# Electric discharge machining narrative essay

PROJECT REPORT ON INVESTIGATIONS INTO ELECTRIC DISCHARGE MACHINING USING EN-31 AND HCHCr WORK PIECE GUIDED BY: PROF. RAJESH MADARKAR SUBMITTED BY: ROSE DEE KAMLESH GEHANI SHARDUL AMIN SIDDHESH TIWARI SUVO SUNDAR CHATERJEE VIVEK WARADE DEPARTMENT OF INDUSTRIAL ENGINEERING SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT KATOL ROAD, NAGPUR-440013 2011-2012 ABSTRACT

The correct selection of manufacturing conditions is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM). It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries.

The objective of this Project Report is to study the influence of operating parameters of pure copper electrode on the machining characteristics such as, material removal rate for work piece material EN-31 and HCHCr ( hardness 20-22 and 55-56) Keywords: EDM; TON; T ; MRR; IP; EN-31; HCHCr Purpose: In this investigation, the effects of various process parameters of sinker EDM like: • pulse on time (TON), • • peak current (IP), Duty Cycle(T) have been investigated to reveal their impact on material removal rate of materials: • EN 31 (Hardness: 20-22) HCHCR (Hardness: 20-22) & • HCHCR (Hardness: 55-56) using one variable at a time approach. The optimal set of process parameters has also been predicted to maximize the material removal rate. . Design/methodology/approach: The experimental studies were performed on ELECTRONICA SPRINTCUT EDM machine. Findings: The material removal rate (MRR) directly increases with increase in pulse on time (TON) upto a certain level after that it shows a declining trend and increases directly with peak current (IP) SHRI RAMDEOBABA COLLEGE OF ENGINEERING AND MANAGEMENT

INDUSTRIAL ENGINEERING DEPARTMENT CERTIFICATE This is to certify that Ms. Rose dee (12), Mr. Kamlesh gehani (48), Shardul amin(76), Siddhesh tiwari(78), Suvo sundar chaterjee(81), Vivek warade(86) has submitted the project work on INVESTIGATION OF MACHINING PARAMETERS FOR EDM USING EN-31 AND HCHCr WORK PIECE duringacademicsession 2011-2012 under the guidance of PROF. RAJESH MADARKAR as prescribed by Nagpur university and their work has been satisfactory PROJECT GUIDE PROF. RAJESH MADARKAR HEAD OF DEPARTMENT PROF. K. N. AGRAWAL PRINCIPAL Dr. V. S. DESHPANDE Acknowledgement

Hard work, sincerity and proper guidance that’s what on needs to be successful in life, that is what we have realized working on a project No successful work can ever be the effect of a individual effort. We take this opportunity to express our deep gratitude towards everyone who has been of immense help throughout and till completion of this work. We earnestly express our thankfulness to Prof . Rajesh Madarkar , without whose invaluable guidance the present work would not see light of this day. The work would have been impossible without his co-operation and direction.

In spite of being ourteacher, his friendly approach has been constant source of inspiration and encouragement. We are really honored to have such a

wonderful person as our guide. We are also thankful to the director of Dulocos Conveyors And Moulds Pvt. Ltd Mr. Khalid Husain We are also grateful towards everyone who has directly or indirectly contributed with their lively suggestions to make the project a success. CHAPTER 1 INTRODUCTION 1. 1 Background of EDM The history of EDM Machining Techniques goes as far back as the 1770s when it was discovered by an English Scientist.

However, Electrical Discharge Machining was not fully taken advantage of until 1943 when Russian scientists learned how the erosive effects of the technique could be controlled and used for machining purposes. When it was originally observed by Joseph Priestly in 1770, EDM Machining was very imprecise and riddled with failures. Commercially developed in the mid 1970s, wire EDM began to be a viable technique that helped shape the metal working industry we see today. In the mid 1980s. The EDM techniques were transferred to a machine tool.

This migration made EDM more widely available and appealing over traditional machining processes. The new concept of manufacturing uses non-conventional energy sources like sound, light, mechanical, chemical, electrical, electrons and ions. With the industrial and technological growth, development of harder and difficult to machine materials, which find wide application in aerospace, nuclear engineering and other industries owing to their high strength to weight ratio, hardness and heat resistance qualities has been witnessed.

New developments in the field of materialsciencehave led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Nontraditional machining has grown out of the need to machine these exotic materials. The machining processes are non-traditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy.

The problems of high complexity in shape, size and higher demand for product accuracy and surface finish can be solved through non-traditional methods. Currently, non-traditional processes possess virtually unlimited capabilities except for volumetric material removal rates, for which great advances have been made in the past few years to increase the material removal rates. As removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of nontraditional process. The Electrical Discharge Machining process is employed widely for making tools, dies and other precision parts.

EDM has been replacing drilling, milling, grinding and other traditional machining operations and is now a well established machining option in many manufacturing industries throughout the world. And is capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries.

Electric Discharge Machininghas also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R&D areas. 1. 2 Introduction of EDM Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining Process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys.

EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive. 1. 3 Principle of EDM In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Show the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0. 025mm is maintained between the tool and work piece by a servo system shown in fig 1. 1.

Both tool and work piece are submerged in a dielectric fluid . Kerosene/EDM oil/deionized water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases. Figure1. 1 Set up of Electric discharge machining This fig. 1. 1 is shown the electric setup of the Electric discharge machining. The tool is made cathode and work piece is anode. When the voltage across the gap becomes sufficiently high it discharges through the gap in the form of the spark in interval of from 10 of micro seconds. And positive ions and electrons are ccelerated, producing a discharge channel that becomes conductive. It is just at this point when the spark jumps causing collisions between ions and electrons and creating a channel of plasma. A sudden drop of the electric resistance of the previous channel allows that current density reaches very high values producing an increase of ionization and the creation of a powerful magnetic field. The moment spark occurs sufficiently pressure developed between work and tool as a result of which a very high temperature is reached and at such high pressure and temperature that some metal is melted and eroded.

Such localized extreme rise in temperature leads to material removal. Material removal occurs due to instant vaporization of the material as well as due to melting. The molten metal is not removed completely but only partially As the potential difference is withdrawn as shown in Fig. 1. 2, the plasma channel is no longer sustained. As the plasma channel collapse, it generates pressure or shock waves, which evacuates the molten material forming a crater of removed material around the site of the spark. 1. 4 Types of EDM

Basically, there are two different types of EDM: 1. 4. 1) Die-sinking 1. 4. 2) wire-cut. 1. 4. 1Die-sinking EDM In the Sinker EDM Machining process, two metal parts submerged in an insulating liquid are connected to a source of current which is switched on and off automatically depending on the parameters set on the controller. When the current is switched on, an electric tension is created between the two metal parts. If the two parts are brought together to within a fraction of an inch, the electrical tension is discharged and a spark jumps across.

Where it strikes, the metal is heated up so much that it melts. Sinker EDM, also called cavity type EDM or volume EDM consists of an electrode and workpiece submerged in an insulating liquid such as, more typically, oil or, less frequently, other dielectric fluids. The electrode and workpiece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. As the electrode approaches the workpiece, dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps.

These sparks usually strike one at a time because it is very unlikely that different locations in the inter-electrode space have the identical local electrical characteristics which would enable a spark to occur simultaneously in all such locations. These sparks happen in huge numbers at seemingly random locations between the electrode and the workpiece. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine so that the process can continue uninterrupted.

Several hundred thousand sparks occur per second, with the actual duty cycle carefully controlled by the setup parameters. 1. 4. 2 Wire-cut EDM Wire EDM Machining (also known as Spark EDM) is an electro thermal production process in which a thin single-strand metal wire (usually brass) in conjunction with de-ionized water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks. a thin single-strand metal wire, usually brass, is fed through the workpiece, submerged in a tank of dielectric fluid, typically deionized water.

Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods. Wire-cutting EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material. If the energy/power per pulse is relatively low (as in finishing operations), little change in the mechanical properties of a material is expected due to these low residual stresses, although material that hasn't beenstress-relieved can distort in the machining process.

Due to the inherent properties of the process, wire EDM can easily machine complex parts and precision components out of hard conductive mate 1. 12 Application of EDM 1. The EDM process is most widely used by the mould-making tool and die industries, but is becoming a common method of making prototype and production parts, especially in the aerospace, automobile and electronics industries in which production quantities are relatively low. 2. It is used to machine extremely hard materials that are difficult to machine like alloys, tool steels, tungsten carbides etc. 3. It is used for forging, extrusion, wire drawing, thread cutting. . It is used for drilling of curved holes. 5. It is used for internal thread cutting and helical gear cutting. 6. It is used for machining sharp edges and corners that cannot be machined effectively by other machining processes. 7. Higher Tolerance limits can be obtained in EDM machining. Hence areas that require higher surface accuracy use the EDM machining process. 8. Ceramic materials that are difficult to machine can be machined by the EDM machining process. 9. Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R areas. 0. It is a promising technique to meet increasing demands for smaller components usually highly complicated, multi-functional parts used in the field of microelectronics. 1. 13 Advantages of EDM (a) Any material that is electrically conductive can be cut using the EDM process. (b) Hardened workpieces can be machined eliminating the deformation caused by heat treatment. (c) X, Y, and Z axes movements allow for the programming of complex profiles using simple electrode. (d) Complex dies sections and molds can be produced accurately, faster, and at lower costs.

Due to the modern NC control systems on die sinking machines, even more complicated work pieces can be machined. (e) The high degree of automation and the use of tool and work piece changers allow the machines to work unattended for overnight or during the weekends (f) Forces are produced by the EDM-process and that, as already mentioned, flushing and hydraulic forces may become large for some work piece geometry. The large cutting forces of the mechanical materials removal processes, however, remain absent. (g) Thin fragile sections such as webs or fins can be easily machined without deforming the part. . 14 Limitation of EDM (a) The need for electrical conductivity – To be able to create discharges, the work piece has to be electrically conductive. Isolators, like plastics, glass and most ceramics, cannot be machined by EDM, although some exception like for example diamond is known. Machining of partial conductors like Si semi-conductors, partially conductive ceramics and even glass is also possible. (b) Predictability of the gap - The dimensions of the gap are not always easily predictable, especially with intricate work piece geometry.

In these cases, the flushing conditions andthe contamination state of differ from the specified one. In the case of die-sinking EDM, the tool wear also contributes to a deviation of the desired work piece geometry and it could reduce the achievable accuracy. Intermediate measuring of the work piece or some preliminary tests can often solve the problems. (c) Low material removal rate- The material removal of the EDM-process is rather low, especially in the case of die-sinking EDM where the total volume of a cavity has to be removed by melting and evaporating the metal.

With wire-EDM only the outline of the desired work piece shape has to be machined. Due to the low material removal rate, EDM is principally limited to the production of small series although some specific mass production applications are known. (d) Optimization of the electrical parameters - The choice of the electrical parameters of the EDM-process depends largely on the material combination of electrode and work piece and EDM manufactures only supply these parameters for a limited amount of material combinations. When machining special alloys, the user has to develop his owntechnology.

CHAPTER 2 LITRATURE SURVEY 2. 1 INTRODUCTION Literature review is one of the scope studies. It works as guide to run this analysis. It will give part in order to get the information about electrical discharge machine (EDM) and will give idea to operate the test. From the early stage of the project, various literature studies have been done. Research journals, books, printed or online conference article were the main source in the project guides. Literature review section work as reference, to give information and guide base on journal and other source in the media. 2. Important parameters of EDM (a) Spark On-time (pulse time or Ton): The duration of time (? s) the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on-time. This energy is really controlled by the peak current and the length of the on-time. (b) Spark Off-time (pause time or Toff ): The duration of time (? s) between the sparks (that is to say, on-time). This time allows the molten material to solidify and to be wash out of the arc gap. This parameter is to affect the speed and the stability of the cut.

Thus, if the off-time is too short, it will cause sparks to be unstable. (c) Arc gap (or gap): The Arc gap is distance between the electrode and workpiece during the process of EDM. It may be called as spark gap. Spark gap can be maintained by servo system (fig no. -1). (d) Discharge current (current Ip): Current is measured in amp Allowed to per cycle. Discharge current is directly proportional to the Material removal rate. (e) Duty cycle (? ): It is a percentage of the on-time relative to the total cycle time. This parameter is calculated by dividing the on-time by the total cycle time (ontime pulse offtime). f) Voltage (V): It is a potential that can be measure by volt it is also effect to the material removal rate and allowed to per cycle. Voltage is given by in this experiment is 50 V. (g) Diameter of electrode (D): It is the electrode of Cu-tube there are two different size of diameter 4mm and 6mm in this experiment. This tool is used not only as a electrode but also for internal flushing. (h) Over cut – It is a clearance per side between the electrode and the workpiece after the marching operation. 2. 3 Characteristics of EDM

EDM specification by mechanism of process, metal removal rate and other function that shown in this table no . 1 2. 4 Dielectric fluid In EDM, as has been discussed earlier, material removal mainly occurs due to thermal evaporation and melting. As thermal processing is required to be carried out in absence of oxygen so that the process can be controlled and oxidation avoided. Oxidation often leads to poor surface conductivity (electrical) of the work piece hindering further machining. Hence, dielectric fluid should provide an oxygen free machiningenvironment.

Further it should have enough strong dielectric resistance so that it does not breakdown electrically too easily but at the same time ionize when electrons collide with its molecule. Moreover, during sparking it should be thermally resistant as well. The dielectric fluid has the following functions: (a) It helps in initiating discharge by serving as a conducting medium when ionised, and conveys the spark. It concentrates the energy to a very narrow region. (b) It helps in quenching the spark, cooling the work, tool electrode and enables arcing to be prevented. c) It carries away the eroded metal along with it. (d) It acts as a coolant in quenching the sparks. The electrode wear rate, metal removal rate and other operation characteristics are also influenced by the dielectric fluid. The dielectric generally fluid used are transformer on silicon oil, EDM oil, kerosene (paraffin oil) and de-ionized water are used as dielectric fluid in EDM. Tap water cannot be used as it ionizes too early and thus breakdown due to presence of salts as impurities occur. Dielectric medium is generally flushed around the spark zone.

It is also applied through the tool to achieve efficient removal of molten material. In this experiment using the Commercial grade EDM oil (specific gravity= 0. 763, freezing point= 94°C) was used as dielectric fluid are used it is using as coolant and medium of workpiece and tool during the process of erosion. 2. 5. Flushing method Flushing is the most important function in any electrical discharge machining operation. Flushing is the process of introducing clean filtered dielectric fluid into the spark gap.

There are a number of flushing methods used to remove the metal particles efficiently. 2. 5. Tool Material Tool material should be such that it would not undergo much tool wear when it is impinged by positive ions. Thus the localized temperature rise has to be less by tailoring or properly choosing its properties or even when temperature increases, there would be less melting. Further, the tool should be easily workable as intricate shaped geometric features are machined in EDM. Thus the basic characteristics of electrode materials are: 1.

High electrical conductivity – electrons are cold emitted more easily and there is less bulk electrical heating. 2. High thermal conductivity – for the same heat load, the local temperature rise would be less due to faster heat conducted to the bulk of the tool and thus less tool wear. 3. Higher density – for the same heat load and same tool wear by weight there would be less volume removal or tool wear and thus less dimensional loss or inaccuracy. 4. High melting point – high melting point leads to less tool wear due to less tool material melting for the same heat load. 5.

Easy manufacturability. 6. Cost – cheap. The followings are the different electrode materials which are used commonly in the industry: 1. Graphite 2. copper 3. Tellurium copper – 99% Cu + 0. 5% tellurium 4. Brass 2. 6. Design variable Design parameter, process parameter and constant parameter are following ones, Design parameters – 1. Material removal rate. 2. Tool wear rate 3. Over cut (OC) Machining parameter – 1. Discharge current (Ip) 2. Pulse on time (Ton) 3. Diameter of U-shaped tool Constant parameter1. Duty cycle 2. Voltage 3. Flushing pressure 4. Polarity 2. 7. Workpiece material

It is capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. There are different types of tool material are using the EDM method. And the tool steel contains carbon and alloy steels that are particularly well-suited to be made into tools. Their suitability comes from their distinctive hardness, resistance to abrasion, their ability to hold a cutting edge, and/or their resistance to deformation at elevated temperatures (red-hardness).

Tool steel is generally used in a heattreated state. Tool steels are made to a number of grades for different applications. In general, the edge temperature under expected use is an important determinant of both composition and required heat treatment. The higher carbon grades are typically used for such applications as stamping dies, metal cutting tools, etc. 2. 8 MACHINING PARAMETER SELECTION In this project , material removal rate (MRR) is important. This characteristic material removal rate (MRR) is a major influence resulting the machining performance.

Among the numerous parameters affecting the EDM performance, the dielectric fluid has a very important role. The physical properties of the fluid influence the breakdown voltage and the ignition delay: however, the debris concentration in the fluid modifies these parameters, decreasing the dielectric strength by many orders of magnitude . But this parameter is neglect due to limitation of scope of studies. Surface roughness is also a very important parameter but is not taken into consideration due to unavailability of perthometer. 2. 9 MACHINING PERFORMANCE EVALUATION

Material removal rate (MRR) is used to evaluate machining performance. The material removal rate (MRR) is expressed as the work piece removal rate (WRW) under a period of machining time in minute (T), which is : Ww= Weight loss Pw= Density of material The density of materials was measured on basis of volume displacement method using weighing machine and beaker 2. 10. Objective of the present work From the research papers refered , it is observed that few works has been reported on EDM on the material Al-Sic, EN-19, SKH 57 and various composite materials.

The objective of the present work is an attempt to finding the effect of machining parameters on EN-31, HCHCr for material removal rate using a pure copper electrode . The machining parameter selected for experiment are pulse on time , peak current and duty cycle , using one variable at a time approach analysis for responses MRR has been carried out. CHAPTER 3 EXPERIMENTAL SETUP 3. 1 LABORATARY USED: 1. ENVIRONMENTAL ENGINEERING LAB USED FOR WEIGHING WORKPIECE 2. WORKSHOP USED FOR CONDUCTING EXPERIMENT ON EDM 3. 2 Materials Used 1. 2. 3. 1. HCHCR (55-56) 2. HCHCR (20-22) 3. EN-31 (20-22) ELECTRODE Uses of Workpiece Materials:

EN 31: • High tensile strength machine parts. • Gears and pinions. • Axles • Shafts • Connecting rods • Plastic moulds • Forging dies for smaller section of ferrous & non-ferrous items. HCHCr: • Plastic moulding • Dies • Hot shearing tools • Hardened rolls • Thread rolling dies HARDNESS DEFINITION : • It’s the ability of the material to resist permanent shape change. • Rockwell scale is a hardness scale based on indentation hardness of material in which resistance of permanent plastic deformation due to a constant compression load from a sharp object • Rockwell intrument used from DULOCOS CONVEYORS AND MOULDS PVT.

LTD. DENSITY = Mass/Volume 1. Measured the mass of workpiece from weighing machine. 2. Measured the volume displaced with the help of beaker. 3. 3 EXPERIMENTAL CONDITIONS WORKING PARAMETERS Work piece materials DESCRIPTION EN-31(20-22), HCHCR(2022), HCHCR(55-56) Copper(Cu) Positive Kerosene 4, 6, 8 amps 35, 45, 55, 65 TYPE CONSTANT Electrode Material Electrode Polarity Dielectric Fluid Peak Current(Ip) Pulse Duration(Ton) CONSTANT CONSTANT CONSTANT VARIABLE VARIABLE Duty Factor Working Time (Ton variable) 9 40 mins CONSTANT CONSTANT CONSTANT Working Time (Ip variable) 30 mins . 4 CALCULATING MRR: FORMULA USED Where: Ww: Weight of the material in gms. ? w : Density of the material in gm/cm3. T : Machining time in mins. CHAPTER 4 OBSERVATIONS AND RESULTS 4. 1 MATERIAL : EN-31 , HARDNESS : 20-22 ON ROCKWELL SCALE DENSITY: 5. 57 g/cm3 CHANGING PARAMETER: PULSE ON TIME(Ti) CHANGING PARAMETER: PEAK CURRENT (Ip) 4. 2 MATERIAL : HCHCr , HARDNESS : 20-22 ON ROCKWELL SCALE DENSITY: 5. 228 g/cm3 CHANGING PARAMETER: PULSE ON TIME(Ti) CHANGING PARAMETER: PEAK CURRENT (Ip) 4. 3 MATERIAL : HCHCr , HARDNESS : 55-56 ON ROCKWELL SCALE DENSITY: 8. 47 g/cm3 CHANGING PARAMETER: PULSE ON TIME(Ti) CHANGING PARAMETER: PEAK CURRENT (Ip) CHAPTER 5 RESULT ANALYSIS • The experiments are based on one factor experiment strategy. • In this only one input parameter was varied while keeping all others input parameters at constant values. • During this experimental procedure, 6 sets of experiments were performed varying the Peak current( Ip) and Pulse time on (Ton) for three different materials. After analyzing the results of the experiments performed, various facts came into light. EXPERIMENT SET 1 PULSE ON TIME IS INCREASED The above graphs shows that material removal rate increases with the increase in the pulse on time and decreases after some time. So the pulse on time can be adjusted to get the desired material removal rate. The Declining Trend Of Graph • Ton:- During pulse on time spark erosion takes place and metal is melted/vapourized • Toff:-During pulse off time metal is washed away and solidified • But as the Ton is increased at constant Input parameters, Toff starts to decrease due to which metal is stuck and is not removed properly and MRR decreases

EXPERIMENT SET 2 PEAK CURRENT IS INCREASED • The above graphs shows that material removal rate increases with the increase in the peak current. So value of peak current should be high to obtain higher MRR. CHAPTER 6 CONCLUSION The following conclusions are drawn from the experimental study: 1. The parameter PEAK CURRENT (IP) has direct effect on material removal rate as we increase peak current material removal rate increases 2.

The PULSE ON TIME parameter has direct effect on the material removal rate with a declining trend, as we increase the pulse on time the material removal rate increases upto a certain level but starts to decrease after certain time. REFERENCES • Saurabh kumar saha, Experimental Investigation of the Dry Electric Discharge Machining (Dry EDM) Process • S. H. Tomadi, M. A. Hassan, Z. Hamedon, IAENG R. Daud, A. G. Khalid, Analysis of the Influence of EDM Parameters on Surface Quality and Electrode Wear of Tungsten Carbide • M. M. Rahman, Md. Ashikur Rahman Khan, K.

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