Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Manufacturing Process Technology – Part- 2

Module- 31
Analysis of RC circuit for EDM

by
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Hello and welcome to this manufacturing process technology module 2 part 2module 31.

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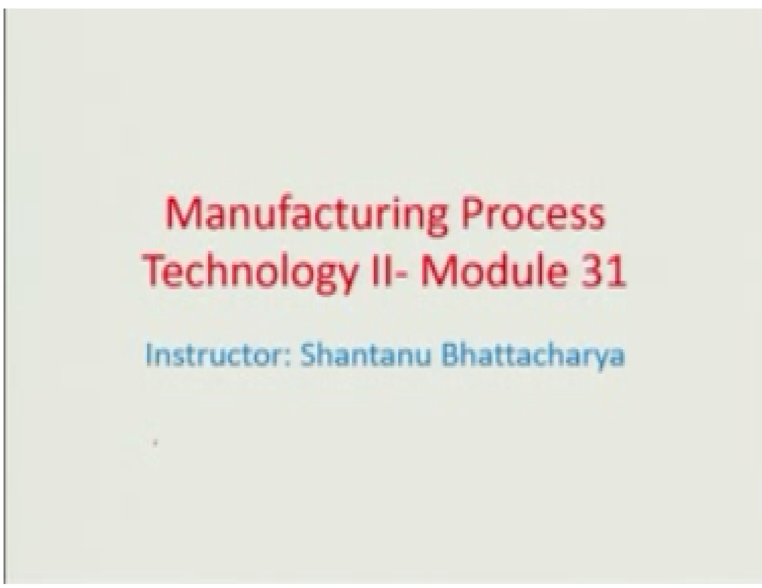

We were actually discussing about EDM circuits and in context of that we mentioned about the famous resistance capacitance circuit which issued for feeding power to an EDM systems in context of that we were trying to look at the maximum power transfer which happens in such a circuit and we found out the total power that is delivered to the discharging circuit would really be the product VCT times office and we already know that VCT can be represented in terms of v01_ e to the power of _ t by RC c and ICT can further be represented as v0 by RC times of e to the power of _ t by RC times of see.
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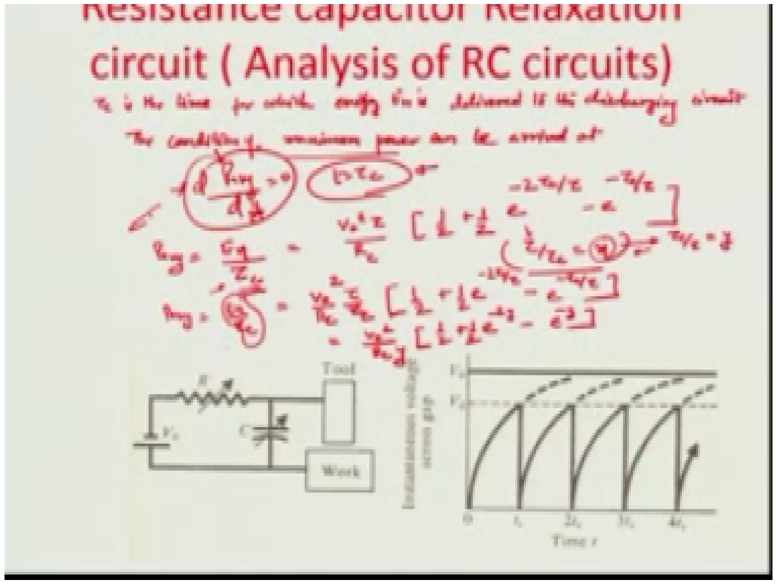

The total energy d en would actually be a product PDT in thisparticular case because obviously power time gives the total energy which is transferred so here we would like tohave the total energy transferred to the discharging side as a product as written here times of DT where dt is the elemental time for which the power is being transferred so if we integrate this on both sides we are left with the value of en which is v 0 square by RC times of _ tau to the power of _ T by tau + by 2 e to the power of _ 2 T by + k2 where k 2 is the constant of integration and we have assumed this RC times of C to be the time constant t.

Which we are just simply replacing herein all these terms just for derivative in the way we are representing the reformulation of the equation so let us now try to evaluate what this k2 is so at time T equal to zero we know that the total energy that is delivered from the charging to the discharging side is 0because it is still not hit the point when there is going to be a discharge between the anode and the cathode okay.

So therefore if we put or evaluate to this equation 1 let us say under this boundary at time T 0 en is 0 we get the value of k2 to be equal to v-0 tau by twice RC so as you know this term will go off so with this and we are only left with _ tau + tau by 2 this is 1 this is 1 this is 1 at T equal torero so you are left with only V 0 squaretail by twice RC as the K 0 so if substitute this back into this equation here right here the en final formulation can be written down as V 0 square by RC times of one half + half e tote power of _ twice t by _ to the power of _ T by Z.

So that's going to be the total energy transfer between the input circuit or the discharging of the charging circuit and the discharging circuit so if we look at now what is going to beverage power to be transferred so we have to really concentrate on the charging time,

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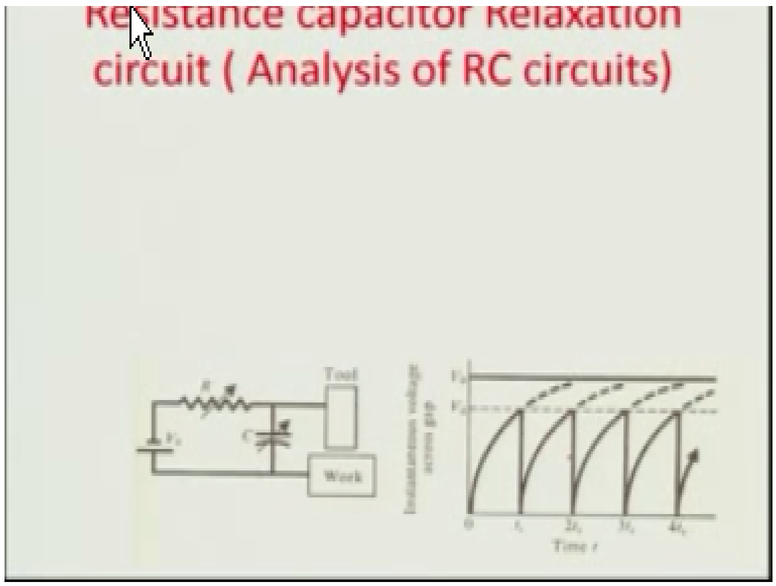

And sorry the time for which the energy is being discharged so let us suppose that TC is the time for which the energy en is delivered to the discharging circuit the condition of maximum power can be arrived at by simply differentiating the average power which will just calculate in the next step okay some variable here which I am going to map okay and let us now look at first of all what is this average power and what are the variables so average power is nothing but the amount of energy which has been discharged into the gap by the discharging circuit per unit the time for which the energy n is delivered to the discharging circuit.

So let us consider that time to BTC the time that it takes to discharge the tool completely and so this also can be considered as a park Stein spark time for a single spark even and if I were to consider you know by substituting the value of TC in the expression we have now the en value from the last step borrowed from the last error v 0 squaretail by RC times of half + one-half to the power of _ twice now we put the value of t equal to t see here the amount of time.

It takes for the whole discharge process to complete so you have to t 2 tau c by tau ok _ of to the power of _ again tau c by and if I were to again use the value of let us say tau by tau C as some value X okay this is some ratio that we are assuming that the actual time constant you know or how many times of the this parking time or the discharging time is really.

The time constant of the circuit so this tea with tau by tau C is a very important parameter X here so I can convert the whole equation the power equation of theaverage power equation here as en by C equals V 0 square divided by RC times of you can call this tau by tau SI en by C remember times of half + half to the power _ twice tau C by tau_ of e to the power of _ tau C by tau okay.

So we consider again you know the inverse of this tau c by tau to become function y so I have v 0 square b x of y times of half + one-half to the power of _ twice y _ of to the power of _ y and we can actually put the value of y here and equate equal to 0 for the maximum power transfer condition okay so if I were to calculate the deep our average parent dyand acquired it to zero we would actually end up getting a solution for the maximum power transfer condition.

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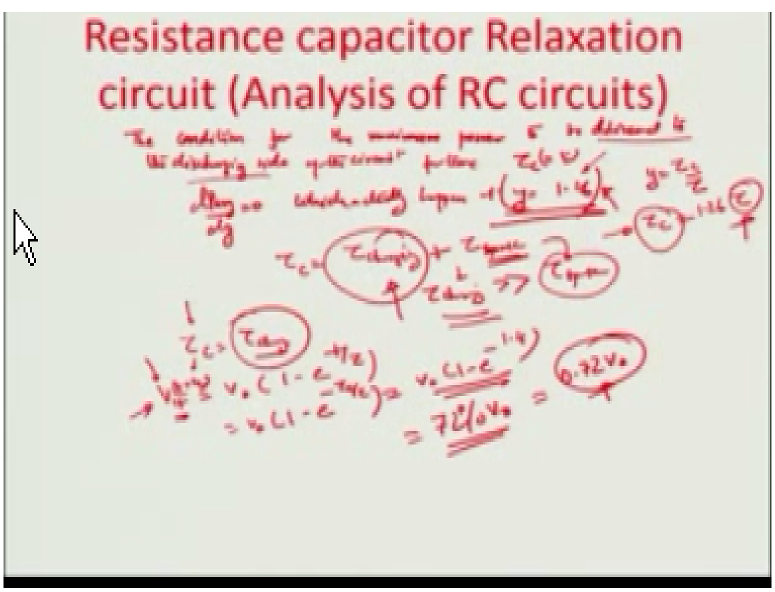

Okay so the condition for the maximum power to be delivered to the discharging side of the circuit for time tau C equal to two get you know DP average by equals zero which actually happens I am going to show the calculation here but it actually happens add a value of equal to one point two six so which actually corresponds to you know because Y here has been assumed to be a ratio of TC by T.

So this is a condition which says that the total amount of you know time. That is needed to deliver the old charge to the discharging side I am going to just talk about what all components are there in this time that should be at least equal to one point two six times the total time constant where there is a sixty-three percent power rise in the charging side so this is the condition corresponding to which really the maximum the start should make some power transfer should take place through the DM gap now let us look at what this TC corresponds to so obviously it is the amount of total time that is needed for the maximum power.

To be delivered which would definitely include the charging time so if I look at different components of TC so it would-be the time to charge so time charging + you can say you know a small amount of time which is spent in the spark to happen so the time of spark T spark added on to the charging time obviously this is much greater so this charging time is much greater than the sparking time because this park is really a very short lasting momentary kind of phenomena and we can safely neglect the sparking time and just consider TC to be equal to the charging time the capacitor okay.

So if I want to do that here at this particular case I would get a very different kind of situation so let assay the is actually the charging time you know the time in which the capacitor let us say charges to the full extent actually and so I can actually get the value of v CT which is actually the voltage across the capacitor as a function of time and it has been earlier calculated as v01 _ e to the power of _ T by the time constantan the RC circuit.

So in this case the VCT at the point of time corresponding to t equal to TC let us say or the charging time let us say is going to be equal to V 0 1 _ e to the power of _ tau C by tau R v01_ e to the power of _ 1.26 ok this corresponds to the maximum power transfer voltage of V CTE or capacitor as a function of time which is needed for the voltage charge delivery to happen which is in fact about seventy-two percent of v-0 so it is 0.72 v-0.

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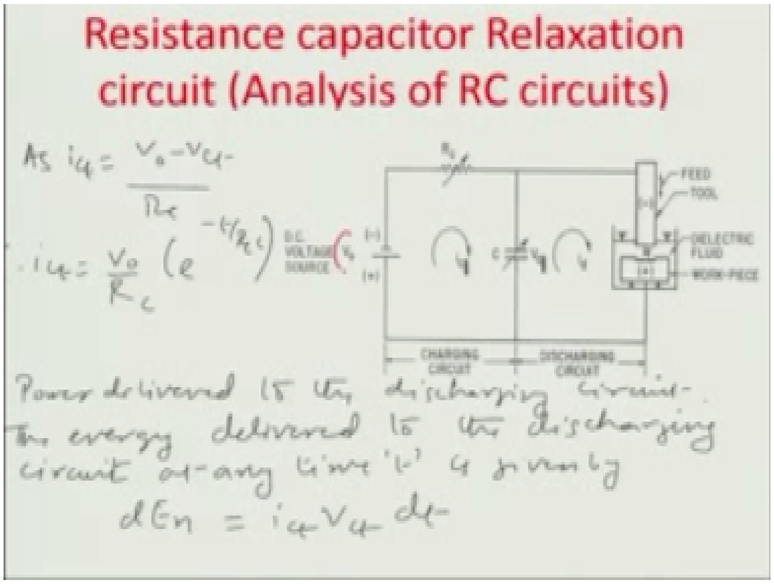

So if you want to operate the circuit that was being shown earlier in one of the modules here where this is let us say the V 0 this is what the VCT is and this is what the delivery side discharge voltage is so the maximum power transfer can only happen when this guy hits about seventy two percent of the total output where the source voltage v-0 okay.

So this is a sort of a smooth operating condition that the circuit should be maintained at typically if you wanted maximum power so to be transferred from the DC voltage source across a gap in the in the EDM circuit so that is about it so we necessarily just let us go back to the concern slide so that is the discharging voltage for maximum power delivery to happen is corresponding to seventy-two percent of supply voltage.

So for maximum power delivery through the gap the breakdown voltage and the supply voltage should follow the relationship v be approximately equal to seventy two percent of V zero so the breakdown voltage that the circuit needs to be operated as about seventy two percent of be zero so the current in the discharge circuit if were present the sparking resistance by let us say RS would actually be equal to let us say I d _ DQ by DT equals_ c v c t by DT.

So this is how the discharge would happen assuming that the voltage as a function of time is going down in the charging capacitor when the discharge starts to happen and you know the IDE can also be represented a v CT by RS and this condition this is while discharging right so this condition can only happen when DBC t by v c t equals _ t by RS times of c+ some constant of integration k3 and obviously if we assume that at time T equal to 0.

The VCT value or the charging capacitor or the capacitor value is charged to some value VC 0corresponding to time T equal to zero we have k3 represented as L n vc0 or VCT represented as VC 0 e to the power of_ T by RS times of C so that's about you know how you can actually represent the variation of the VCT on the discharging side earlier we were doing mostly on the charging side and you can see what is the operating point of the charging capacitor where the power transfer should really be the maximum.

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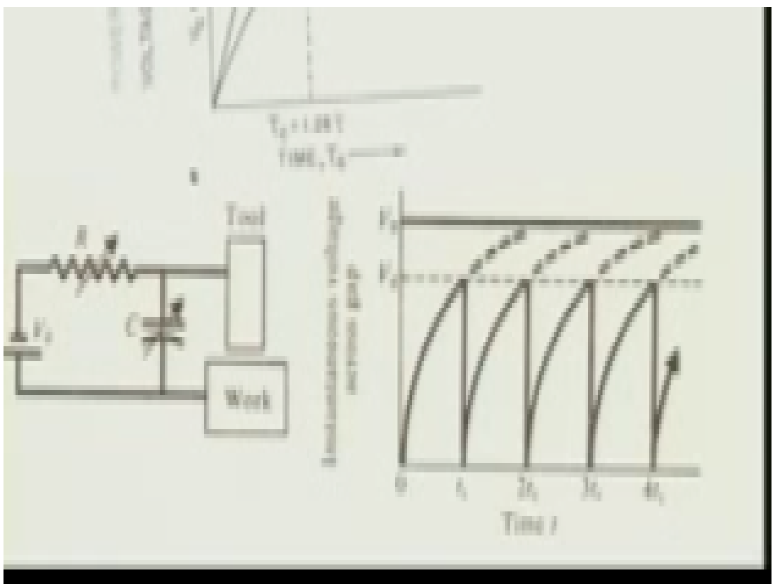

Let us kind of plot and see if we can understand what is going on here so here you have a output or an operational voltage of the power source V 0and we know that if we wanted to operate the charging discharging side of the circuit given here the best idea would-be to sort of you know go all the way up to about the value of VD discharge voltage to an extent of seventy-two percent of v-0 and then start discharging.

You know from this level so if I want to do it multiple times forgone charging cycle this is typically TC we assume that the sparking time is almost insignificant in comparison to the charging time ok so the charge delivery would really happen as a function of T C and then again you know in each cycle it gets protruded forward by TC so you have two TC three TC for TC so on and each time having the charging discharging cycle to take place at an instance VD.

Corresponding to seventy two percent of the power of the input voltage v-0 and also if we had to plot the VI product which is the power the power would definitely be maximum at a corresponding value of the total time TC equal to about 1.2 six times the time constant of the charging circuit so this is really the operational extend up to which the circuit should be ideally operated for maximum power transfer to take place.

So we will now try to look into a little different aspect and try to actually get into a little bit of you know studying of the behavior more from a standpoint of the discharging side behavior and then maybe do some numerical examples where we can try to see if all these concepts together can be utilized for looking at material removal rate so again going back to the ID value the discharge current value the ID was given as v CT by RS in other words.

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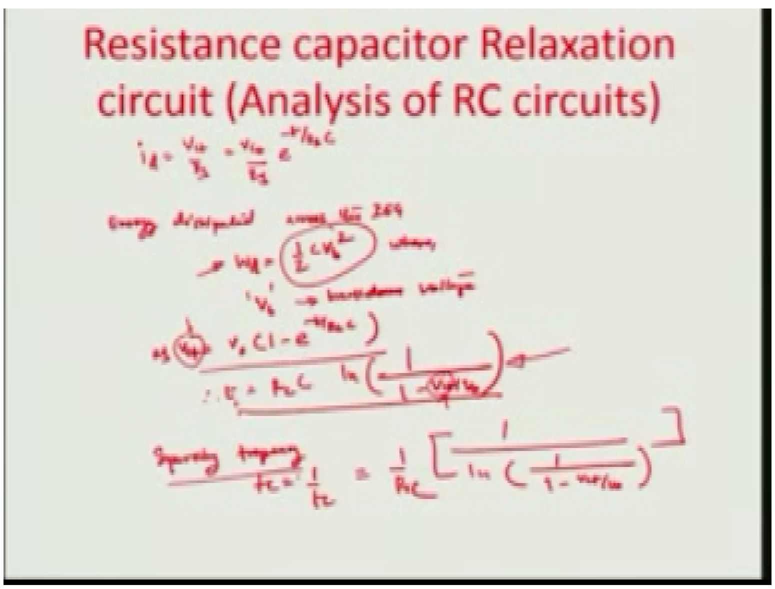

It was taken as VC 0 by RS e to the power of _ T by RS times of see from the last step so if we look at the energy dissipated across the IEG the interelectrode gap that would be given by WT equal to half CV square where again VB is the breakdown voltage as v CT is already known to be v01 _ e to the power of _ T by RC times C.

So we can find out the value of the spark frequency or the total charging time from this expression right here the total time that is sort of needle in this case for the VCT to reach its value from the output power value V zero from zero to v c t as the output power is v-0this time is given by again just algebraically changing this equation so it is RC times c l n 1 divided by 1 _v c d by v0 ok obviously vice by be 0 and1 _ vf t by v0 can be e to the power of _ t by RC c and so you can take natural logs on both sides.

And this gives you the time so from this wean actually have an idea of this parking frequency because obviously as you are found in the earlier trend that the signal goes all the way up to seventy-two percent of do on the resource voltage and then falls down and the falling down this parking time is very short in comparison to the charging time so most of the total duration of sparking is covered with charging time and there is very less value as such that this working process itself adds to the overall time value so the TC can really be estimated through this.

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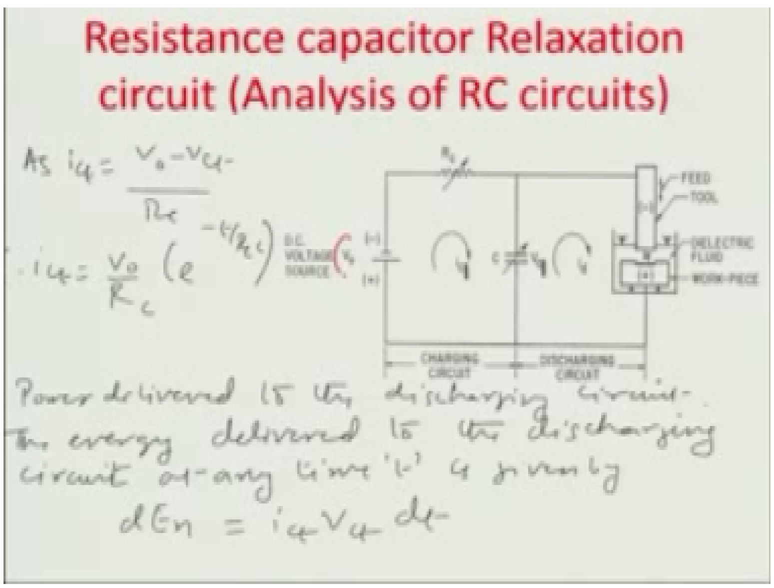

You know whatever operational voltage you actually operate the circuit and these far tin frequency then FC would actually be 1 by TC which is actually 1 by RC c times of again 1divided by L n of this whole term 1divided by 1 _ vf t by v0 so that is about what the sparking frequency is going to be in this particular case soothe minimum value of resistance particular this resistance RC needs to be maintained.

So that you know the circuit does not cause an arcing like behavior and it should limit itself to only the sparking behavior so this is known as the critical resistance okay this is the critical resistance and it actually helps inpreventingarking for long durations to happen so obviously if the RC were zero in the expression here if I just want to look at this particular expression and if RC were zero so it would be almost indefinite spark frequency or very large frequency.

Which would be considered as a theoretically it will be considered as a continuous park for a long time so that becomes essentially arc and that we want to avoid in this situation so therefore there has to be some value of RC critical value of RCwhich is non zero and obviously the critical values driven by some guidelines as another process and if we had some inductance in the discharging side which is otherwise given normally to avoid any kind of surge of X on the power supply here.

So at least the minimum value of resistance should be given by root of lay c I am NOT going to get into why this would be the critical value at which you should operate but it has been found out that if you operate at the root over inductance per unit the capacitance here C value and that is going to be your minimum resistance it is going to prevent the frequency in finite condition you know to arrive at so frequency infinite means very less gap between the switch on and switch off time and it means continuity.

Or it means arcing rather than sparking so you have to be careful about placing our RC in the circuit in a manner so that is at least root over whatever is the inductance in the discharge side which is otherwise given because you want a surge protection to happen typically you could give an inductance you know in this particular region so that there is a you know surge voltage protection of at least the power source to happen when there is a sparking condition created.

So if such an inductance is there in the circuit it is easy to design what is going to the minimum threshold existence to prevent this condition of arcing from happening we do not want an arc in EDM for many reasons one of them is that we need the hole machining the whole surface to be machined and mark at one point would really create a pitting or it would create machining at only one place and typically the criteria of a spark dancing all around the surface which would create uniform wear of the surface will not be happening or it will be prevented okay.

So which loses the essence of the hole machining process so today we are going to just stop at this level but in the next class we are going to sort of module we are going to take up that this energy given at a certain rate would really be the amount of power that is going to do the material removal and there are empirical relationships of power with respect to the material removal through which we will try to predict some of the material removal rates that would come.

So typically now if you change your circuit design you could actually influence the material removal rate in terms of power etcetera which is being delivered and it a lot depends on what is the dielectric fluid and what are also going to be the electrodes like the tool and the and theworkpiece so we'll finish this module here and look forward to doing some material removal rate calculations in the next module till and until then goodbye thank you.

Acknowledgement

Ministry of Human Resources & Development

Prof. Satyaki Roy
Co – ordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan
Tapobrata Das
Ram Chandra
Dilip Tripathi
Manoj Shrivastava
Padam Shukla
Sanjay Mishra
Shubham Rawat
Shikha Gupta
K.K Mishra
Aradhana Singh
Sweta
Ashutosh Gairola
Dilip Katiyar
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