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PRACTICAL APPLICATION OF MATHEMATICS IN HUNGARY

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FOREWORD

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The wide application of mathematics is due to several factors: 1. the sciences tend to replace qualitative and approximating observations with quantitative facts: 2. mathematics in its evolution created new chapters which broadened the fields where mathematics can be applied; 3. the highspeed computers became capable of handling mathematical calculations with astonishing speed; 4. and last but not least, we have gone so far towards understanding Nature's laws that comprehension of the newly discovered principles and their practical application became impossible without utilizing the highly developed methods of modern mathematics.

The Mathematics Research Institute was organized in 1950 under the sponsorship of the Hungarian Scientific Academy. The Institute now has ten years of experience. During this period we have solved nearly 1200 problems, mostly connected with practical life. The problems were given to us from without the Institute, and this shows that the MRI has become known by many organizations of the country and is being utilized by them.

The work of the Institute

Our tasks can be divided into four groups: those related to the natural sciences, technology, management and to the economic sphere.

Our economists are getting acquainted with economics. The Karl Marx University of Economics will start the training of so-called planning mathematicians in the next academic year. There seems to be no resistance in the field of planning against the application of mathematics, especially since the Second Five-Year Plan expressly asks for the help of mathematicians in the solution of economic problems.

The situation is different in the natural sciences. While there are as yet only a relatively few economists trained extensively in mathematics, in the exact sciences there are many engineers, who in their studies received mathematical training, and who in their everyday work, use their mathematical knowledge. They ask the question: is there a need for mathematicians in the industry? Can't we ourselves carry out those calculations? The basis of these questions is ignorance. We wish to answer them by the sort of problems which our Institute has solved and discuss a few cases in some detail.

Before starting, we wish to remark that specialization is growing not only in the various production industries, but among scientists as well. The continuous absorption of mathematics among our engineers is appreciated. Nevertheless, it is our conviction that theirs cannot very well be a thorough study, since it requires a great effort just to keep abreast with the new developments in one's own technological field. Furthermore, the mathematical problems that crop up in practice usually do not have any direct and easy solution, and need the special talents of a mathematician.

In our Institute we deal with machinery, construction and optimum size problems, mathematical considerations of complex mechanisms (such as cogwheels) and calculations in electrotechnics and servo mechanism. In all these problems the solution is achieved only by the knowledge of special mathematical methods which include complicated differential and integral equations and variation calculations.

In other cases the grasping of a problem and stating it, was significant, as opposed to tackling them. The creation of a mathematical model is very significant, since this gives the first descriptive approach to the problem on hand. Often this model has to be based on empirical grounds, and in such cases the methods of mathematical statistics are of help. Models are usually needed in the course of the analysis of technological problems and in the experimentation of new production processes.

The Institute also carries out problems dealing with energy-, raw material-, and water consumption of factories.

The lifetime of manufactured goods was calculated with the help of the probability theory and mathematical statistics. The same methods are useful in solving some management problems, as well as problems in storage, distribution and reservation. Some problems deal with the prevention of large overheads and occasional lack of parts. Among management problems, transportation and the planning of optimum production figure significantly.

The Institute produced tables and monograms for many companies. We also gave numerical solutions of many differential and other equations which could not be solved by rountine methods. We will now discuss a few problems in some detail.

1. Connection of Autoclaves.

The Almásfüzitő Aluminum Foundry asked us to improve their stirring process. Bauxite, suspended in alkaline solution, flows into a fixed number of autoclaves which are interconnected. Stirring is continuous in these autoclaves. k M^3 mixture flows into the first autoclave for an hour and the same amount leaves it for the second inline. This is emptied at the same rate by the third autoclave. All autoclaves are of the same size. Some particles will spend less than an hour in each autoclave and some will spend more than an hour. There is a certain minimum time necessary for the completion of the chemical reaction between the bauxite and the alkali. Probability calculations enabled the company to use a more economical interconnection (one autoclave after another).

2. Transformer design.

The Telecommunications Research Institute asked us to find an optimum plate size used as core material in small transformers. The plates are made according to a German (DIN) standards and by a pressing process which makes for very little waste. The problem is wheither the pressing method, while it was clearly advantageous, due to its low waste, could be supplanted by other methods, or indeed, the material by other materials. On the company level, the economic considerations involved the price of iron and copper, while on the national level we wanted to find the electrical loss in the transformers' coils and iron core and the price of this projected energy loss in forints in ten years. The mathematical model was diddicult to set up. The problem can be reduced to an extreme problem for functions of several variables. The calculations showed that the German standard was of optimum economy only up to a certain plate size. Above that size, however, plates manufactured from the same material and by the same process become most uneconomical. Hence a new material and/or a new process had to be devised for larger transformer core plates. To our knowledge, the Ministry of Machine Industry has already introduced a new standard for two types of transformer core plates.

3. Countercurrent cooling of grainy materials.

The Canning, Meat, and Refrigeration Research Institute approached us with a problem concerning the design of a countercurrent pea-refrigerating apparatus. Countercurrent cooling means that the material to be cooled moves in one direction and the cooling medium flows in the opposite direction. Our problem is much more complex than ordinary countercurrent problems, due to the graininess of the material to be cooled. When dealing with materials of small grain size only the grain-medium heat transfer is taken into account because temperature differences among the grains are only ephemeral and the grain has a rather uniform temperature. But in cases when the grains' diameter is not negligible, and the maerial is a poor heat conductor - and the peas are poor heat conductors indeed - we have heat conductivity problems inside the peas. This problem poses a new type of heat transfer. Our Institute solved the problem. We made detailed derivations and proposed formulae for refrigerating spherical particles.

4. Studies in coaldust distribution.

The Research Institute for Heating Techniques gave us the following problem:

Economy of coaldust furnaces depends greatly on the praticle distribution, injection speed and the quality of the coaldust.

The particle distribtion is usually determined by sieving the dust twice. The economists want to get out as much information on particle distribution and specific surface per kilogram as possible from these two sievings.

Up to now the Rosin-Rammler-Bennett (RRB) method was used everywhere in the world. The method has not yet been theoretically confirmed. The method approximates the distribution curves with a two-parameter family of curves which yielded a monogram. This was helpful in deciding which RRB curves correspond satisfactorily to the empirically obtained multi-curves (they were set up on the basis of empirical experience) in the region which can be sieved, but they don't give a true picture of the wide particle-size range. This is so, partly because according to the RRB approximation there is an infinite number of particles in practically every distribution, and partly because the RRB curves give an infinite specific surface which is impossible in practice. Since the determination of the specific surface is very important for knowing the burning efficiency, the failure of the RRB curves is very disconcerting. Many fueling problems could not be solved for the lack of a satisfactory model of coal grinding and particle distribution.

The RIHT asked us to work out formulae, monograms and diagrams, based on the Kolmogorov probability theory which is mathematically consistent. According to this solution, under certain conditions the resulting distribution will be of the lognormal type. We solved the problem and presently we are working on a mathematical model which describes the distribution of the coaldust when it is not ground under conditions which satisfy the Kolmogorov theory. These formulae now form the basis of the research conducted in the RIHT.

5. Optimum revolutions of spinning machines.

The Budapest Flaxspinnery asked us to examine the productivity of the ringspinning machines of the fiber industry. An operator tends 118 spindles. If the yarn breaks on one spindle, that spindle will produce waste until the operator repairs it. While he is doing that, other spindles may go faulty and start producing waste. The yarn's tear is influenced by the revolution of the machine and by the temperature of the watting liquid thorough which it passes prior to entering the spinning machines. It was our problem to dind the optimum revolution as a function of the wetting liquid's temperature at a given yearn thickness.

The actual mathematical calculation was preceeded by doing a statistical study on the spot. The troublefree times had to be determined at several revolution-temperature conbinations as well as the average time spent on repair. The obtained statistical data was the basis of the calculations, which eventually resulted in the determination of the optimum conbination.

6. Operating safety of microwave chains.

A several thousand kilometer long oil pipeline is accompanied by a microwave chain. Telemechanical signals are forwarded on 24 channels. Several channels branch off. The signals forwarding and branching is donw by stations. The stations can function in three ways: the so-called end-stations register the signals and emit new ones, the relay stations amplify. Besides these functions the branching stations branch off certain lines. Every station has a number of electron tubes, signal receivers, condensers, resistances and other parts. These parts can go wrong in a random fashion. In the breakdown of some instruments, communication will stop entirely, while the breakdown of another group of instruments will only result in a partial disability. The fault is recorded by a signaling setup. Every station has a second station in reserve. An automatic switch insures that the properly functioning station is the one that is operating on the line. We had to compute the probability of breakdown of the individual parts; the average repair type and probable operating time of the whole line. The problem is very significant on a national scale, since the Hungarian telecommunications industry has contracts ranging for several years to build several microwave chains for the Eastern European Countries, and the quality requirements for such installations are quite high.

7. The problem of the REMIX Company.

The REMIX asked our help in their management problems. The demands on the company have increased so much that it became almost impossible to run the factory in their traditional manner, which is basically of a small-scale character.

The factory produces resistors, condensors and potentiometers. These three main products are produced in five different climatic divisions. Every division satisfies a certain climate. Each division is huge in itself (e.g. the crystal cargonlayer resistance has 1538 variations.) They differ in parameters such as loadability, ohm value, level of noise potential, etc. Every variation counted, about two million different items can be produced. In reality, in a given period 8-10,000 different parts are ordered. The volume of such orders may run from 50 each to half a million each.

Our contract with the factory involves three main interests:

1. To find a planning model which enables the management to deal with orders (that arrive a short time before a given period) with respect to
   - a. the relation of the orders to capacity
   - b. raw material, semi-finished products and tool demands
   - c. employee need for a given period.

   The model must be adaptable to computer calculations and must include provisions for optimum calculations.
2. Drawing a satisfactory supply model so that there will be always enough raw material, etc. in the company store room, with the lowest possible overhead.
3. To find out the demands on REMIX at the end of the Five Year Plan (at least in the same order of magnitude). This calculation involves the studying of the developments of those companies that use REMIX products.

We are working on all three problems. The first and third group will be probably solved by linear production models. The storage problem will have to be approzched from several angles.

We detailed some of our typical problems. We find that problems still come to us in a random fashion. The companies turn to us in a random manner. We would like to be of help to more companies because we find that our assistance saves considerable sums with very little or no investment.

Obstacles to the application of mathematical methods. There are several obstacles still existing which hinder the wider spread of the application of mathematical science.

1. The various organizations tend to try to solve their problems inside the company so that their employees can get innovation bonuses, etc. If outside help is received, they lose this benefit. We understand this attitude and don't want to hurt anybody's financial interest. We, however, advocate laws which award bonuses to employees even in those cases when they receive solutions to their problems from outside institutions. This would make cooperation with research institutions much more widespread.
2. Our clients consistently underestimate the time necessary for the solution of their problems. Very often they turn to us only when the solution is very urgent and if we cannot promise to solve the problem in the short time available to the companies, the negotiations break off. Very often people think that our Institute is a collection of ready-made recipes and solutions, and all the mathematician does is apply existing formulae to given problems. Last year the representative of one of the large companies came to us with the belief that he could take the solution home with him the very same day. ("Let's find the formulae for my case and substitute the data") The problems which come to us are usually not routine and solutions often take a long time to find, especially if they involve long numerical calculations. (But it is not the numerical part that consumes time in most cases.)
3. Our work is not yet widely known. To improve the situation, the Academy decided to publish a series of publications which deal with the practical applications of mathematics. Our scientists are urged to publish articles on their work in technical, economic, and other scientific publications. Co-productions of articles, representing our scientists and the representatives of our clients are welcomed. We are also planning to organize small conferences and meetings.
4. Several times we failed to produce a satisfactory solution to the problems or we couldn't find a solution at all. Some clients lost their confidence in us. We want to emphasize that this is natural. Such cases, however, are not typical to our institution and we should not be judged solely by them. The institute is involved in research and this word itself expresses that we cannot always find results.
5. Frequently we don't find a common language with our clients and misunderstandings come about. If the clients would employ mathematicians who could formulate the problems in a concise mathematical language, this would not occur.
6. The greatest obstacle to our work is a lack of understanding of what constitutes a mathematical problem.

Mathematics is useful when a complex mathematical problem comes up or an old method is applied to a new field. But in many cases, the mathematics inherent in a factory are not discovered, although their discovery would result in significant savings. These problems would be discovered by mathematicians employed by various organizations. Although, a mathematician cannot solve all the problems that come up in a certain company (they can be as wide apart as probability or integral equation theory, mathematacal logics, etc.), co-operation with other mathemataicians or our institutions usually brings a solution.

We've to add that if someone heeds this advice and asks us to recommend a mathematician for employment, we couldn't comply. At the present time there's no unemployed mathematician. Since the training period was lengthened on the Eotvos Lorand University, no sgudent will finish his studies this year. There'll be only seven applied mathematics students finishing next year. What this means can be best comprehended if we realize that in Czechoslovakia 2,000 programming mathematicians will be trained by the end of the next Five Year Plan. In East Germany university and even high school mathematics professors leave their positions in great numbers for interesting and well paid industrial mathematical jobs. The Zeiss Optical Company employs 60 mathematicians. Similar situations exist in the industrialized capitalist countries.

It is obvious that this will happen sooner or later in Hungary. We must prepar for this time, expecially since at present there is a shortage even of mathematics professors, and at the university there is a small number of applicants in this department.

SOME PROBLEMS IN THE TRAINING OF MATHEMATICIANS

The question may be asked: why didn't we raise our voices earlier, forseeing this trend for more applied mathematicians? We don't find ourselves guilty in this respect. We brought up this question many times. But the various organizations resisted employing mathematicians, and when industrial orders changed the situation and a few mathematicians were employed, they were misplaced. One young scientist became a (railway) station manager, another onw wasput in the wage-calculation department. Of course, there're many mathematicians who use their training in the right places.

It is usual to criticize young mathematicians just out of the university. One of the criticisms is that they cannot be supplied with jobs. When a young engineer or doctor goes to his first place he is just as inexperienced as a mathematician, but he is given assistance by the older colleagues. Applied mathematics is a new field in Hungary and there are hardly any places where young graduates of this science can find older colleagues who would initiate them to the problems of their company. Time must be given to the young mathematicians to become familiar with the local situation. This investment in time and money will pay off, if not in the first months, then in later years. Why then aren't the applied mathematicians given training which would serve as a satisfactory background for the various fields? This question is often asked and in answer we want to give the list of those organizations who asked for our help in 1959: Agricultural Experimental Research Institute, Planning Offices and Telecommunications Department of the Ministry of Machines and Steel Mills, Plant Pathology R. I. University of Architecture, Bridge Department, State Sanitarium (Sopron); Clinic of Internal Diseases; Magyaiovai Bauxit & Konuid Factory; Beloiauin's Telecommunications Factory; Ministry of Food Industry; Flaxspinning Factory; Local Transportation Company (BP) Economics Research Group; Highpressure Experimental Institute; Hungarian Bureau of Standards; University of Technology, Chemical Operations Department; Forestry Scientific Institute; Experimental Station (Ugod); Linguistics Institute; Phys. Ed. Science. RI; Hunnia Film Studios; Telecommunications RI; Military RI; Electromechanical Company; RIHT, - Furnace Department; Instrumentation RI, Canning, Meat and Refrigeration RI, METRIMPEX; Animal Husbandry RI, County Hospital, Eger; and Szombathely; Medical University BP, Electrical Energetics Research Institute.

Is there any university training which gives a background for so many fields? There is not, and there cannot be one. But the fact that our Institute solved problems of such varied backgrounds shows that there is co-operation between mathematicians and other scientists, and success will come and the special knowledge of a mathematician will be utilized.

We suggest the following:

1. The various organizations should consider employing mathematicians;
2. Short specialized mathematics courses should be set up to satisfy present needs;

Increase the stimulation for mathematics among university applicants by offering company scholarships to interested students. The student should get acquainted with the problems of his future company while still in his training period.

The need for applied mathematicians will increase at a fast rate -- this process has already started -- and this increase will create a few problems. We tried to publicize the situation and suggest a few improvements.

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