has several benefits. The service crew of 4 persons may become a harmonious group soon. The number

Table II/1
SID parameter list

No.	Name	Weighting factors
1	Automatic wiring	3
2	Mechanization of drum change (independently from the crane)	15
3	Systematical storing of drums	
4	Mechanization of soldering	4
5	Isolation of cable drums with appliance	3
6	Single-purpose instruments for wheel change (change wheel)	12
7	Single-purpose instruments for cutting	
8	Mechanization of speed change	6
9	Simpler fixing of centering bush	
10	Mechanization of bobbin change	6
11	Machine alarming and stop	5
12	Mechanization of chopping	2
13	Protecting rotating elements	4
14	Automatic end position signalling	3
15	Automatic measurement of material consumption	
16	Effective bobbin-storage	
17	Mechanized moving of full bubbins	5
18	Automatic zero reading	
19	Decreasing machine length	
20	Silent operation (noise reduction)	
21	Fixing of the wind-off drum to the machine	

Table II/2

No.	Name	Weighting factors
22	Making the crane operator interested in production results	
23	Using local material handling instead of crane	5
24	Fixed real length	3
25	Mechanization of tag linking	7
26	Mechanization of fixing the cut tag	
27	Shafting on the drum	5
28	Form designed machine	1
29	Mechanization of instrument change	3
30	Better access to manual working places	·
31	Organizing parallel activities	21
32	Adjustment of shaft distance with templet, torque spanner	
33	Unbroken cable conduction with small space requirement	4

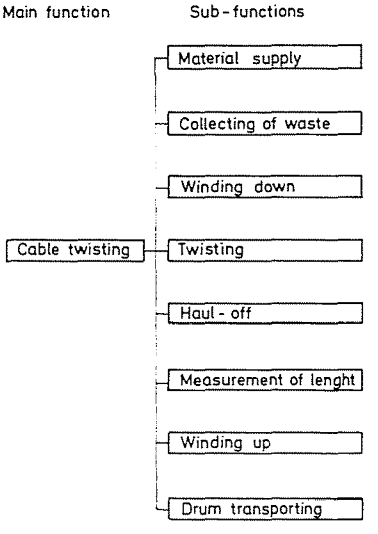

Fig. 2. Newly developed functional scheme of a cable twisting machine with subfunctions

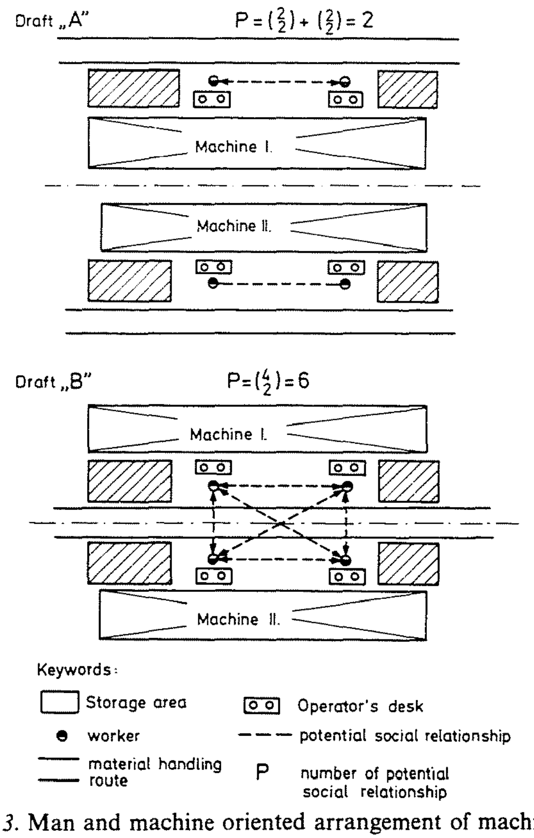

Fig. 3. Man and machine oriented arrangement of machines

of potential social relationships increases significantly. Machine handling may be done by three persons (not by two), resulting in shorter service times, and increasing production—without investment. This kind of layout has been successfully implemented in the practice even in case of rearrangements.

The non-traditional layout of machines is not only a new solution from technical-technological point of view, but it may promote the forming of efficient work organizations, e.g. to certain extent self-contained working groups.

Controlling the fulfilment of the requirement system

There are many development projects in the practice started with a sound decision, which don't meet in the end all the requirements defined. One of the reasons for this is the lack of feedback to the decision, to the original aim. When using SID this situation is avoided by evaluating the new equipment's operation according to the following aspects:

— making flowchart

— composing scenario, designing adjustments, shooting, cutting, copying

— setting up a professionally mixed management working group

— watching the film, filling out the scoring sheet

— discussing the results with the participants; proposals related to development methods.

Filling out the scoring sheet

It is advisable to watch the film on the new system twice as well. Similarly to the sequence described above, the first watching is informal, the second one follows the representation of the decision criteria defined earlier. After the second watching the participants are requested to fill out the scoring sheet.

The summarized results of the scoring should be presented, and in detail discussed. Table III shows an individual scoring sheet of a cable twisting machine as an example. Note, that the parameter "organizing parallel activities", being first in the importance sequence has got a very negative qualification. It shows the efficiency of the model, that a new norm system has been introduced soon by workshop management, to decrease idle times, and to make group working possible.

Table III
Evaluation sheet

Parameter used as decision base	solution		
	bad	satisfactory	good
Organizing parallel activities	X		
Mechanization of drum change		X	
Mechanization of wheel change			X
Mechanization of end linking			X
Mechanization of bobbin change	X		
Machine alarming			X
Mechanization of shafting			X
Using local material handling			X
Protection of rotating elements			X
Fixed reel length			X

Making use of results

The evaluation is to be used for coordinating the analyzed working process, and for harmonizing future tasks. Referring to our example it is to mention, that the parameter "mechanization of the change of drum" has got "appropriate" qualification, since the equipment did not contribute to idle time reduction. Although investment specialists had made several proposals to solve this problem, only SID could make it evident, that this expensive solutions which reduces idle time will be recovered soon.

Other well-known advantages of film technique will not be discussed here.

Main areas and restrictions of using SID

SID—like all the other organizational subtechniques—is not suitable for solving problems alone. It's main advantage is, that by strict control of the group work, it makes thus system aspect prevail, without respecting organizational limits.

Using SID is proposed mainly for organizing reconstructions, developing new mechanical equipment and production systems, introducing additional automation and preparing microprocessor application. Several weeks of training is needed before making films or video-recoding. The purchase price of a video recorder is recovered after 4–5 SID application.

In case of non-planted industries deeper professional knowledge is required for film making, a longer training period is therefore essential.

The rules of group working require a new kind of discipline from the participants. Even small violation of the rules may cause serious problems. Any change in the rules is to be considered thoroughly, since its consequences cannot be always estimated in advance.

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